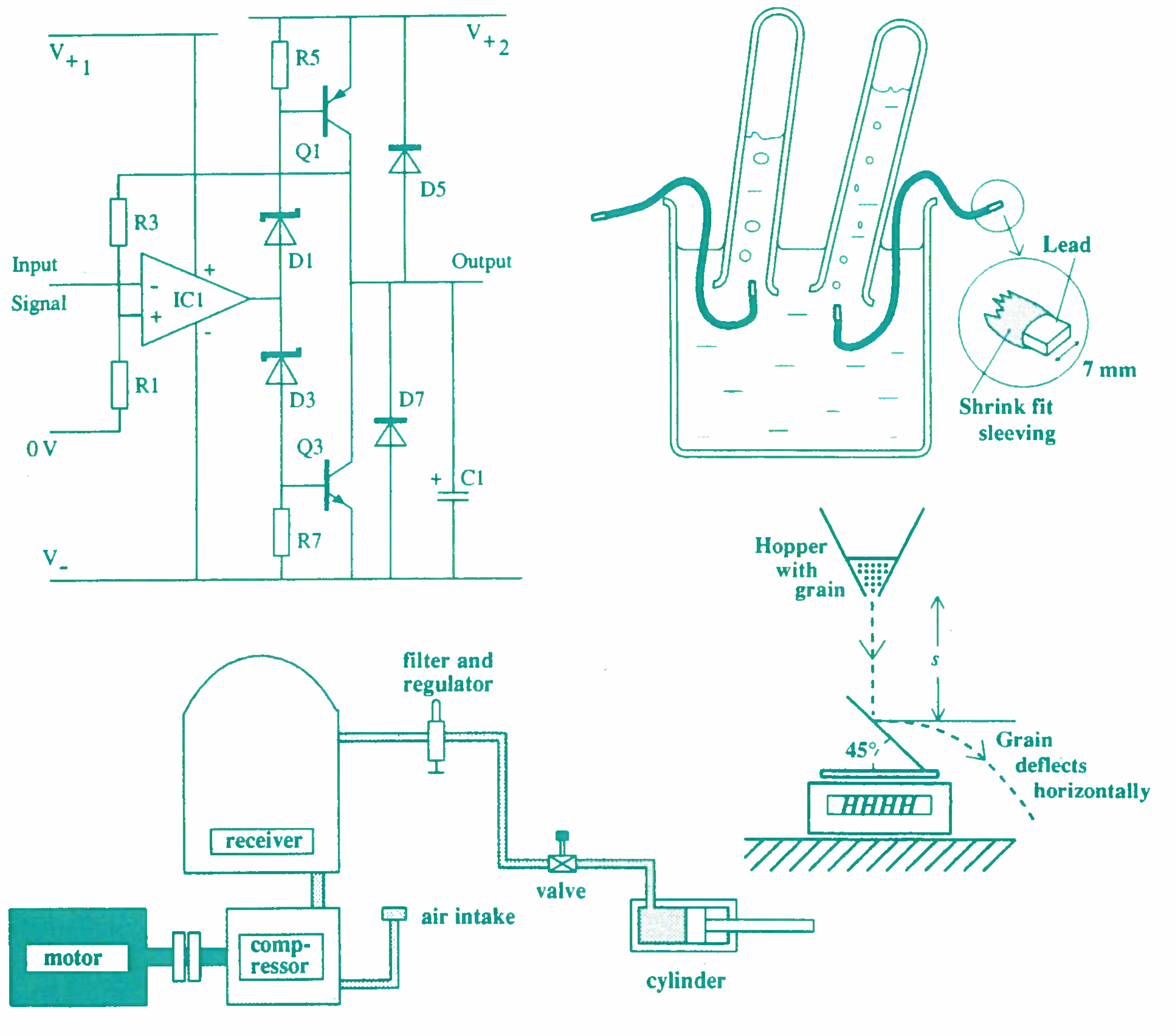
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE



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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).

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Opinion

Sometimes I arrive at work in a dwam, having no recollection of anything seen or done in the twenty minute walk from the station. But more usually it is the impressions made by the people and places seen along one of Edinburgh's busiest thoroughfares - the road south from Waverley - that crowd in the mind.

Of people, I particularly recollect the teenage boy, head covered in a woollen cap, being pushed in his chair by a mother, prematurely aged through the illness of her son. Nothing ever relieved the misery of sighting the pair until the day both had expressions radiating joy. Good news, perhaps, or a shared joke? I often wonder why I have never, since that occasion, sighted them again.

Of the places passed, it is the buildings rather than the shops which interest. Eighteenth and nineteenth century tenements, some crumbly, or eroded, others better preserved either because of a superior stone, or through renovation. The plainness of, and lack of decoration on, Edinburgh tenements are offset by qualities which their master builders clearly understood: each block is uniquely different, yet bears a sense of proportion and spacing of its features - windows and facade - which are absolutely right.

The main University building dominates the South Bridge, its mixture of mighty arches and massive columns celebrating the twin classical traditions which inspired the age of enlightenment. But what inspired Playfair to add the domed tower to enhance the original Adam design? In search of an answer I thought back to the time of construction. What other buildings might have been the source? Apart from thinking of Wren's St Paul's, a building that predates the Old College by a few decades, it was a visit to the City Art Gallery in Aberdeen which provided the clue. In the Canalettos on loan from Windsor Castle the same church appeared again and again in Gran Canal scenes - a squat rectangular building topped by an enormous dome. Looking from one picture to another the change in aspect resembled the glimpses of the Playfair dome snatched on the walk to and from work.

So perhaps etchings of Canaletto's had been an inspiration for the Old College? If we take the chain further back in search of what had inspired the Venetians we are off on the Orient Express to Constantinople, the Byzantine Empire, and the ancient civilisations of Asia Minor and Persia.

Another chain of inspiration can be remarked upon. Churchill acknowledged his talent for wartime leadership to his ancestor, Marlborough, who in turn acknowledged his propensity for the doing of great deeds on his school study of Shakespearian heroes. What inspired Shakespeare can only be guessed at. It was presumably Plutarch's histories of the greats of ancient Greece and Rome.

Of all the concerns I had as a beginner at teaching that which most humbled me was the obvious requirement to be able to inspire, and, on the other hand, the pointlessness of the job should that be found lacking. The challenge of how to rise above the boots of, let alone live up to, the best of those who had taught me, was chastening to contemplate.

Yet it was a goal to be striven for. To have had a dwamful of a class would have been a sure sign of failure. But to have them gaze at mountains with that joy of wonder - is that the reason most of us, I ask, took up the calling?

INTRODUCTION

Bulletin format

It will be obvious to regular readers that, as promised (threatened?) in issue 165, for this Bulletin we have changed both the origination method and format. As we go to press, several pairs of fingers are crossed in the hope that we will indeed get back from the printer a better quality publication.

Never, it is wisely said, apologize in advance. We did however upset not a few folk the last time we changed the format from A4 to quarto. So, to anyone who changed their filing system to accommodate that change - sorry! (The quarto thing wasn't my bright idea, by the way).

Put up a poster

This issue contains an A4 loose-leaf insert for use as a poster and reminder on SSERC services. We would be grateful if you would display a copy in your staff base, prep. rooms or other technician work areas.

Farewells

Ta ta, wee Rab!

Short term, cash funded projects are a pain. Ask any educational manager who has to recruit skilled staff on short, fixed term contracts.

Our JSA (Joint Support Activity) project has already presented the first symptoms of that well known, fixed contract affliction - *Temporaryitis twitchus nervosa*. By the time you read this, Robert Little, our erstwhile JSA Applied Science Technician, will be doing things biotechnological for a different organisation.

In his relatively short time with SSERC, Robert got through a great deal of work and endeared his quiet, effective self not only to Centre staff but also to a significant number of teachers and technicians he has advised or helped to train. We wish him all the best in his new post with Fermentech, the biotechnology company (a permanent and better rewarded position - Central and Local Government funders please note!).

Twin loss

Retirals are always half-sad, half-happy occasions. It depends, to some extent on your viewpoint. From here, we are sorry to have to say professional farewells to two doughty fighters in the cause of quality science education. We refer, of course, to Messrs Pirie and Cattan, science advisers for Tayside and Central Regions respectively. Both entered the advisory fray at about the same time and they will retire within a matter of months of one another.

By the time this Bulletin is printed A.F. ('Sandy') Pirie will already be enjoying the first weeks of his well earned retiral. Knowing him, that won't mean any slowing down - on the contrary. You are probably just more likely to find him setting out for a stroll up some Munro or other. Jimmy Cattan on the other hand, he of the music hall school of science advising will, some weeks after Sandy's retiral, achieve his own life-long ambition of a permanent position in golfing (strictly unpaid of course except occasionally at so much a hole). He may thus launch a whole new era in the annals of the national game, amateur-celebrity golf!

Joshing apart, we will miss them. For all their years' experience, both in teaching and in the advisorate, neither of them ever took their eye off the ball. In their own way, with their own distinct style, each has always had at the front of his mind the real clients in the business - the "bairns". Any differences we might have had with either of that pair arose from that prime concern, and almost always they were right. If being customer-orientated is a "primary performance indicator" then both Cattan and Pirie could have earned their corn anywhere.

Summer opening

The Centre will remain open on weekdays right over the Summer break. Official opening hours will be the usual 9 a.m. to 5 p.m. but in practice someone will usually be around from about 8.40 in the morning and up to at least 5.15 p.m.

We confirm our announcement in Bulletin 165 of the suspension of Saturday opening over the holidays. The last Saturday we will open this session will be the 9th of June.

Centre staff will be taking leave on a rota basis. If you wish to see a particular member of staff or seek advice on specific problems you are advised to give us a ring before your visit.

Traditionally the Summer is when we tend to see folk from the Highlands and Islands or other distant airts who pop in to the Centre as an excuse to escape Princes Street shopping and the tourists. We look forward therefore to welcoming some of our Summer regulars to our new premises.

Equipment Sales

This issue contains a truncated list of items and materials for sale. Because of school closures over the long holiday we saw little point in printing our entire stock list. The first issue of the new session (No.167) will contain a full list. In the interim we suggest that anyone wishing to place orders over the Summer should refer to the fuller list in Bulletin 164, dated December 1989.

More on SAPS

In Bulletin 165 we gave some publicity to the "Science and Plants for Schools" (SAPS) programme. Since then the first SAPS related event has already been held in Scotland. This was part of an evening programme in the Royal Botanic Gardens staged as part of the 1990 International Festival of Science and Technology. Dr.David Ingram the new Curator spoke on the general educational role of the Gardens and on his hopes for its further development. Richard Price, SAPS Director, and Stephen Tomkins, a teacher seconded to the project, then gave a presentation on the SAPS programme.

A full day (10 a.m. to 4 p.m.) "Fast Plants" workshop is now planned for the 10th of November 1990 at the Royal Botanic Gardens, Edinburgh. The Scottish Association for Biological Education (SABE) have agreed to help co-ordinate the event. Further information is available from Dr. Johanna Carrie at the address given on the inside cover of this issue.

SSERC PUBLICATIONS

Standard Grade Chemistry

Updated databases and lists

The SSERC databases, from which can be derived equipment and chemicals lists, have been updated and extended since the first drafts appeared early in 1988. The original information was based largely on the first drafts of the SSERC Practical Guides for Standard Grade Chemistry.

To date, two volumes of these Guides have been published, with only Topics 14-16 remaining to be covered. SSERC can now offer updated information on equipment and chemicals, including those items necessary to undertake the practical work set out in the revised Higher syllabus.

Data is held on two computer databases - one for equipment and the other for chemicals. These were generated by the Beebugsoft *Masterfile II* database program running on a BBC B or Master Computer. Copies of the datafiles are available from SSERC on two $5^1/_4$", double-sided, 80 track discs or on a single $3^1/_2$", E-format disc for use with the Archimedes range of computers. The latter operates with the Archimedes version of Masterfile II, available from Beebugsoft at £16.50 to members, or £22 to non-members.

The databases are global in that they assume no existing provision and that all practical work set out in the SSERC Practical Guides or the Higher "Conditions and Arrangements" may be attempted. The costs indicated are therefore likely to be the maxima applicable at the start of April 1990. Because of existing provision and potential savings by timetabling and other managerial means, actual costs are likely to be below these figures.

We will shortly be sending out to each Scottish EA (and to divisions in Strathclyde) a copyright-free master of our "first choice" printout for equipment and chemicals. Science Advisers or nominated SSERC/EA correspondents where there is no such adviser will receive these masters. Where an EA also has a resource service's senior or chief technician they too will receive a master copy. Each subscribing independent school will get a copy.

What is a "First Choice" list? For major capital items the choice is usually made as a result of our test and evaluation programmes. Price plays an important part but weight will be given also to aspects of performance. Particularly valued features may well, within reason, override considerations of costs.

For more prosaic consumable items like glassware and chemicals price may be more important but meeting a given minimal specification may still be a basic criterion. In most cases, the costs of such items have been compared across two, often three, different suppliers. Largely, but as indicated not solely, on the basis of price the apparent best buy is given as first choice. Generating your own shopping list from such a printout will thus give a mix of suppliers. If you wish, or are only allowed through contractual arrangements, a sole source of supply, then a list can be generated showing a range of choices from a number of major suppliers.

The following sections explain how you may obtain the databases themselves and other more specialised printouts.

Databases on disc

Anyone in an establishment in membership of SSERC may obtain copies of the actual datafiles. To do so please send an order or written request stating the format required: $5^1/_4$", double sided 80 track for BBC B or Master or a single $3^1/_2$", E-format disc for Archimedes. The charge for the discs or disc, with documentation explaining how the datafiles may be used, is £6 inc. p. & p.

Specialised printouts

For those without access to Masterfile II we are willing to supply a range of special printouts for specific applications. The charges for each of these will be nominal, reflecting our copying and postage costs, and will be from £1 to £2 depending on printout length. The range of printout types available for each datafile is described below.

Equipment database

Within the records in the datafile the following fields are available:

a brief *Item* description;

a technical *Specification* which also denotes the number of items or packs of items and the relevant unit price;

Supplier and *Cat.No.*;

Price which is the total cost of the items as shown under *Specification*;

the number of items (*Lab.1*) required for a first lab. and for any general departmental or technician use;

a figure (*Total 1*) for the cost of any item per first lab.;

the numbers of any given item (*Labs +*)needed to stock subsequent labs, and

a Topic number (*Topic ref(s).*) for items required specifically for any Topic with any specific Higher Topic references being preceded by an 'H'.

Printouts available

First Choice Equipment List - alphabetically sorted by *Item* (the apparatus type) then *Specification* (number of items supplied at quoted price). This gives only our "best buys" and is the version which is being circulated copyright free to members.

All Choices Equipment List - alphabetically sorted complete database showing every supplier and price we have researched.

Higher Grade Equipment List - alphabetically sorted list showing all items which have a specific Topic reference related to Higher Grade practical activities. Note that a complete Higher Grade Equipment List would also include basic and general items (see below).

Basic Equipment List for the sciences - alphabetically sorted list of equipment which may be required for any science lab.

General Equipment List for Chemistry - alphabetically sorted list of items used widely throughout Standard and Higher Grade Chemistry.

Chemicals database

The chemicals datafile is based on close analysis of the Chemistry practical work at both Standard and Higher Grade. Such analysis included, for 'S' grade, some estimation of the likely quantities required per pupil group. The quantities suggested in the database entries are based on a combination of such analysis, of the minimum pack sizes available and on other factors such as any limits on shelf-life.

Records have fields giving: chemical names, and any alternatives; likely annual quantity required per 5 x 20 pupil groups; anticipated consumption per year per pupil group; units or pack sizes for the 5 group quantities quoted; estimated annual cost per 20 pupil group; health and safety information as simple codes; specific course topic references for both Standard and Higher grades and a "Status" field with miscellaneous information on applications, shelf life etc.

Additional fields have been set aside to allow some modification to more closely meet the needs of individual chemistry departments. For example the database may be used for managerial tasks such as reordering stock and location referencing.

Printouts available

First Choice Chemicals List - alphabetically sorted by *Chemical* and using the SSERC recommended first choice sources. This is the version to be circulated to EAs as copyright-free masters.

All Choices Chemicals List - alphabetically sorted complete database with reference numbers and prices for several different sources of supply.

Higher Grade Chemicals Only List - alphabetically sorted list showing only those chemicals which have a **specific** Topic reference related to Higher Grade practical activities. Note that a complete list, with every chemical needed for Higher, would include also many of the chemicals with specific Standard Grade Topic references.

Technological Studies

In-service materials

Since the Spring of 1989 and the start of our Scottish Joint Support Activity Project for TVEI, we have been developing and trialling in-service materials for teachers of Technological Studies. Danny Burns one of our Senior Project Officers and Ian Buchanan, our Technical Officer, have been running such courses. Aimed firstly at teachers of Standard Grade our course programmes have more recently been concentrating on the new Higher.

If the results of our own evaluation exercises are anything to go by, these courses have been successful in helping teachers prepare for this new subject. We are therefore giving advance notice of our intention to make more widely available the materials which we have developed.

The approaches adopted are broadly those outlined in a series of articles in Bulletins 163 to 166. The target for the launch of the materials is Autumn 1990 to co-incide with the Annual Meeting of the Scottish Technical Teachers' Association.

Standard Grade

Materials which will be made available include:

- Teachers' Notes; Worksheets; sample Project Briefs and Resource Sheets for the Introductory Unit; and
- Main Unit Project Briefs with Resource Sheets.

Higher Grade

To support training and teaching at the Higher, trialled in-service materials to be made available will include:

- sample Case Studies with analyses showing how likely activities might be related to learning outcomes;
- Resource Files with information on electronics, control and instrumentation at a level appropriate to the Higher Grade;
- lists of useful data sheets obtainable from supply companies; these lists provide guidance to teachers who wish to build up a collection of source material which provides them and their students with further detailed technical information on particular devices and applications;
- information on equipment, components and sources of supply.

Distribution and costs

The materials rely on the use of specific teaching and learning styles. A "Tutor's Guide" will be made available for each training package but we would prefer potential trainers to have attended a SSERC course, or at least to have been briefed by a member of the Centre staff.

Our preferred distribution mechanism therefore is for an EA to negotiate the equivalent of a site-licence for the course materials. Under such an arrangement they would receive copyright-free masters with permission for unlimited production of further copies of the material for the use of their own teachers. Part of that same arrangement could be a number of places on a relevant SSERC course at discounted fees.

Where teachers cannot be released to attend such a trainers' course then Centre staff would be pleased to attend at local in-service days. If the materials are distributed to key staff at such a meeting then SSERC personnel can be on-hand to explain how they may best be used by staff both to further their own professional development and as a basis for the development of other materials for use by pupils.

We are still working out some of the details of the format and production for both of these training packages. We also have to negotiate copyright clearance through third parties with interests in such matters. Detailed costings cannot therefore be given at this stage. Order of magnitude estimates put the cost per school in the tens rather than the hundreds of pounds. We would be pleased to hear from potential customers for these in-service materials. We will keep a record of those who note such an interest and will circulate further information just before the launch date.

Safety Notes

Electricity at Work Regulations 1989

Introduction

The Electricity at Work Regulations 1989 [1], made under the Health and Safety at Work Act 1974, came into force on the 1st of April 1990. These are referred to, in the text below, as the "Regulations" and the "Act".

This article notifies you of the Regulations, discusses their purpose, scope of application and nature, describes some of their requirements and outlines their possible impact on methods of working.

The article does not attempt to draw up rules of conduct. We are ourselves still trying to interpret in detail what the Regulations require. We are aware that regional safety officers and the Health and Safety Executive are carrying out similar exercises. Once we have liaised with them and reached a measure of agreement we shall then be in a position to advise you more fully.

Purpose of the Regulations

The purpose of the Regulations is to prevent death or personal injury to any person from electrical causes in connection with work activities.

Electrical causes comprise:

electric shock;

electric burn;

fires of electrical origin;

electric arcing; or

explosions initiated or caused by electricity.

Why the Regulations were made

There are several reasons, all of which parallel the COSHH Regulations:

-simplicity, believe it or not, in that they replace a host of earlier regulations many of which were made under the old Factories Acts;

-to place the emphasis on general principles and systematic approaches rather than on technical detail which may quickly be superseded;

-to underpin the principle of self-regulation which is behind the whole philosophy of the Act; and

-to comply with EEC directives in the interests of harmonization.

Scope of application

Like other regulations made under the Act these apply to all places of work, including schools.

The Regulations pertain to everything electrical. Like the Act they are described as all-embracing.

All voltages are covered, from one volt to kilovolts. Their main impact in schools will undoubtably be on work activities with mains carrying conductors. Other hazardous activities include work with 110 V portable power tools, welding equipment, and experimental work at HT and EHT voltages.

The all-embracing nature of the coverage relates also to activities which are only indirectly electrical. For instance were water splashing from a sink to wet a socket outlet the Regulations would be contravened even although electricity was not being used at the time.

Nature of the Regulations

The Regulations consist of pithy, general statements which must be complied with.

Unlike the various regulations they replace they contain no technical detail. Reliance for technical detail must therefore be made on whatever up-to-date codes of practice are appropriate to the work activity. Relevant codes of practice include Guidance Notes published by the HSE, British Standards and the IEE Wiring Regulations. The HSE Guidance Note GS23 "Electrical safety in schools" [2] is one such appropriate code.

The HSE has published a set of guidance notes [3] on the Regulations. Like the Regulations they are general and non-technical.

To give you a flavour of the substance of the Regulations, Regulation 4 (Part 2) states:

> "As may be necessary to prevent danger, all systems shall be maintained so as to prevent, so far as reasonably practicable, such danger."

Responsibilities

In common with the other regulations made under the Act responsibilities and duties are placed on everyone who enters or uses, or is affected by the activities at, the workplace.

The employer has the duty to comply with the provisions in so far as they relate to matters within his control.

The employee has the duty:

to enable any duty placed on the employer to be complied with; and

to comply with the provisions in so far as they relate to matters which are within his or her control.

Description of the requirements

The Regulations impose requirements with regard to:

the construction and maintenance of electrical systems;

the carrying out of work activities (both with electrical systems, and near to electrical systems);

the provision of protective equipment;

the strength and capability of electrical equipment;

the construction and protection of electrical equipment placed in adverse or hazardous environments;

the insulation and protection of conductors;

the earthing or insulation of electrical systems;

the suitability for use of electrical connections;

the protection against the effects of excess current;

the means for cutting off the supply, and for isolation;

the precautions to be taken when working on equipment which has been made dead; and

the provision of adequate working space, lighting and means of access.

In addition the Regulations impose restrictions with regard to:

the integrity of referenced conductors such as earth conductors;

working on or near certain live conductors; and

who may be engaged on work activities where technical knowledge or experience is necessary to prevent danger or injury.

Many of the Regulations apply more to those who design and manufacture electrical equipment, or who design, install, or work on, mains wiring in buildings, than to teachers or technicians. However all the Regulations listed here impinge on work which teachers or technicians might reasonably undertake, and some are particularly relevant.

Impact on methods of working

We can find nothing within the Regulations that would seem to be especially onerous or frightening. Indeed they can be regarded as a formalization of those sensible approaches already regarded as proper professional practice.

Most of the requirements of the Regulations already appear within GS23, with which we trust all schools and authorities currently already comply.

For instance Regulation 4 (2) quoted above requires that electrical systems and equipment are regularly maintained. This therefore gives statutory backing to the need, expressed within GS23, to have a programme of routine checking and repairing of electrical apparatus. We are aware that many authorities have such programmes.

Possible difficulties

Restrictions may have to be made to work activities on live conductors, but we can see no reason for placing a general prohibition on such activities. Justification for the occasional need to work on live equipment should be beyond doubt. For instance live working might reasonably occur when looking for a fault.

It would seem, to comply with the Regulations, that a code of practice should be devised by employers to control this type of activity.

Restrictions may also have to be made on who shall be allowed to do certain kinds of work. In principle we support this need, but in practice we can foresee operational difficulties.

How do you assess who has appropriate technical knowledge, or experience? Decisions on this, and on any requirements for training programmes, need to be made by employers.

The reputed response of one authority to restrict to its school janitors the persons who are allowed to wire 13 A plugs is a response that is unlikely to find the acceptance of much of our readership.

Concluding remarks

This article has been written to flag for your attention the existence of the Electricity at Work Regulations. Clearly at this initial stage the onus is on employers to examine present practice against these new Regulations, to determine what, if any, actions they need to take, and to put priorities on such requirements.

References

1. The Electricity at Work Regulations 1989, S.I. No.635, HMSO.
2. "Electrical safety in schools", GS23, Health and Safety Executive, HMSO. NOTE: new edition due April 1990.
3. "Memorandum of guidance on the Electricity at Work Regulations 1989", HS(R)25, Health and Safety Executive, HMSO.

Safety Notes

TV set modifications

We draw your attention to a warning circulated at the end of last session by the Health and Safety Executive. It described two particular fault conditions caused by modifications carried out to a TV set. Both of these fault conditions presented risks of potentially fatal shocks. The warning also contained a general principle, the import of which it would be prudent to heed.

The first fault was the diversion of two loudspeaker leads to a switched chassis socket outlet mounted through the rear casing of the television. The set, manufactured in 1986, had a live chassis, which resulted in the headphone socket and any headphones connected to it being live at 350 V d.c. to earth when the set was in operation. Extension loudspeakers would present a similar risk.

The second fault was caused by the bolting down of the set to an unearthed metal trolley. One of the bolts used was very close to a track on the printed circuit board which was also live at 350 V to earth. Had the bolt touched the track the trolley would have become live.

Both modifications were apparently simple operations that anyone with a small amount of technical knowledge might undertake. But both were clearly dangerous because the persons carrying them out had insufficient technical knowledge and did not appreciate the dangers resulting from their actions. This is the general principle which can be drawn from the accident.

The HSE warning concluded by pointing out that television sets provided with headphone sockets by the manufacturer, or modified to a manufacturer's specification, should not present the risks above. Any other modifications to a television set which are not approved by the relevant manufacturer may be dangerous.

A dangerous music power supply

This note is about a mains to 12 V power supply from the Music Centre, 48 Campbell Street, Hamilton, or from a branch in Paisley. The supply bears the legend "Multiple Outlet Power Supply" on a blue, glossy paper label that covers the front of the enclosure. Two 4 mm sockets, from which 12 V may be drawn, protrude from the opposite, bottom corners of the front.

The supply is of shoddy construction. Its various defects include insufficient insulation, inadequate protection against excess currents, inadequate mechanical strength, switching on the neutral rather than the live conductor, and improper marking.

Part of the enclosure of the supply we inspected consisted of a rectangle of plastic cut off a Blue-Band margarine tub.

Please ask your colleagues in your school, and in particular in the music department, if they are an unfortunate possessor of any of these supplies. If they are they ought to be advised to withdraw them from service. They could either return them to the shop and seek reimbursement, or contact the local Trading Standards department. This latter action should prevent any further circulation.

Microscope lamps

We have been sent for inspection a microscope lampholder marked "Olympus Tokyo Japan" consisting of a black plastic enclosure within which there is an Edison screw lampholder for 240 V lamps. It bears the following features:

- -no colour coding on the 2-core flexible cord;
- -single pole switching;
- -no cord grip at the entrance of the cord to the enclosure;
- -no means of ensuring the correct polarity of conductors where they connect to the ES lamp-holder;
- -inadequate connections at the lampholder provided by compression between conducting and non-conducting parts; and
- -inadequate labelling.

The first, second and fourth features can all be corrected by replacing the flexible cord with cord colour coded brown and blue. But the other features cannot readily be corrected. Basically the device has not been constructed so as to prevent, so far as is reasonably practicable, danger. If you recognize you have any lampholders with these features, you should consider returning them to the supplier and, under consumer protection legislation, claim your money back. Or, if the lamps are old, dispose of them.

Routine checks

Although these features relate to one particular model of lampholder, we suspect that the virus may reside in other models too.

Features like these should be spotted on the annual safety checks of electrical apparatus and appropriate correcting action taken.

Rewiring soldering irons

A recent Bulletin issue (163) carried advice about precautions to take while soldering and made a recommendation to use irons with heat resisting flexible cord.

We know that some of our readers are interested in rewiring irons to this safer standard. However in trying to help them find suitable materials we have failed miserably in finding a supplier of cord of the optimum size, that is of conductors having a cross sectional area of 0.5 mm^2. We have therefore had to resort to finding a means of using 0.75 mm^2 cord.

Rewiring with 0.75 mm^2 cord

The scheme below has been devised for one particular model of iron, but should be generally applicable.

The problem lies with the cord grip. As these do not accept 0.75 mm^2 cord they have to be replaced with a home-made substitute. This consists of a length of heat resisting sleeving sandwiched between layers of heat shrinkable sleeving (Fig.1).

The main mechanical strength and rigidness comes from the heat resisting sleeving. The cord screw on the iron's enclosure needs to grip into this.

The inner heat shrinkable sleeving gives a tighter fit to the heat resisting sleeving. The short, outer, heat shrinkable sleeving prevents the ends of the heat resisting sleeving from fraying.

Materials

The Centre has obtained a stock of 0.75 mm^2, silicone rubber, flexible cord for resale in small quantities (Surplus item 716). Any school or authority wanting a large quantity should buy direct from Electrocables.

Description	RS stock no.
heat resisting sleeving,6 mm dia.	398-896
heat shrinkable sleeving, 6.4 mm dia.	399-934
heat shrinkable sleeving, 9.5 mm dia.	399-940

Caution

Heat resisting sleeving consists of an impregnated glass fibre. Handling this sleeving can irritate the skin.

Compressed Air Supplies

We have recently received an excellent publication on safe practice in the use of compressed air supplies and pneumatic circuitry [1]. The booklet is published by the Health & Safety Executive and is entitled 'Compressed air safety'. Although these guidance notes are mainly aimed at the industrial user they contain much information and advice which will be of value to teachers and technicians in Technology Education Departments.

We did publish our own general technical advice on compressors and supply arrangements in early in-service materials and in our "...Resource Review : Technology Room and Equipment Guidelines : Final Report". Because those documents were not as widely circulated as we might have wished, in the "Equipment Notes" section of this issue we provide a short summary of the main points for consideration by school departments installing air supplies for pneumatics teaching equipment.

Reference

1. "Compressed air safety", 1990, Health & Safety Executive. Health & Safety Series HS(G) 39, HMSO, ISBN 0 11 885529 8. From HMSO, HMSO Bookshops and accredited agents etc. £4-00.

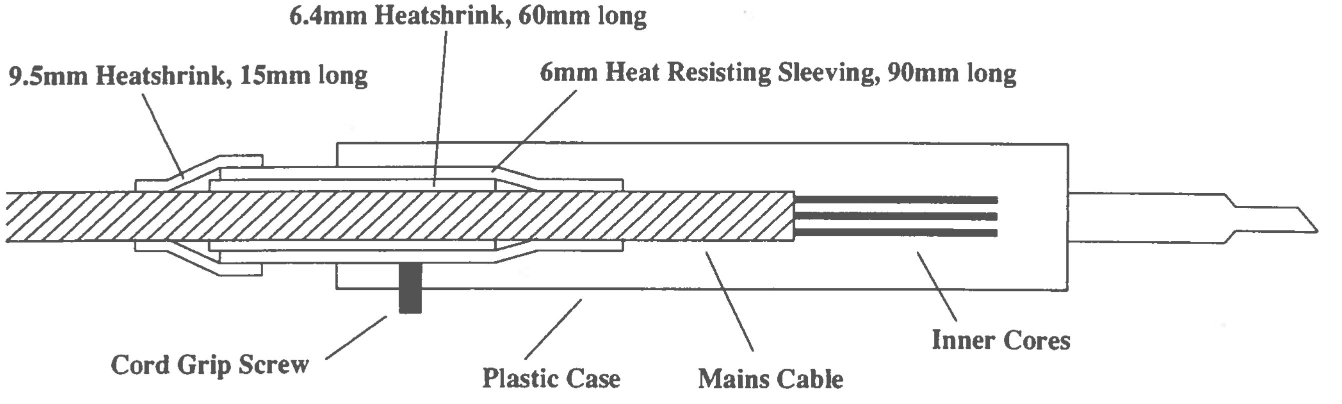


Fig. 1 Cord Grip Design

Standard Grade Technological Studies

The Project Folio

Bulletins 163 to 165 carried a trilogy of articles on a project based approach to the course. Since publication of those articles we have received a number of requests that we describe more fully one sample project. That is what we attempted to do in the article which follows.

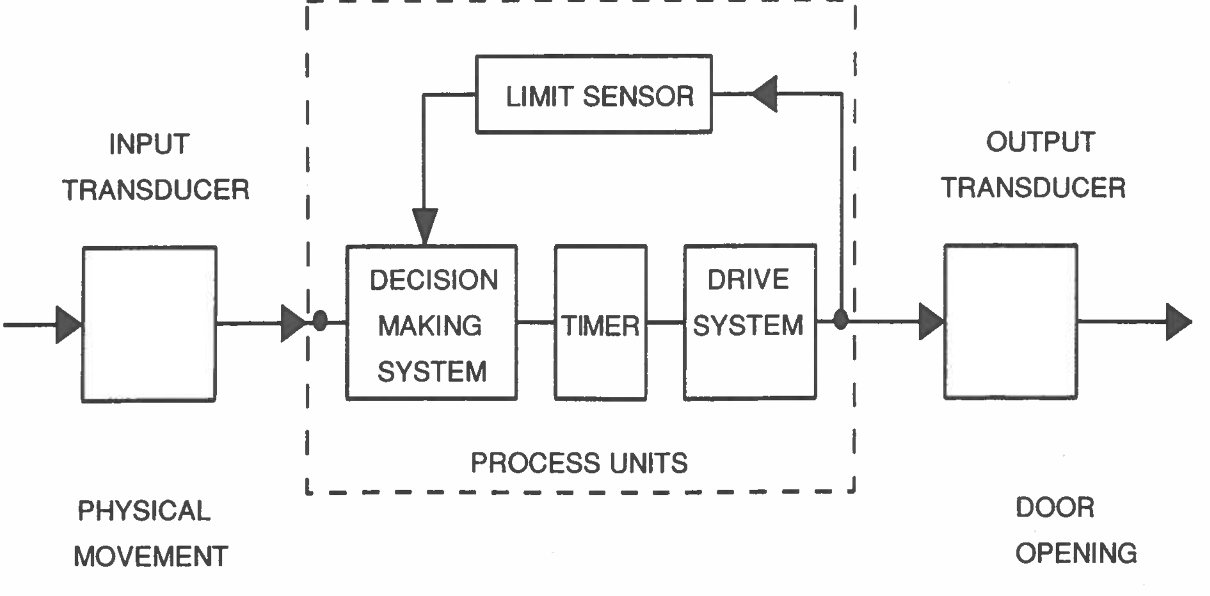
The problem

In the body of the article we look at possible solutions to the "Automatic Door System" problem outlined in Bulletin 164. One such solution is selected, the selection justified, and its evaluation and modification described.

PROBLEM ANALYSIS

The task here is to make it possible for a handicapped person to move more freely about their home. There are many possible solutions to this problem e.g. permanently removing doors or perhaps even the placement of the disabled persons in 'sheltered housing' where trained staff can assist them. However in this case a technological solution in the form of the provision of an automatic sliding door is demanded.

A SYSTEMS DIAGRAM



PROJECT TITLE	NAME	DATE
An automatic door	*D. Burns*	*17/4/90*

The format used is closely linked to that suggested in "Starter Materials Pack 3" [1]. It may be that discussion of this solution would form a useful staff development exercise. The aim would be to match the solution, as documented in the suggested Project Report format, with the extended grade related criteria. This should improve understanding of the SEB requirements for assessment of the problem solving parts of the course.

Reference

[1]. "Technological Studies: Project Briefs: Standard Grade Starter materials - Pack 3". SG/TGS/004/SM 1988 SCDS (now SCCC).

PERFORMANCE CRITERIA OR SPECIFICATIONS

The completed system must:

1. *physically open the door;*
2. *respond to more than one input;*
3. *have input sensors which can detect movement;*
4. *ensure that the door is in the correct position (i.e. open or closed);*
5. *stay open for an appropriate period of time;*
6. *automatically reset the timing period each time an input sensor is activated;*
7. *not pollute the home environment;*
8. *above all, be safe to use.*

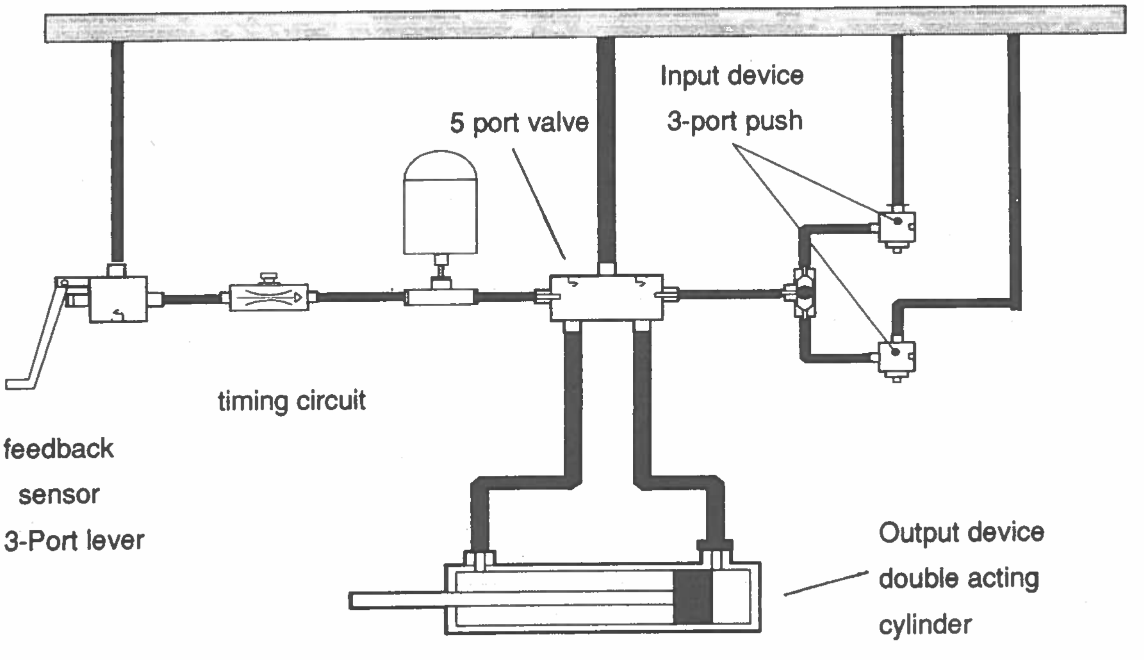
PROJECT TITLE *An automatic door* NAME *D. Burns* DATE *17/4/90*

Idea No.1

The diagram below illustrates how a pneumatic system can satisfy the functional criteria of the demanded system. The two 3-port push button valves act as the input sensors and are placed one on either side of the door.

The door 'hold open' function is provided by the timing circuit. This circuit is activated when the door opens and comes into contact with the feedback sensor. The hold time can be varied by altering the position of the flow restrictor valve.

The other components in this system are the pilot operated 5-port valve (the main process valve) and the double acting cylinder (to provide the linear motion of the door).



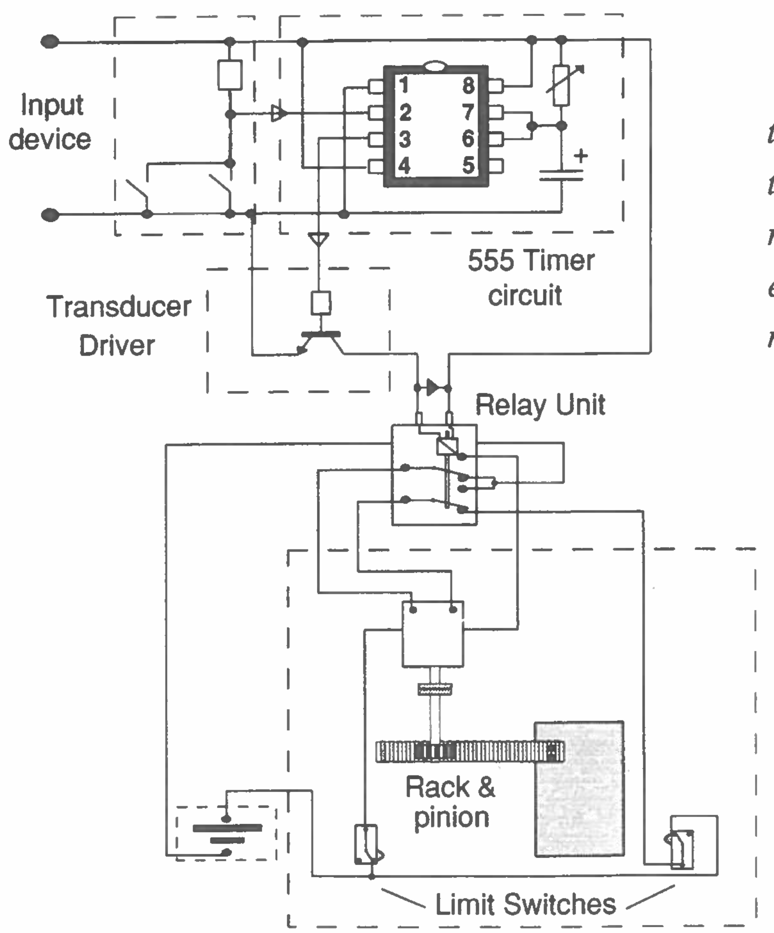
PROJECT TITLE *An automatic door*	NAME *D. Burns*	DATE *17/4/90*

Idea No.2

Illustrated below is an electro-mechanical solution. Here the input sensors are two contact switches formed from membrane switches. The parallel arrangement of these switches provides the logical OR function.

The 'hold' function this time is obtained using the 555 timer (the resistor capacitor voltage divider dictates the timing period).

To physically move the door a rack and pinion connected to an electric motor is used. The motor is controlled not only by the output of the 555 timer but also by the feedback from the micro-switches. This feedback ensures the positive positioning of the door.



The transistor drives the double pole, double throw (DPDT) relay. This relay interfaces the electronic system with the mechanical one.

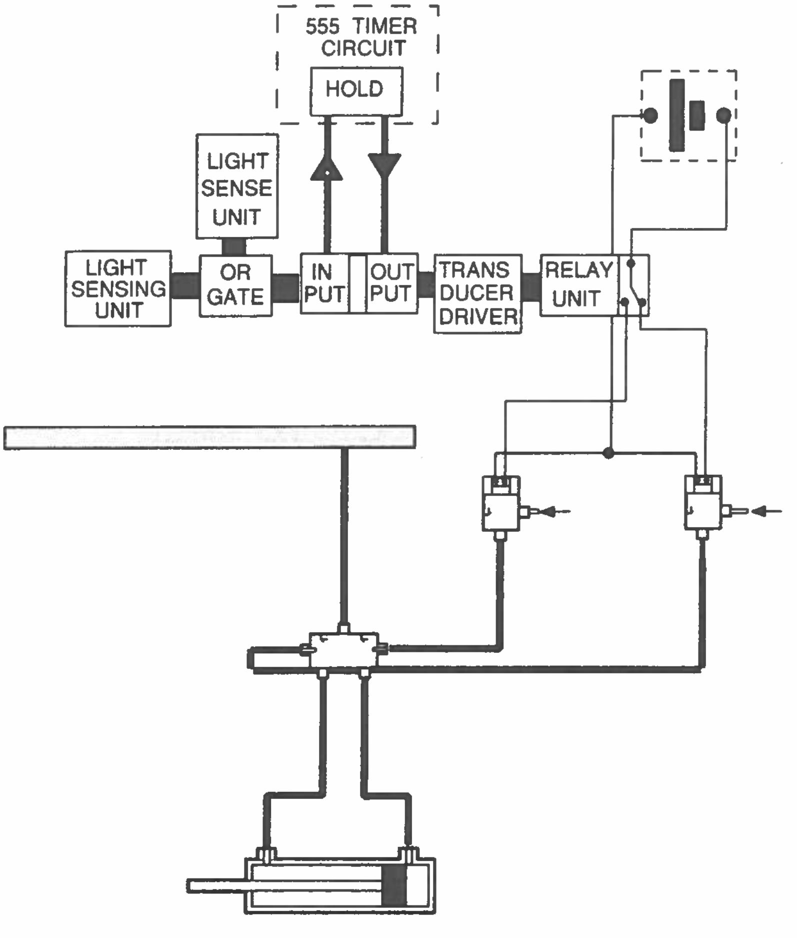
PROJECT TITLE	*An automatic door*	NAME	*D. Burns*	DATE	*17/4/90*

Idea No.3

This idea draws upon the two previously detailed. The control of the system is provided by the electronic systems boards as indicated and the power for the linear motion being obtained from the pneumatic system.

The interface between the two systems is the combination of the relay unit and the 3-port solenoid valve.

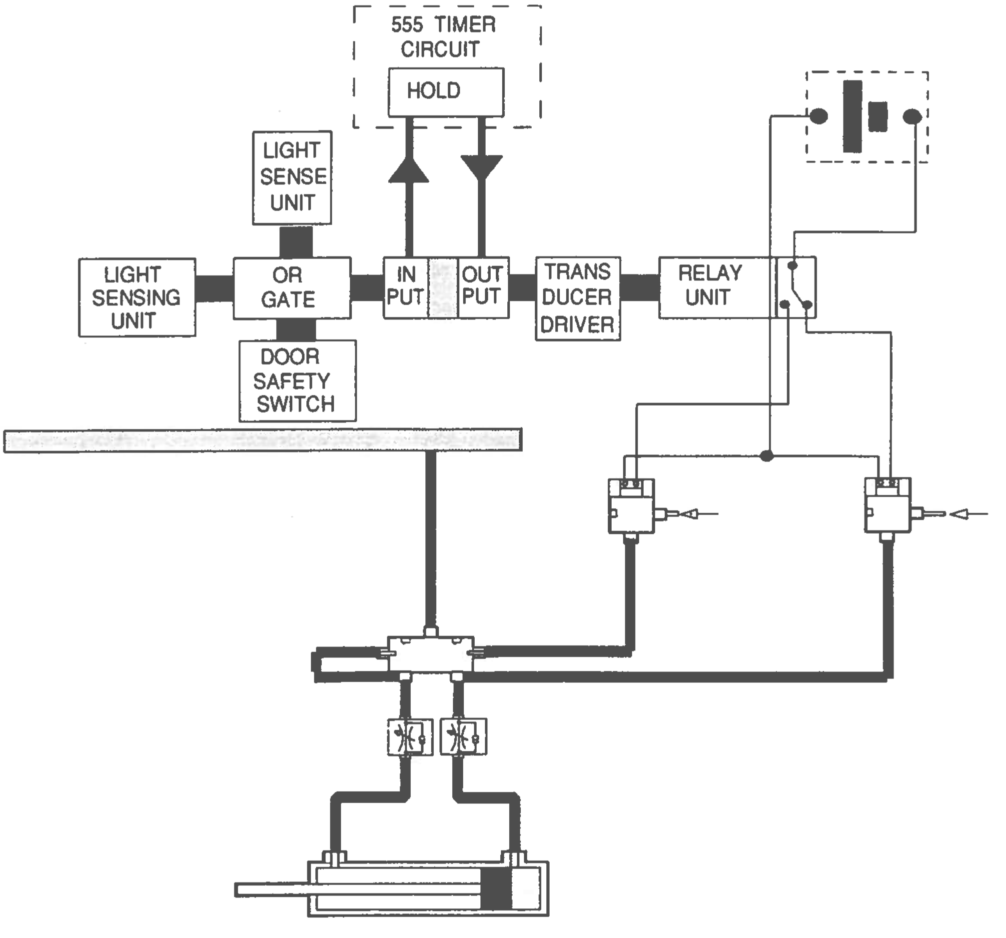
The light sensing units, which are used as input sensors, should be easier for a disabled person to operate.



This option looks the most promising as it offers the flexibility of electronic control with the smooth operation of pneumatics. However the costs of both equipment and installation may be high.

PROJECT TITLE	*An automatic door*	NAME	*D. Burns*	DATE	*17/4/90*

BUILDING AND TESTING



Each physically separate subsystem was tested independently. This made fault finding easier. A considerable amount of time was spent ensuring that the timer circuit was correctly set. A voltmeter and the BBC computer (with 'SENSE IT') was used for this purpose. When building the pneumatic system I was careful to test the operation of the combination of valves and cylinders before interfacing it with the electronic system. The operation of the logic system was also checked in isolation.

PROJECT TITLE *An automatic door* NAME *D. Burns* DATE *17/4/90*

RESOURCES

Systems boards:

two light sensing units, one push switch, two OR gates, two inverters, one transducer driver, one input / output board and one relay unit.

Discrete components:

one 555 timer chip, one prototype board, one 10 microfarad capacitor, one 600K variable resistor.

Pneumatic components:

one pilot operated five port valve, 2 solenoid operated three port valves, one double acting cylinder, two flow restrictors.

PROJECT TITLE *An automatic door* NAME *D. Burns* DATE *17/4/90*

MODIFICATIONS

The modifications that were required were:

1. *flow restrictors on the output side of the cylinder;*
   this was done to slow down the motion of the door;
2. *a safety switch was placed on the forward edge of the door.;*
   this was done to prevent anyone being 'caught' by the door;
3. *minor adjustments to the capacitor / resistor voltage divider,*
   to establish the optimum opening time.

EVALUATION

Looking back at the performance criteria demanded for this system it is fair to say that most, if not all, of these criteria has been met. In other words:

1. *the door does open;*
2. *the system responds to more than one input;*
3. *the input sensors can detect movement;*
4. *the door is held positively in the open or closed position;*
5. *the door stays open for an appropriate time;*
6. *the is timing period is reset if an input transducer is activated;*
7. *no noise or other pollution should be present in the home*
   (as long as the compressor is placed outside);
8. *it is safe to use.*

IMPROVEMENTS

A further improvement I would like to make is to incorporate some sort of lock in the system. This, I think, would give the disabled person a greater sense of security. In addition I think a back-up system would be required in case power failure or fire prevents this system from working.

PROJECT TITLE	*An automatic door*	NAME	*D. Burns*	DATE	*17/4/90*

Some experiments to underpin Newton's Second Law of Motion

Two experiments are described which support the concept that the unbalanced force is equal to the rate of change of momentum.

Preamble

Descriptions of both experiments, [1], [2], were originally published in the 1960s. That was the time, you remember, when physics was actually believed to be fun, when much of the corpus of present day laboratory methods was under development. So much was then devised that inevitably many excellent ideas, for one reason or another, were not widely taken up.

The revision of the Higher is our excuse for trying to popularize ideas from that period which are not, now, too well known, but merit reairing.

Experiment 1: Pellets dropping on a balance

Description

A stream of pellets of total mass m is allowed to fall from a hopper through a known distance s and impact on an electronic balance (Fig.1). If there is a baffle on the scale pan making an angle of 45° to the horizontal then the pellets, to a rough order of the truth, deflect horizontally. Therefore, on that assumption, we can write that the entire vertical momentum of the pellets is imparted to the balance.

The force F measured by the balance should then correspond to $\Delta(mv)/\Delta t$ where v is calculated from $(2as)^{1/2}$ and Δt is the period of impact.

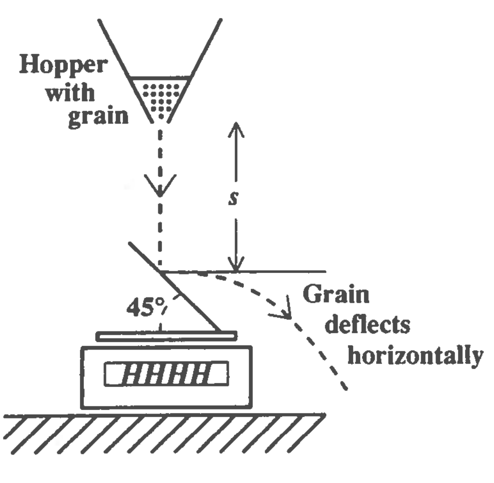


Fig.1 - Apparatus: pellets falling on balance

A simple but effective hopper can be made from nothing more than a sheet of paper suitably rolled and sellotaped. The nozzle diameter should be about 1 cm. It can be pinched shut by hand until the moment to release the pellets arises.

The method relies on the multiple collisions being as nearly elastic as possible. Therefore both the pellets and baffle should be composed of hard materials.

We find that thickish perspex, around 6 mm thick, does for the baffle. The area should be about 150 mm square. The baffle should be cemented to a wooden support, cut to an angle of 45°, that sits on the balance scale pan. Any dried grain should suffice as pellets, but glass beads or steel ball bearings might be better substitutes. We find however that dried grain seems to be sufficiently and surprizingly hard. An aggregate mass of 200 g is about right.

Going to the other extreme, dry sand could be used, and would have the advantage over larger sized pellets that the flow can be made regular, but presents the risk of fouling the balance. Were sand to be used it would be necessary to stand a cantilever on the scale pan that overhangs the opposite sides of the balance. One arm should have a 45° incline so that sand does not fall on the balance; the other arm should have a counterweight.

The balance must be able to react sufficiently swiftly to register the force. One that takes several seconds to settle and register would not be suitable. If possible choose one that reads in newtons.

A storage tray, tilted at an angle to the benchtop, should be placed alongside the balance to catch the falling pellets.

Procedure

It is advisable to set up a clampstand by the side of the balance and position a bosshead at a known vertical height above the centre of the baffle. This marks the level at which the hopper nozzle should be held.

Tare the balance before releasing the pellets. Try to let the pellets stream out through the nozzle at a uniform rate, and note both the balance reading and period of impact.

Sample readings and calculation

Measurements:	$s = 0.23$ m $m = 0.22$ kg $\Delta t = 8$ s $F = 5$ g
Calculation of speed of impact v:	$v^2 = 2as$ $v^2 = 2 \times 10 \times 0.23$ $v^2 = 4.6$ $v = 2.1$
Calculation of rate of change of momentum F:	$F = \Delta(mv)/\Delta t$ $F = (0.22 \times 2.1)/8$ $F = 0.058$

Therefore the calculated force is 58 mN. This roughly matches the measured force, which was around 50 mN.

Discussion

We usually find that the measured force has a value lying between 10% to 20% lower than the calculated rate of change of momentum.

However it may be sufficient at Higher Grade to note that the two values are in rough correspondence and leave it at that.

But if the discrepancy were noticed and required explaining it can be interpreted as a consequence of the collisions not being wholly elastic. The pellets rebound with an angle of reflection greater than 45°. Clearly the actual downward rate of change of momentum of the pellets is less than it would be for a 45° reflection.

This could be investigated more fully in a CSYS project.

Experiment 2: The reaction of a jet of water leaving a nozzle

Description

The downward rate of change of momentum of water flowing from the tube (Fig.2) causes a reaction which exerts an upthrust on the nozzle. This force can be measured on a spring balance.

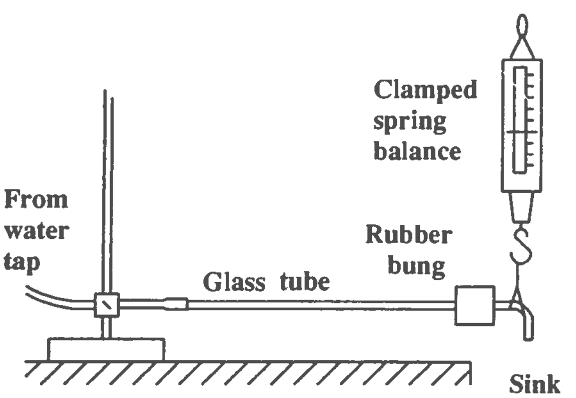


Fig.2 - Apparatus to measure the reaction of a jet

A glass tube of i.d. about 6 mm and length 700 mm should be mounted horizontally as shown (Fig.2). The tube should have a short vertical downturn of about 30 mm, which can be fashioned by heating. A large rubber bung should be placed at the end of the tube to add inertia. Without this the end shakes about uncontrollably because of the upthrust exerted by the jet.

Procedure

Let the tube fill up with water, turn off the tap and read the spring balance.

Turn on the water and let it flow steadily for 10 s, reading the spring balance. Collect the water in a 1000 cm^3 beaker and measure the volume.

Sample readings and calculation

Measurements: diameter of bore $2r = 6.3$ mm
volume of water $V = 630$ ml
period of flow $\Delta t = 10$ s
balance readings:
water not flowing = 1.12 N
water flowing = 1.01 N

Calculation of water speed:

Let s be the length of an imaginary column of water of volune V and diameter $2r$ flowing at speed v

Then
$v = s/t$
$v = V/\pi r^2 t$
$v = 630/(3.142 \times 0.315^2 \times 10)$
$v = 202$

Therefore speed of jet is 2.02 ms^{-1}

Calculation of rate of change of momentum F:
$F = \Delta(mv)/\Delta t$
$F = (0.63 \times 2.02)/10$
$F = 0.13$

Therefore the calculated upthrust of 0.13 N is in rough agreement with the upthrust measured on the spring balance, namely 0.11 N.

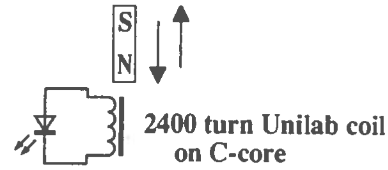
References

1. Maclennan, J.D., School Science Review, Vol.48, No.166, June 1967, page 880.
2. Mace, W.K., School Science Review, Vol.49, No.169, June 1968, page 840.

Flashing LED paradox

Connect a LED (Fig.1) across an induction coil that is fitted with a C-core and orient, if that is the right word, a magnet such that the LED flashes brightly if the magnet is smartly withdrawn from the C-core. Keep the same orientation of the magnet in what follows.

Fig.1 - The paradox circuit



First bring the magnet down gently on the C-core and confirm to your pupils what they ought to expect - namely, that the LED remains unlit. Repeat the cycle a few times (UP - FLASH; DOWN - NO FLASH) explaining to those in need of explanation, and reinforcing to the rest.

So far, so good. Now for the paradox!

Once you feel assured that everyone understands what they are witnessing bring the magnet down fast so that it smacks on the C-core. Hey presto, the LED flashes! Confirm with repetition. DOWN SLOW - NO FLASH; DOWN FAST - FLASH.

Whatever is the reason for that?

An op-amp power supply

The design of a dual rail power supply with voltage regulation is discussed. The design is such that the circuit can be safely run unboxed on an open board. The article should be of interest to anyone wanting a cheap and simple means of supplying power to op-amps.

Design features

The circuit diagram is shown in Figure 1. Some of the special design features are discussed below.

1. The input to the power supply is 12 V a.c. taken from a proprietary mains to LT supply. This is applied to two half-wave rectifiers acting as a voltage doubler to provide the two output rails of +12 V and -12 V. Two 1000 μF capacitors smooth these rails.

Note that the circuit will work off neither a d.c. input, nor an a.c. input whose voltage is less than 12 V r.m.s.

2. The main risk of harm to the user of an unboxed, open-board power supply (at low voltage) is caused by the overheating of components such as rectifiers, voltage regulators, or power transistors. The surface temperature of such components, or even of the heat sinks on which they are mounted, can rise to 150°C. Clearly anyone touching such a component would get a nasty burn.

In our design this hazard has been avoided by not using the standard 1 A or 1.5 A regulator, or even the less common 0.5 A regulator, but by going right down to 100 mA regulators.

This of course limits the current which can be drawn on either output rail to 100 mA. However we think this ought to be sufficient for almost any work you might consider undertaking with op-amps. For an application in which an op-amp were to be used to control a power device such as a motor, lamp, or heater, it is wise to follow our counsel in the last issue of the Bulletin by using two separate supplies - a regulated supply for the electronics, and a second supply, smoothed, but not necessarily regulated, for the high power parts.

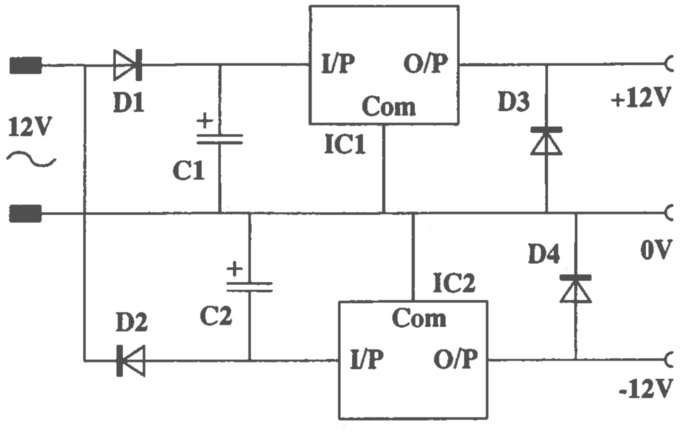


Fig. 1 Circuit Diagram: Dual Rail Supply

Returning to the risk of harm, 100 mA regulators are less hazardous than their larger brothers on open boards merely because they have less thermal inertia. They too can get hot, but are sufficiently small that contact burns are unlikely to be severe.

3. The main risks of harm to power supplies of the type designed here come from (1) overloading the outputs, and (2) applying 12 V a.c. across the output instead of the input.

Short-circuiting the output is perhaps the most likely form of overloading. One form of short-circuiting is the making of a connection between one of the power rails and the 0 V rail. This is taken care of by protection circuitry to be found within the regulator. The other form of short-circuiting is a connection between the positive and negative power rails. This form is looked after by the diodes D3 and D4. These prevent the outputs of either regulator swinging beyond 0 V into destruction.

The circuit is therefore fairly immune to damage from overloading and short-circuiting. But every abuse afflicted on a regulator takes its toll. As with teachers, so with regulators: life expectancy is inversely proportional to physical stress!

The second risk cannot be removed, the constraint being that the power supply has a 12 V rather than 240 V input. As an aside we find that one of the more frequently occurring mishaps to electronics kits is this application of an LT voltage from an LT supply to a wrong point on a circuit board. An apparent common practice is the wrong application of an LT supply to the output of a power supply regulator.

Can careful design significantly diminish this risk?

The following features should all be included on the finished board. The combination of them ought to suffice.

a. Bring the 12 V a.c. input to the left hand side of the board, and take the dual rail output from the right. Clearly label inputs and outputs.

b. The board must consequently have an identifiable right way up. All the labelling should therefore be printed with the same orientation.

c. The input connectors should be male-type, i.e. 4 mm plugs on flying leads. Both plugs and leads should be colour-coded yellow.

d. The output connectors should be female-type, i.e. 4 mm sockets on short flying leads. Each lead should have the same colour as the socket to which it is attached, viz. +12 V - red, 0 V - black, -12 V - blue.

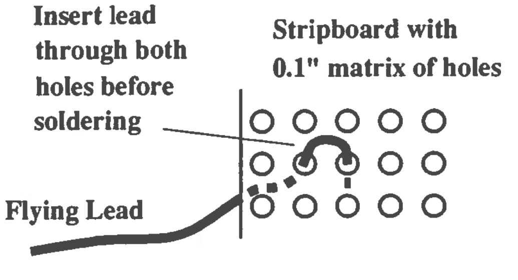


Fig. 3 Strain Relief

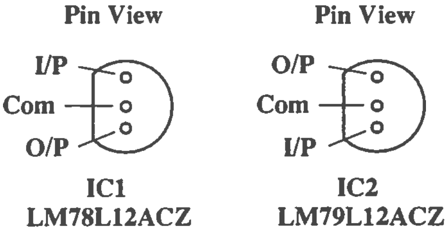


Fig. 2 Pin-outs of Regulators

Construction

The circuit should be assembled on 0.1" stripboard. A suitable size, neither immoderately small nor large, is 75 mm long by 95 mm deep. Watch out for the difference in pin-outs of the regulators (Fig.2).

Use flexible wire for the flying leads. A suitable gauge is 16/0.2 mm. If the flying lead burrows through a hole in the stripboard next to the one where it is soldered, strain on the connection will be relieved (Fig.3). The hole through which the wire tunnels has to be slightly enlarged by drilling.

The assembled board should be finished off by labelling and by fitting stick-on feet to the four underside corners.

Components

A description of the main components is given in Table 1. Both Farnell Electronic Components and RS Components list all the items in their catalogues. The total cost is around £1.50 at today's prices.

Circuit no.	Part no.	Description	Farnell stock no.	RS stock no.
D1, D2, D3, D4	1N4001	silicon rectifier diode, 1 A, 50 V	1N4001	261-148
C1, C2	-	capacitor, 1000 uF, 35 V, electrolytic	107-578	105-880
IC1	LM78L12ACZ	voltage regulator, +12 V, 100 mA	LM78L12ACZ	648-494
IC2	LM79L12ACZ	voltage regulator, -12 V, 100 mA	LM79L12ACZ	648-523

Table 1 - Components for dual rail supply

Technical Notes

A bi-directional motor driver

Introduction

We have been contributing to the work of the Central Support Group (CSG) in the development of material for the SEB Short Courses in Electronics. The Electronic Systems Short Course is based around the Unilab Alpha boards, but a need arose for an additional circuit to drive small d.c. motors, providing linear voltage control from zero to maximum in either direction.

The circuit had to be able to run from a 6 V lantern battery, so as to harmonize with the rest of the Alpha system. It was therefore important that as small a current as possible should be drawn, to avoid flattening the battery; and that, with the maximum signal on the input, there should be as little series voltage drop in the circuit as possible, so as to deliver maximum power to the motor.

We have designed a suitable circuit. It is likely to be useful in a wide range of applications in Electronics, and probably more generally in Technology and Physics.

The problem

A normal transistor push-pull amplifier stage has its input connected to the bases, the collectors connected to the power rails, and the emitters connected to the output (see Fig. 1). Both transistors are 'off' if the input is within one diode drop (about 0.6 V) either side of zero. When the input is more than 0.6 V above zero, the upper transistor begins to conduct, pulling the output up to 0.6 V below the input; when the input is more than 0.6 V below zero, the lower transistor conducts, pulling the output down to 0.6 V above the input.

Fig. 2 shows this behaviour. Each transistor acts as an emitter follower: the output voltage, on the emitter, follows the input voltage, 0.6 V behind. The current is amplified, but there is no voltage amplification; in fact the output voltage swing is two diode drops (1.2 V) less than the input voltage swing.

This rules out the use of an ordinary push-pull output stage for our application. With only 6 V available from the supply, the op-amp driving stage can only provide a swing of about 4.8 V, and the final output swing would be only about 3.6 V.

There are more expensive op-amps which offer rail-to-rail output swings, but only with much smaller currents than those required by the bases of power transistors. Darlington pairs, which have suitably small base currents, could be used instead of the power transistors (Fig. 3); but each output voltage would follow 1.2 V (two diode drops) behind the corresponding input voltage and the maximum output swing would still be about 3.6 V.

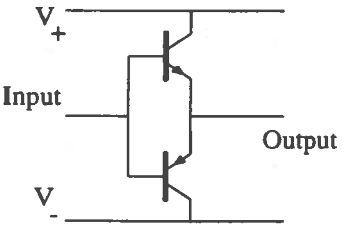


Fig. 1 - Push-pull amplifier

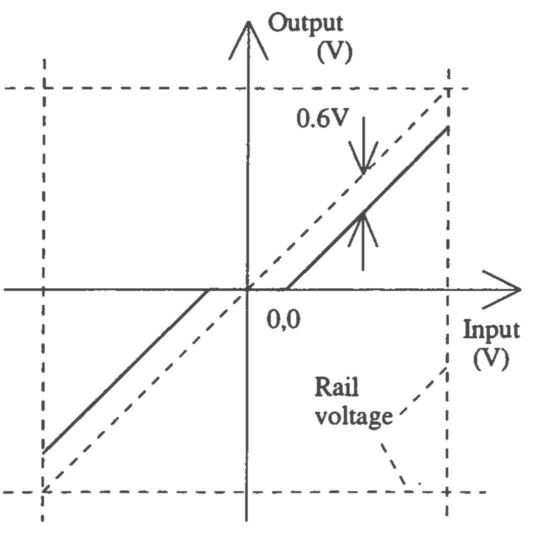


Fig. 2 - Push-pull amplifier characteristics

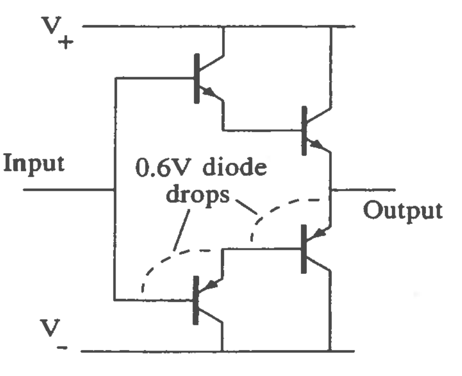


Fig. 3 - Push-pull amplifier using Darlington pairs

The solution

Our solution is to swap the transistors round. This converts the stage to an inverter. Each transistor is off when the base is within about 0.6 V of the corresponding power rail. As the voltage between the rail and the base increases beyond this, the transistor begins to conduct. A further change of a few tens of millivolts turns it completely on.

If the two bases were simply connected together, this would mean that over most of the input voltage range, both transistors would be on - short circuiting the battery and possibly destroying the transistors. It is thus necessary to push the voltages on the bases apart. We use two zener diodes (Fig. 4). This also reduces the output swing required of the op-amp to only a few hundred millivolts around zero.

Fig. 5 shows the behaviour of this amplifier stage. It has a very nasty non-linear characteristic. However, driving it with an op-amp, and arranging negative feedback around the whole combination, we can regain very good linearity (Fig. 6). We use the + input on the op-amp for our negative feedback because the transistor stage is an inverter.

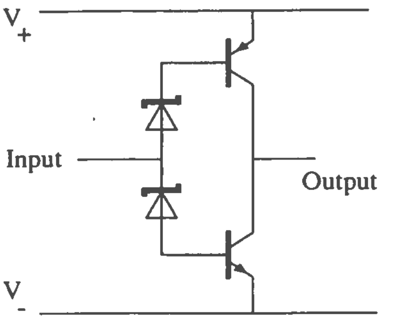


Fig. 4 - Basic "pull-push" amplifier - the output can swing from rail to rail

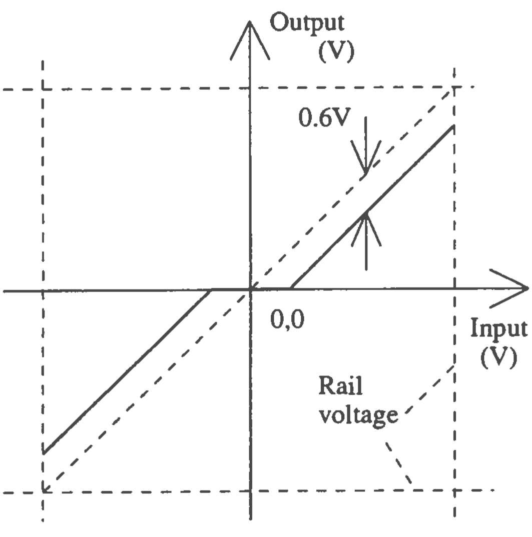


Fig. 5 - "Pull-push" amplifier characteristics

The higher the voltage of the Zener diodes, the wider will be the flat spot in the middle, where both transistors are off. The output swing required of the op-amp is a little more than the width of this flat spot. The Zener voltage must be low enough to keep the swing required to drive the output stage within the driving capabilities of the op-amp.

However, the higher the supply voltage, the narrower the flat spot will be. It is important that it doesn't disappear altogether; this would mean that both transistors would turn on at once with small input signals. Within the first constraint, the Zener voltage must be as high as possible, to protect the circuit should it be connected to too high a supply voltage.

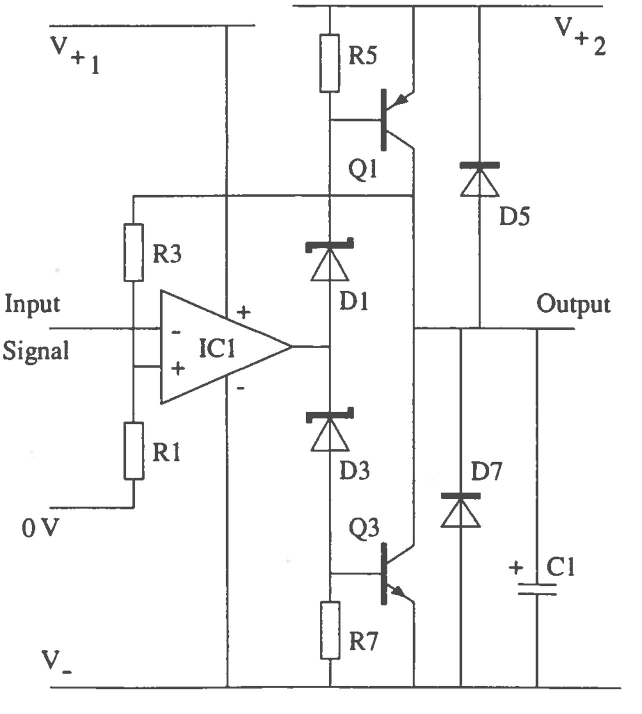


Fig. 6 - The real circuit (one half)

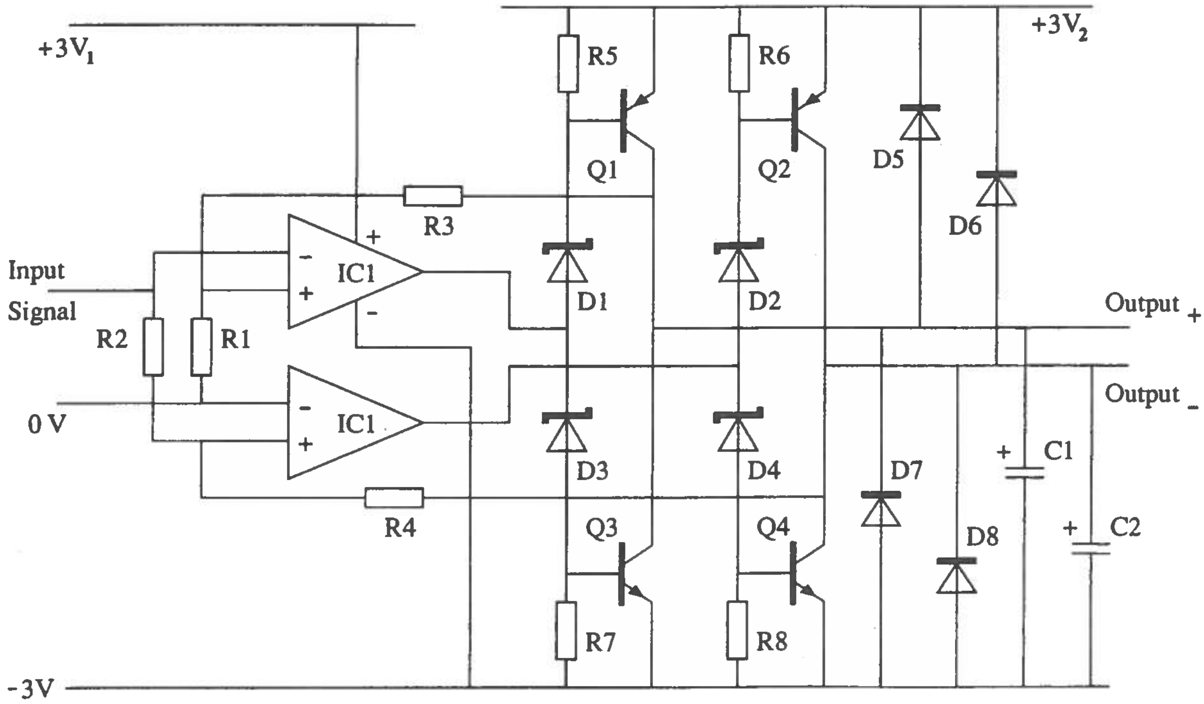


Fig. 7 - Bi-directional motor driver

The circuit

We connect our load between the outputs of two such circuits, one arranged as an inverter and the other non-inverting, and control them with the same input. This completes our bi-directional motor driver (Fig. 7).

Table I shows the component values and types. Different transistors and op-amps could be used, but we haven't tested any other combination. They would need to be selected with care.

At maximum in either direction, almost the whole of the battery voltage is delivered to the motor. This is achieved using cheap, readily available components.

Component	Type or value	Comments
R1,2	10 K	None of the resistors dissipate more than a few milliwatts. Use the cheapest you can find!
R3	33 K	
R4	22 K	
R5-8	120 R	
D1-4	BZX55C3V3	or similar - but see text
D5-8	1N4001	any 1A diodes will do
C1	10nF	exact value not critical
Q1,2	BD438	See Fig. 9 for pinout
Q3,4	BD437	
IC1	LM358N	See Fig. 8 for pinout

Table I: Component values and types

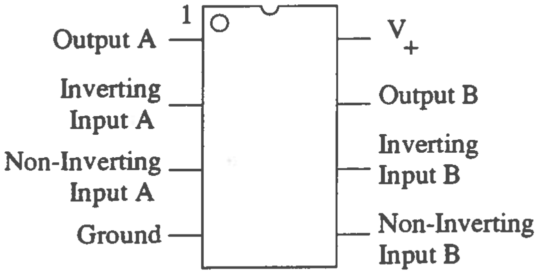


Fig. 8 - Pin-out of LM358N (top view)

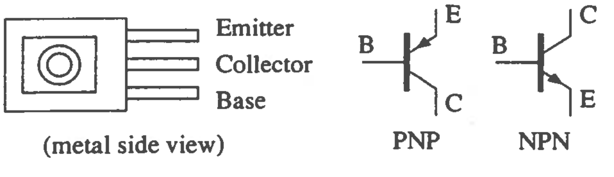


Fig. 9 - Transistor pin- outs **BD438** **BD437**

Zener diodes

An ideal Zener diode would be non-conducting up to its Zener voltage, and then pass current (up to some limit) without further increases in voltage. Unfortunately real Zeners are not like this. Fig. 10 shows their actual behaviour.

Ordinary diodes, forward biased, have a much better characteristic in the sense that the transition from non-conducting to conducting is much more abrupt (Fig. 11). Unfortunately, we'd have to use five of them in series to achieve the voltage we need.

We use resistors R5 - R8 to provide about 5 mA bias current. Otherwise, as in Fig. 4, a small base current would flow, just enough to bring the voltage at the end of the Zener diode to 0.6 V away from the power rail. As a result, both transistors would be slightly on over the middle of the input voltage range.[1]

Zener diodes from different series are characterized at different currents. This complicates selection. Our circuit uses BZX55C3V3 diodes, with a nominal voltage of 3.3 V. With 5 mA or 20 mA flowing, the voltage is 3.25 V or 3.75 V respectively. A 4V3 diode from the BZX85C series gives an almost identical current/voltage relationship.

Protection and asymmetry

D5 - D8 are to prevent current spikes from the load producing high voltages on the collectors of the output transistors, or on the inputs of the op-amps (via the feedback resistors R3 and R4). The provision of a separate power supply to the output transistors (and load) also helps to protect the op-amp inputs, and whatever electronics may be driving the op-amps. C1 and C2 also help with this protection, but are principally to prevent high frequency instability in the feedback loop.

Note that R3 and R4 are not the same value. This is because we are producing a symmetrical output from an asymmetrical input. The +ve output is equal to the signal plus R3/R1 times the difference between the inputs, whereas the -ve output is equal to 0V minus R4/R2 times the difference. That is, the -ve output is referred to 0 V, whereas the +ve output is referred to the signal. If R3 was the same as R4, the +ve output would swing more than the -ve output, by an amount equal to the signal. If the signal was small and the voltage amplification large, this would be negligible. Our circuit is designed to produce its maximum output swing for an input swing of ±1 V, with a voltage amplification of 3.

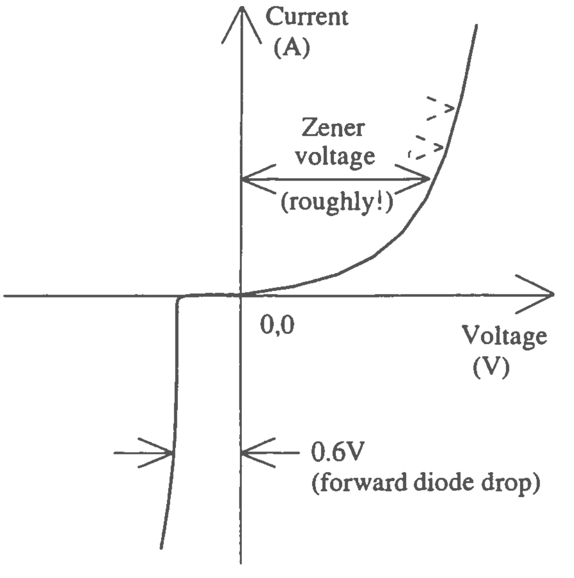


Fig. 10 - Zener diode characteristics - with the "forward drop" backwards, the way Zener diodes are really used!

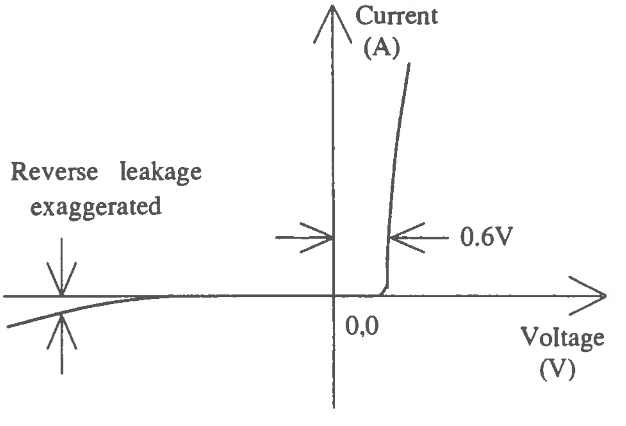
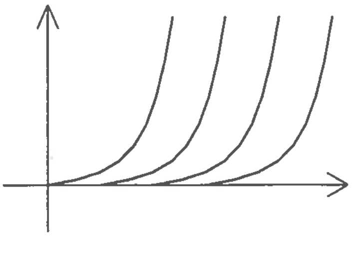


Fig. 11 - Ordinary diode characteristics

Point of interest: higher voltage Zener diodes are much better. The absolute change in voltage with current is much the same for any Zener diode. Thus the change as a proportion of the higher voltages is much less. Why don't manufacturers produce packages integrating several ordinary diodes in series, instead of low voltage Zener diodes?



[1] The collector current of a junction transistor is controlled by the base current. The current gain, h_{fe}, is a more or less constant ratio over a wide range of currents, for any one transistor at one temperature. It varies considerably from transistor to transistor, even within one batch. Transistor specifications usually quote a minimum value.

While several of the Electronics Short Courses are designed for Unilab Alpha boards, other kits could be used. Any manufacturer wishing to use this circuit, or one based on it, is requested to mention SSERC in any literature relating to it.

Technical Articles

DIY coulometer cells

Coulometer cells are required for experiment D1 (as described in SCDS Memorandum 16) in the CSYS Chemistry course, but the counter cells are no longer available from suppliers. Described here is the construction of diy cells and ancillary items, namely, a platinum electrode and a constant current supply.

Coulometer cells

The first version is simply a mat of mashed Whatman No.1 filter paper pressed into the base of a short length of plastic tubing (Fig.1). The diameter is not critical, but we used clear plastic tubing of 25 mm bore. The paper was tamped into this with a glass stirring rod which had a large flattened end. In practice the largest error found for a range of quantities of 0.01M sodium thiosulphate was no greater than 1 second when the theoretical period was 194 seconds. The plug should be the lowest part of the counter cell, otherwise it is difficult to place the cell in the iodide solution without having air bubbles in the pocket.

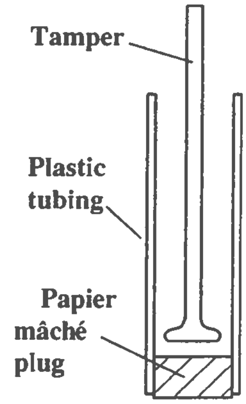


Fig.1 - Cell with papier mâché junction

Could there be yet another use for the ubiquitous, redundant pill box, this time having its base peppered with small holes? The lack of visibility of the contents through the sides would be no real disadvantage. Those old test tubes which have become holed have been used as salt bridges, and ion exchange and chromatography columns. Another use is as a counter cell (Fig.2).

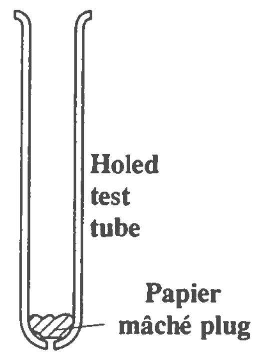


Fig.2 - Holed test tube cell

If you prefer something which looks more like the former commercial product and less like a lash-up, then the version in Figure 3 is for you, and is still relatively inexpensive. Despite its appearance it performs no better than the paper plug variety. The cell consists of a sintered-glass filter disc araldited inside the bottom of a length of glass tubing (Fig.3).

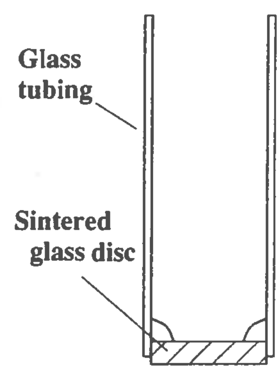


Fig.3 - Filter disc cell version

Again the dimensions are not too critical provided that the disc fits snugly into the tube. As before, the disc must be at the bottom of the glass tube so that no air pocket exists.

Orme Scientific can supply a disc and tube, which we found to fit together well: filter disc, 20 mm dia., porosity grade 2 (40-100μ): catalogue no. S40-124, price £1.92; and soda glass tubing, 24 mm o.d., catalogue no. T75-132 (3 lengths of 1.5 m), price £4.50.

There is no reason why a disc of smaller diameter, e.g. 10 mm at £1.09, should not also perform well.

Platinum electrodes

A saving can be made by substituting the platinum electrode in the counter electrode compartment with a carbon rod (Fig.4). This was found to make no difference to the operational efficiency of the cell, or to the time required to oxidise the thiosulphate.

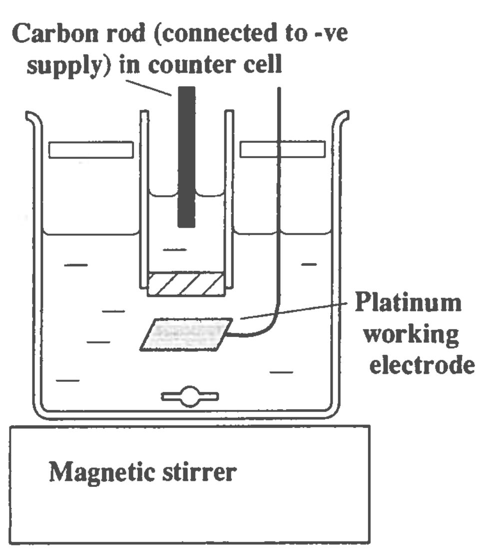


Fig.4 - Coulometry apparatus

If you have some platinum foil and wire in stock, why not make your own electrode by heat welding the two together as follows:

Place the foil on a small sheet of steel, about 5 cm x 5 cm, which acts as the anvil as well as the hearth. Lay the platinum foil with the wire on top of it as shown in Figure 5. Play the roaring flame of a microburner or of a blowpipe on the area of contact between the wire and foil. When the metal is white hot, strike it two sharp blows with a light hammer. The wire should now be welded to the foil.

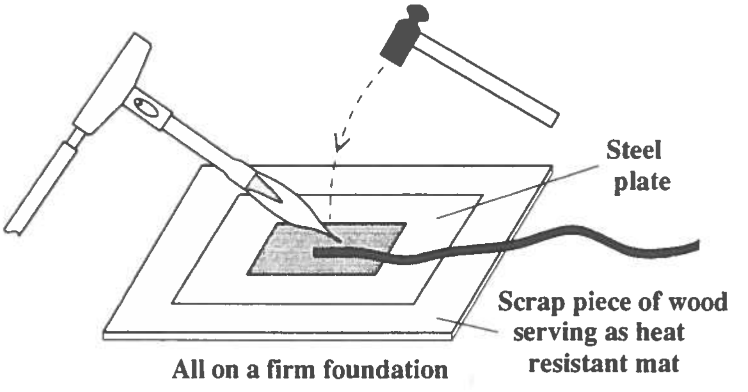


Fig.5 - Welding platinum wire to foil

Constant current supply

The constant current supply listed in Memorandum 16 as S76-130 in the Griffin catalogue, which was later replaced by EKW-650-010Y, is no longer available from Griffin. Unfortunately there is now no commercial substitute. DIY designs are to be found in Bulletins 31 and 68. Luckily for you we try to keep abreast of the times. An updated version is described below (Fig.6).

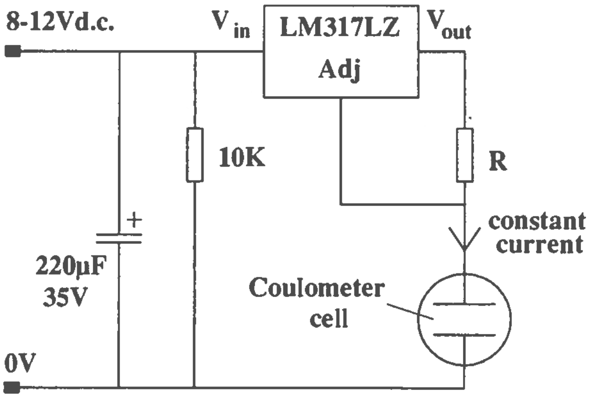


Fig.6 - Constant current supply (10 mA rating)

The voltage regulator (LM317LZ, Fig. 7) monitors the potential difference established across resistor R (between V_{out} and Adjust), which it strives to maintain at a constant voltage called V_{REF}. The circuit therefore acts as a constant current source delivering a current I from V_{out} which is

$$I = V_{REF}/R$$

The nominal value of V_{REF} is 1.25 V, lying between lower and upper limits of 1.20 V and 1.30 V. The tolerance of V_{REF} is therefore 4%.

If you want to build a supply whose output is exactly 10.0 mA with a tolerance of 1% firstly use a 120 Ω resistor for R and measure the p.d., V_{REF}, across it using a digital multimeter on its most accurate range, namely 2 V d.c. Then calculate the exact value of R from

$$R = V_{REF}/0.01$$

Add a low value resistor in series with the 120 Ω value to build up to the exact required resistance.

The components list below specifies resistors with a 1% tolerance. If they are used, the output current should also have this tolerance.

Component	RS item no.
regulator, LM317LZ	641-695
capacitor, 220 μF, 35 V	105-852
resistor, 120 Ω, 1% tolerance	148-281
resistor, value under 12 Ω selected by measurement, e.g. 5.1 Ω, 1% tolerance	150-739

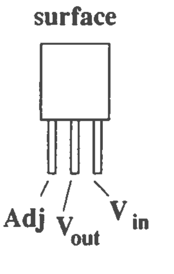


Fig. 7 - Pin-out of LM317LZ regulator

Technical Articles

Gas collection and d.i.y. electrodes revisited

Two good ideas on this theme have been sent to us from Stromness Academy. The teacher reporting to us says he was inspired by an article in Bulletin 156. We think his ideas are excellent in that they can be cheaply and easily constructed and are most effective in use.

Gas collection

The device described below removes the need to have to place a finger or thumb under the surface of a solution of an electrolyte. In Bulletin 156 we had suggested using disposable syringes as either the gas collection tubes themselves or as the means of drawing the electrolyte solution to the top of a calibrated gas burette. There can be obvious problems with plastic syringes if they are moved into a flame to, say, test for hydrogen. The open end of the Stromness gas collection tube is of glass and does not suffer from this problem. The mode of displacing the air is shown in Figure 1.

The glass tubing can be from soda glass because of the easier job of polishing, or from yet again one of those holed test tubes. Different pairings of sizes of glass tube and one-holed bung can be used to give a freely sliding yet fairly gas tight fit. One no.11 bung fits nicely inside a tube with 16 mm outer diameter. But the fit also depends on the taper of the bung and on the softness of the rubber, so a few trials are needed.

Because of the glass rod used for the plunger handle the whole assembly is a little top heavy. Replacement by a wooden dowel rod, or by a disposable chop stick, lowers the centre of gravity.

Use of this device could be seen as a control measure for COSHH in that the skin is kept out of contact with corrosive or otherwise harmful chemicals.

Electrodes

Simple 'S'-shaped electrodes have the advantage over the usual linear rod-type that they can be hung on the sides of a beaker (Fig.2). This type of cell has several good points. It has a low centre of gravity, and there is little chance of the crocodile clips accidentally touching and causing a short.

To make an electrode cut a strip of lead 11 to 12 cm long by 7 mm wide from a sheet of thickness 2 mm. For insulation, partially enclose it with a slightly shorter length of 6.4 mm heatshrink sleeving so that about 10 mm are left exposed at both ends. This sleeving is available in a variety of colours, but red and black are the obvious choice. Carry out the shrinking operation in a well ventilated area, or better still in a fume cupboard.

The choice of lead has two advantages. Firstly, oxygen is liberated at the anode and, secondly, the lead, being nice and pliable, is easily shaped to fit round the lip of a beaker. The unexpected results of using lead,

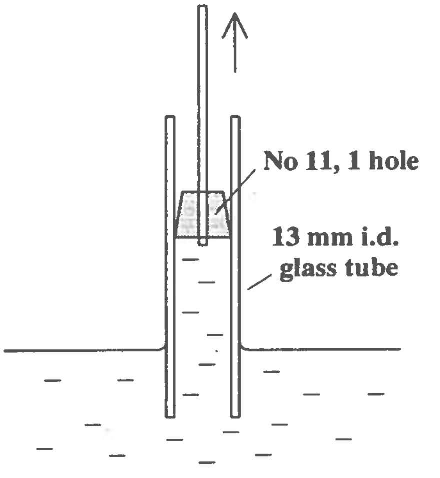


Fig.1 - Filling gas collection tubes with solution

which might cause the more observant pupils to ask some questions, are:

- the formation of a deposit, especially when electrolysing solutions of dilute sulphuric acid, sulphates, or other salts with whose anions lead cations form insoluble salts; and

- the fact that the cell becomes a primitive secondary one and can hold some charge; this effect is unlikely to be noticed when using the cell for electrolysis; only the more creative fiddlers playing around with a bulb, multimeter, or miniature motor, would come upon it.

Table 1 lists the minimum quantities available. These should suffice to make at least forty lead electrodes and to sleeve twelve pairs.

Material	Supplier	Cat.no.	Price
lead sheet, 2 mm thick, 1 kg	Hogg	C3605	£3.70
heatshrink sleeving, 6.4 mm bore, red	RS	398-290	£1.186
ditto, but black	RS	398-183	£1.186

Table 1 - Materials for 'S'-shaped electrodes

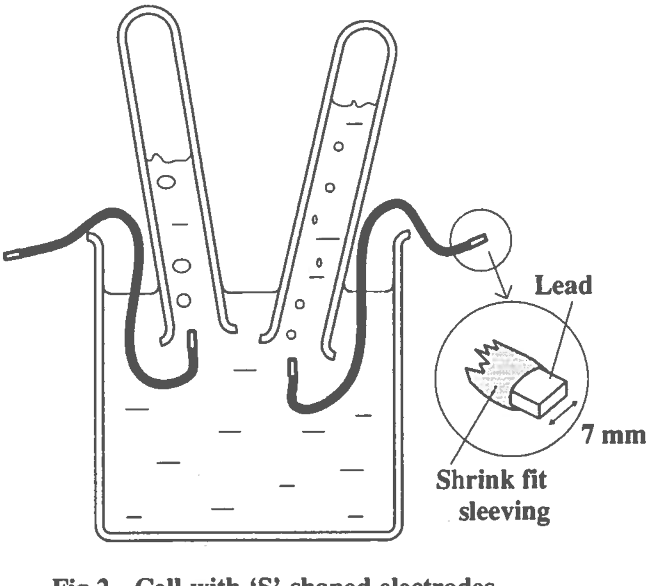


Fig.2 - Cell with 'S'-shaped electrodes

Equipment Notes

Fermenters - Part I

Part I of this article describes three broad categories of fermentation apparatus for use in schools. Distinctions are made on educational grounds. Commercial devices are reviewed.

In Part II, to be published in Bulletin 167, sources of documented ideas for d.i.y. systems will be given and development work thereon described.

Introduction

Over the last two or three years we have had an increasing rate of enquiries on equipment for teaching biotechnology. Apparatus related to fermentation technologies has figured greatly in such enquiries. The question most frequently put goes roughly: "Which fermenter should I buy?". Our usual answer has been "That depends on what you want it for". Such a response points to the nub of the matter, which is that we are being asked to compare apples not only with oranges but probably with pears as well.

This parallels difficulties with early data-logging packages when folk were expecting direct comparisons of the features and benefits of things which had been designed to carry out quite specific and different sets of tasks.

It recalls also the early approach taken by some over the provision of technology education equipment. This was, broadly, to buy the latest gismo, mainly because it was just that. Only then did they start to worry over whether anything educationally useful might be done with it.

Such approaches are backside-foremost. The first part of this article thus seeks to establish some broad educational principles for the application of biotechnology teaching equipment. On such principles we base categories of equipment and describe their attributes. We then review particular bits of equipment against specific criteria.

Biotechnology or technobiology?

Biotechnology topics in the school curriculum are best not viewed solely from a content or informational standpoint. They are also vehicles for the development of skills and the learning of key techniques. The question is: are these topics providing technological vehicles for biology education or are they biological contexts within which to develop technological education? The answers to such questions provide a basis for specifying particular kinds of equipment.

Biology education basis

In 'S' and 'H' grade biology, teachers will rightly wish to concentrate on biological concepts. It is biology they are teaching, not electronics or control technologies. The use of a commercial fermenter is justifiable in these courses only in that it provides an up-to-date and technological context in which to learn about basic biological ideas. Given that, in these circumstances, biology teachers will not want too many technology generated distractions, then it may be acceptable to hide away much of the electronics and controls in some ready-made, user-friendly, black box.

Technology education basis

A purely black box approach may not be acceptable where the aims are rooted in technology education. There teachers will look to the use of a fermenter as a context in which to set technical problems, for example, in instrumentation and control. They would not wish all the technology to be hidden away or all of the creative, design work done and dusted. They require either identifiable sub-systems which can be explored, with opportunities to look also at alternative solutions, or that there be some other aspects allowing of further development. Depending on the type of technology course, teachers may look also for some possibility of design-and-make activities.

Technology from biology

There is a third category of equipment which sets out to mix biology with design-and-make technology education but stays firmly rooted in the biology. Unfortunately we know of no commercial apparatus which consistently employs such a strategy. There are however published materials which describe suitable d-i-y based devices. These systems allow a flexible approach, but one where technological problems clearly arise from a basic knowledge of biological requirements.

Within our third category cultures would first be grown in simple apparatus with limitations which would prevent the optimum growth of, or yield from, an organism. Through a series of design and make exercises pupils might explore ways in which these limitations might be overcome to varying extents.

Three categories of equipment

The three kinds of activity outlined lead us to consider three categories of equipment:

the all-singing-all-dancing commercial package where the instrumentation and control problems are already solved and it is mostly the biology which matters;

the commercial package which uses the biology as the context from which to explore technological problems;

and the documented d-i-y systems which start with the biology but explore in active ways technological solutions to essentially biological problems.

Fermenter design - broad principles

The purpose of a fermenter is to maintain selected microbes in environments where they can carry out the required conversions of substrates to useful products at maximum efficiency. The important conditions (see Smith [1]) which have to be satisfied in a fermenter are:

- the bioreactor should be designed to exclude the entrance of contaminating organisms as well as containing, i.e. preventing the egress of, the desired organisms;
- the culture volume should remain fairly constant, i.e. there should be little or no leakage or evaporation;
- for aerobic organisms the dissolved oxygen level must be maintained above critical levels. This is achieved through aeration and culture agitation. For anaerobes, or anaerobic processes, oxygen must be flushed out of the system and thereafter be excluded;
- other environmental parameters such as temperature, pH, etc., may have to be controlled;
- in order for there to be intimate, and optimal, contact between the organism and substrate the culture volume must be kept well mixed (or the organism immobilised and the substrate passed continuaously over it);

In meeting such requirements safety considerations remain paramount. This is true irrespective of whether the fermentation process is run in either batch or continuous mode.

In batch processes, the fermenter is charged with feedstock and inoculated with cells. The fermentation is allowed to proceed until the required amount of conversion has taken place. The products are then discharged for further processing. After cleaning and sterilising, the fermenter is refilled with a further batch of feedstock and the process repeated.

The main characteristic of the batch process is that the conditions inside the fermenter change as the reaction proceeds to completion. In a continuous process there is a maintained flow of substrate into the fermenter, and of product stream out of the fermenter. Constant conditions are maintained in the fermenter by choosing an appropriate rate of addition of substrate and removal of product.

Educational modelling

Teaching fermenters, then, to be useful and realistic, should have the same features as are to be found on industrial fermenters. Failing that, their features should be analogues of the real thing.

This means that they should possess some, or all, of the following features:

- measures to ensure containment of organism and culture medium;
- devices which ensure either an adequate supply of oxygen, or its exclusion;
- means of monitoring parameters which exert significant influence on growth and, or, reaction rates e.g. temperature and pH, and possibly oxygen concentration;
- a measure of control over the above factors and, depending on the degree of technical sophistication required, such control to be exerted either manually or automatically;
- means of determining growth rates, or of appearance of a product, or disappearance of a substrate; and
- features, attendant on any or all of the above and appropriate to the degree of risk, intended to minimise contamination and other hazards whether microbiological, electrical or biochemical.

Because of apparent widespread concern over the dangers of working with fermenters in schools we will deal next with that aspect.

Safety

Educational applications of fermenters, be they commercially produced or d.i.y., pose two major problems for operators.

The first issue is that of microbiological safety where limits may have to placed on choices of organism and culture media. The problem of the very scale of culturing increases the potential risks to the user. Any gross spillage from the vessel is likely to produce an aerosol possibly containing contaminants.

The second major concern is that of electrical safety. Fermenters, by the nature of their design, usually contain significant volumes of liquid medium. If the liquid medium comes into contact with mains powered electrical equipment a risk of electrocution arises. This has implications for the type of electrical equipment used in an educational fermenter system.

Microbiological safety

Microbiological work, particularly that with fermenters, which can be classified within the "Levels of Work" scheme - see [2, 3 and 4] - is the only type of work likely to be routinely permitted. For project work, or novel, curriculum development activities, risk assessments are likely to be required under Regulation 6 of COSHH [5].

"Topics In Safety" - Chapters 5a & 5b [2] describe in detail the criteria which regulate the type of work that can be carried out routinely in schools: - "Risks from fermentation can be minimized by choosing suitable organisms and techniques, using safe ways of handling suitable micro-organisms and keeping the volume of the medium to a practical minimum". (Another useful source of advice is Strathclyde Regional Council Education Department's revised "Code of Practice" [3]).

Contamination

In a fermenter, contamination by unwanted organisms would result in competition for nutrients. In order to maintain a favourable biological environment, as much as to minimise any risks of infection, contaminants are to be excluded. This can only be accomplished for many fermentation processes with sterile procedures. These have two main components - sterilisation of media and hardware before introduction of the chosen microbe, and the maintenance of aseptic conditions in operation.

Sterilisation and disinfection

The fermentation vessel and medium should preferably be steam sterilised in an autoclave (Ref.[2] - Appendix 1). This may not be possible if the vessel is too tall or bulky to fit inside the usual size of school autoclave. Two of the devices reviewed in our summary table - the Philip Harris Fermenter and the GB Biotechnology Air-Lift device (ALF) - are too big to sterilize this way. Chemical disinfection then has to be used. That in turn further restricts the choice of micro-organism. To be fair, in the interests of microbiological safety, that may well have been the deliberate intention of the manufacturers.

Organisms

Apart from non-pathogenic yeasts and algae, micro-organisms which have unusual growth requirements, such as acidic conditions, or high saline media, or temperatures outwith the limits (high or low) for appreciable growth by pathogens, are strongly recommended for use in school fermenters [2,3 & 4].

Final choices of micro-organism may hinge on whether or not samples for analysis have to be removed from the vessel. Two organisms which we have found particularly suitable for work of which sampling would be a part are the bacteria *Vibrio natriegens* and *Lactobacillus bulgaricus*.

Electrical safety

A major concern is the use of mains powered equipment in association both with significant volumes of conductive liquid and with low voltage instrument electrodes or probes. Some devices use a mains (240 V) heater, or a heater with an attached thermostat. This may be done so as to more easily meet power requirements with large culture volumes or to cut down heating times where close control is required.

In general we have a strong preference for the use of low voltage electrical systems within the fermenter vessel. Mains is acceptable, obviously, for providing the primary supply for such low-voltage circuitry, or for supplementary services outside the fermenter vessel such as magnetic stirring, external heating, monitoring or controlling. Apparatus must be arranged so that mains devices are sited, where possible, a reasonable distance from the fermenter vessel itself, and from sinks and water taps.

Instrumentation and control

The extent to which instrumentation features in educational fermenter systems varies greatly. As indicated in the "Introduction", some systems, such as that from Harris, tend to concentrate on the biology and hide the technology in a 'black box'. This, for some, may initially seem ideal. However, it soon becomes apparent that even a basic understanding of the technology of the instrumentation may be important for successful educational usage.

Other systems, such as the MTS Fermenter (see Table 2) do allow some exploration of the technical design features of the instrumentation. For Technological Studies, or use in other technology courses, this provides an ideal context in which to set problems. For biology teaching, it is important that the emphasis does not shift too far. There is then the danger that a forest of wires from the fermenter vessel proves unacceptably daunting for both the biology pupil and teacher.

Instrumentation - what's available

Table 1 summarises the variables commonly measured during fermentation. It shows the method, or range of methods, of measurement used in educational fermenters currently on the market and, where applicable, the control procedure which is usually initiated.

Parameter	Method of measurement	Information gained	Control
Temperature	liquid-in-glass thermometer, thermistor, silicon diode	temperature	switching of heater (manual or automatic)
pH	pH electrode	changes in broth acidity	addition of acid or alkali
Dissolved O_2 concentration	O_2 electrode	oxygen transfer rate	change stirrer speed or air flow rate
Cell mass, measured as turbidity of the broth.	measurement of optical density of broth	growth of the cells	

TABLE 1 - Parameters commonly measured during fermentation

Table 2 provides a short summary of the results of our evaluation programme on teaching fermenters. Omitted are a number of models which we did initially inspect or test but which were then rejected either because they were too expensive or because of risk of infection or injury. Fuller test reports can be provided to establishments in membership of SSERC. Written requests to the Director, please.

For a general, and relatively gentle, introduction to and overview of electronic sensor types see reference [5].

Temperature

Data from a temperature transducer is, in most systems, used to control the switching of a heater submerged in the culture medium (a negative feedback mechanism). Control of temperature to within one degree Celsius of a set point is adequate for a school's fermenter system.

Quite high rates of heating may be required to more finely control temperature in large culture volumes. That in turn may lead to the use of mains (240 V) heaters, with consequent safety problems (see section on "Electrical Safety").

pH measurements

A standard pH electrode inserted into the medium can be used to monitor the progress of a reaction i.e. the formation of an acidic product during aerobic respiration. Depending on the technology available, pH will either be controlled manually or automatically. The Harris Fermenter uses an automatic control system, with a solenoid operated valve, whereas the MTS basic system relies on the operator acting on a computer prompt to manually control the pH.

Other sensors

There are several other probes commercially available which, although not normally supplied along with fermenter assemblies, can be used with such systems. Two of the more popular of such additional sensors are the oxygen electrode and the turbidity probe.

The oxygen electrode most commonly used is of the polarographic type. One model which is particularly easy to assemble and use is manufactured by Russell and is available from Philip Harris. In this probe the membrane is pre-stretched on a small cap which is easily attached to the body of the electrode. Much has been written concerning the reliability of oxygen electrodes. While they may not be the best option when accuracy is required, they do provide useful, if rough, indications of changes in oxygen concentration in a liquid medium. None of the systems we examined used a dedicated oxygen electrode. However some did mention the possibility of using a standard probe with their system.

Turbidity measurements - these may allow you to quantify the cell growth or in other ways indicate the progress of fermentation. The MTS fermenter system provides an in-built sampling mechanism whereby turbidity measurements can be made without having to remove the sample from the overall confines of the fermenter vessel. Harris on the other hand provide, as an optional extra, a combined heater and turbidity probe which also permits in-situ measurement of turbidity.

The MTS turbidity sensor uses an LDR (light dependent resistor) in this case an ORP-12. The response of this device is non-linear over 0 - 300 lux. The ORP-12 cell is also used by several other manufacturers, although Philip Harris can supply a more expensive linear light sensor which uses a silicon photodiode operating in a photoconductive mode. Although the photodiode itself is a less expensive component than an ORP12 or equivalent, it requires more complex circuitry and impedance matching. The Harris system requires the vessel to be shrouded to reduce the amount of ambient or stray light reaching the detector.

SSERC has been working on a prototype continuous measurement system using optical fibres with both the light source and detector being outside the fermenter vessel.

Other considerations

Aeration

Oxygen is only sparingly soluble in water. At the usual incubation temperatures, one cubic metre of culture medium can only dissolve 7-8 grams of oxygen. Maximum oxygen uptake rates during fermentation are typically around 5 g m^{-3} of culture. So in a typical aerobic fermentation all the oxygen initially present in a saturated solution of the gas may be used up in a matter of minutes. Oxgyen must therefore be supplied continuously to such cultures to allow aerobic fermentation to proceed at anything like optimum rates.

The GB Biotechnology Air-Lift Fermenter (ALF) uses aeration not only for maintaining suitable oxygen levels in the culture but also for mixing. Such a fermenter is known as a gas-lift loop fermenter. It uses the principle seen on a huge scale in ICI's Pruteen fermenter.

Inlet and outlet filters

In the GB fermenter, aeration is provided by an aquarium pump through a sterile, in-line, bacteriological filter costing about 50p (or more cheaply using a glass tube packed with non-absorbent cotton wool). It is important to include an air vent in the vessel to prevent the build-up of gases. This vent should also be filtered to trap any aerosol produced within the vessel. The use of yeast, for example, in an anaerobic fermentation will produce a considerable volume of gas which, if not vented, can result in a dangerously high pressure.

Agitation

Where agitation of the culture is not already provided as a by product of aeration, it is best accomplished using a 'flea' driven by a magnetic stirrer. Note that some models of stirrer may heat up the culture. At least one model of teaching fermenter uses a sparger (a baffled disc which rotates when air is pumped down through it) to assist with both aeration and agitation.

Sampling

The safety of sampling procedures is heavily dependent upon the combination of

- the expertise of the person removing the sample;
- the organism being grown; and
- the culture medium used.

Whilst optical density measurements can be made in-situ, measurement of other variables such as specific gravity (alcohol concentration) requires that samples be withdrawn from the vessel. A sampling procedure may provide an interactive task in what otherwise may be a fully automated system. Provided that the correct procedures are implemented, thereby minimising any risk, sampling from a fermenter may be permitted for work at Levels 2 and 3.

Documentation

It is important that documentation provided with a commercially produced system should be clearly and concisely presented. The text used in printed notes should be of a readable size and style for both teacher and students. It is important that diagrams used in the notes should be labelled and correctly referenced in the text. Whilst these points may seem obvious, it was surprising that the documentation supplied with some of the commercial systems we reviewed ignored such obvious requirements and was remarkably poor.

Computer software supplied with commercial systems should meet the criteria described in Bulletin 160 [6].

Open-ended work

Any system should, ideally, permit open-ended project work in both microbiology and fermentation technologies. Whilst most biologists will initially be concerned with the 'biology' in the fermenter, it is important to look also at the technology in the system. The study of fermenter systems provides an excellent opportunity for cross-curricular work, particularly with other subjects in the "Technology Mode".

It is not necessary always to use commercial systems. A d.i.y. approach can introduce more possibilities for open-ended project work. The use of such d.i.y. equipment, however, brings with it its own constraints. Part Two of this article will describe simple home-made fermenter systems and explore some of the areas of work into which they may lead - such as modelling continuous fermentation processes and investigating the problems of scale-up.

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2. "Topics in Safety" - Chapters 5a & 5b, ASE, 2nd Edition, 1989, ISBN 0 86357 104 2
3. "Safety in Microbiology : A code of practice for schools and non-advanced further education", Strathclyde Education Department, 1989.
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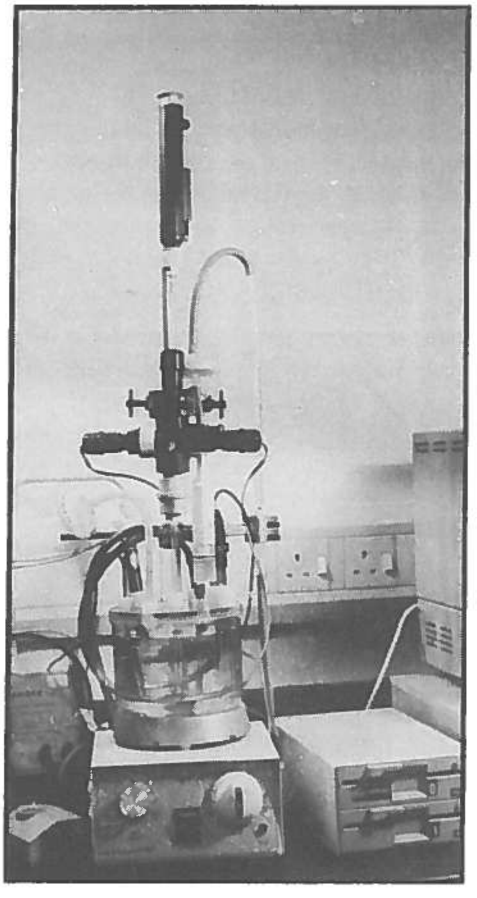
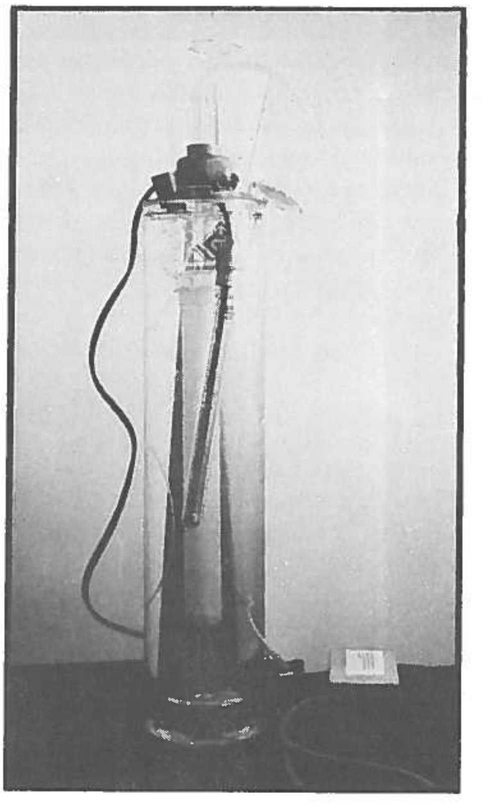


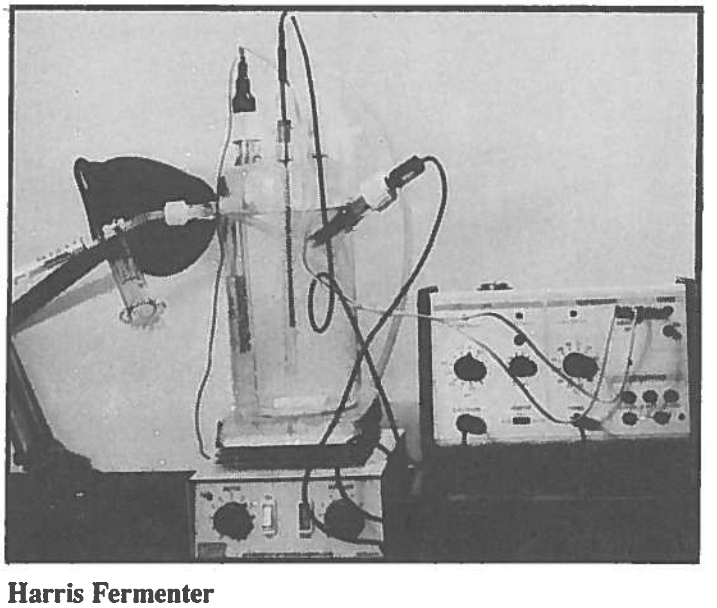
MTS System

Microprocessor Training Systems



Air Lift Fermenter

GB Biotechnology



Harris Fermenter

Philip Harris

PRODUCT	AIR LIFT FERMENTER	MTS SYSTEM	HARRIS FERMENTER
Supplier	GB Biotechnology	Microprocessor Training Systems	Philip Harris
Price	£185	£399	£525
Vessel			
- capacity	4.5 l	500 - 600 cm^3	2 l
- material	polystyrene	polycarbonate	borosilicate glass
- ports	5	10	6
Sterilisation	chemical	autoclavable with media and fittings in-situ	chemical
Heater	240 V - combined heater/thermostat	12 V, 30 W	20 V, 30 W
Probes			
- temperature	mercury thermometer	thermistor	glass enclosed probe
- pH	no	yes	yes
- turbidity	no	yes	optional extra (£26)
Computer	plays no part in control or monitoring; computer required to access instructions	computer essential; computer monitors parameters, but does not control	hard-wired controller is provided; computer can be used to display data output from controller
Control	automatic temperature control using a combined heater/thermostat	temperature and pH controlled manually	main control unit houses circuitry which automatically controls both pH and temperature; pH controlled using a solenoid valve and a gravity feed system
Measurement	temperature by visual checks	turbidity, temperature and pH possible; software prompts indicate when measurements should be made	the main unit has 0 - 1 V analogue outputs for pH and temperature; the voltage data can be displayed on a meter or analysed by computer software
Documentation	stored on three 5 1/4" floppy discs; the notes are terse and would benefit from references to diagrams	comprehensive instruction manual describing experiments and background information; an excellent teaching resource; software - straightforward to use; must be used in conjunction with the supplied ROM chip; screen dump routine permits graphs and tables of data to be printed out	manual quite good, although some areas need amplification e.g. sterilisation and sampling; five different experiments described
Extras required to run system	BBC Micro for instructions	BBC Micro; magnetic stirrer; air pump	air pump, magnetic stirrer, voltmeter. Optional: datalogger, BBC Micro
General comments	large volume of media required - time consuming; relatively over-priced considering the components provided; does not fully meet the needs of either Scottish biology or technology courses; mains heater/thermostat not approved	competitively priced; operater interactive; exposes student to multi-disciplinary aspects of biotech-nology; requires lab sessions of approx 2.5 - 3 hours; useful for biology and Tech. Studies as a Case Study	neatly packaged total system with all the sub-systems out of sight; access to 'Datadisc' a big advantage; ideal for biology departments, limited use for technology departments.
	Not recommended	Recommended	Recommended

A fourth system sold by Griffin and George under the name 'Micro-fermenter' was also evaluated. Griffin and George have since withdrawn this item from their range and no longer market it.

TABLE 2 - Summary of evaluation of commercial fermenters

Equipment Notes

Portable radiation monitors

Scope of report

The instrumentation market has, for a number of years, included several, portable, hand-held radiation monitors. But this market has been aimed, till now, at industry, research and higher education. Such monitors have been too expensive, and possibly over-engineered, for the needs of secondary schools.

Very recently the market has expanded - or descended, you might say - into secondary education. There are now several models that, from above, break the £200 price barrier. This appearance is particularly apposite at a time when curricular changes have introduced the concepts of dose, dose rate and typical background levels.

The two models we have tested and report on are the Radcount from AEA Technology, and the Rad Alert, Model 1201, the most sensitive of a range of models from Perspective (UK) Limited. This latter is also marketed by Irwin Desman Limited.

Description of monitors

Descriptions including physical characteristics and functions are summarized in Table 1.

Note that the separate functions of Radcount and Rad Alert only partly overlap. Both monitors count and display count. The Radcount is sensitive to all forms of ionising radiations, and is a portable and attractive replacement to the scaler with GM tube. The Rad Alert is only sensitive to gamma and X radiation. Its prime function is the measurement of dose and dose rate, being capable of reading down to background levels.

Physical tests

The efficiencies of the GM tubes relative to a Mullard ZP1481 tube, the standard type found in schools, were determined. Test figures (Table 2) are rounded off to the nearest 5%.

Clearly the Radcount can be used as a substitute or supplement to the usual scaler and Mullard GM tube for the standard range of practical work on radioactivity.

The accuracy of dose rate readings was assessed by placing the Rad Alert in the radiation flux of various gamma sources and comparing readings with theoretical estimates of dose rates.

We found a reasonably good correlation. Certainly the Rad Alert indicates to better than an order of magnitude.

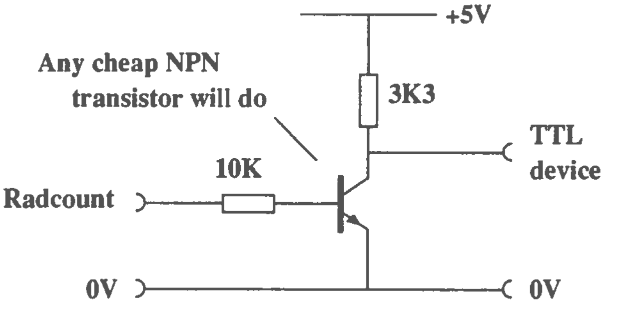


Fig.1 - Transistor buffer to drive TTL

We also judge that its linearity is fairly good and that even down at very low dose rates such as from background, or rock samples, it records to better than an order of magnitude.

Compare the Rad Alert's minimum resolution of 0.01 μSv h^{-1} with the average natural background radiation rate, which is 0.2 μSv h^{-1}, and you find that data which might have seemed remote, obscure and unquantifiably small is now accessible.

Electrical output

The electrical output on Radcount is not, as the specification claims, TTL compatible, but can be made so by the addition of a transistor buffer (Fig.1).

This lack of drive in the electrical output is an understandable trade-off against the need to conserve battery life.

Educational worth

The physical quantities of dose, dose equivalent and dose rate have been introduced into several science syllabuses in the last year or two. The context in which these concepts will be used in schools is likely to be teaching about personnel safety in low radiation fields. The Rad Alert is able to measure quantitatively background dose rates, and distinguish anomalous radiations whether caused by natural geological conditions or man-made sources. One of the most valuable concepts that schools can impart to pupils in the field of nuclear science is the concept of the orders of magnitudes of typical doses and dose rates. The Rad Alert is therefore a valued addition to the range of instruments marketed to schools.

Being battery operated, lightweight, robust and portable, both monitors can be used outdoors in field studies. (Neither however has been designed to withstand wet weather usage.)

The Radcount at even its non-discount price is good value for money. At the discounted price it is unbelievably good value.

Feature	Radcount	Rad Alert, Model 1201
Supplier(s)	AEA Technology	Perspective (UK) (1) Irwin Desman (2)
Price (not including VAT)	£80 for first £199 for further instruments	£199 (1) £208 (2) (ref RA3495)
Detector	GM tube	GM tube
Radiation sensitivity	alpha, beta, gamma and X	gamma and X
Tube dead time	200 μs	110 μs
Counting facility	yes	yes, displays count and counting period
Counting period	100 s in automatic mode, and any period under manual control	any period under manual control
Dose rate facility	no	yes
Range	-	0.5 uSv h^{-1} to 10 mSv h^{-1}
Resolution	-	0.01 uSv h^{-1}
Integrating periods	-	4 s, and 1, 2, 5, or 15 minutes
Dose facility	no	yes
Alarm facility	no	yes, adjustable settings
Speaker	switchable	switchable
Electrical output	yes, will drive VELA, but needs buffer to drive TTL	no
Display	6 digit LCD, large, readable characters	LCD display bearing 2 rows of legends, characters only 3 mm high and not easy to read
Case	injection moulded polycarbonate, very robust	high impact polystyrene, fairly robust
Environmental monitoring	not protected against water penetration	not protected against water penetration
Power supply	9 V battery or eliminator	9 V battery or eliminator
Quiescent current	0.15 mA	10 mA
Battery hours	500 h	15 h
Supporting material	technical data, teachers' notes, user guide, investigation sheets - generally excellent, but some misleading parts	instructions terse but adequate, also NRPB and UKAEA booklets

Table 1 - Radiation monitor features

Radiation	Radcount	Rad Alert
alpha	35%	0%
beta	55%	0%
gamma	80%	75%

Table 2 - Relative efficiency of GM tube with respect to Mullard tube ZP1481

Equipment Notes

Pneumatics - compressors and air supply arrangements

This article provides general notes on the choice, installation and use of compressed air supplies in Standard Grade Technological Studies.

Introduction

> "*Any system which uses the energy stored in compressed air to do useful work is called a pneumatic system*" [1]

Commercial application of pneumatics dates back to the early 1950s when techniques developed in wartime were applied to civil manufacturing in order to introduce more automated production and thus boost profitability. Today it would be difficult to imagine any reasonably sized workshop or factory which does not employ compressed air in some way or another.

Compressed air of itself is of little use without some form of storage, actuation, control and devices which do actual work.

Pneumatics systems

Figure 1 provides a block diagram of a generalised, basic pneumatic system. At the heart of this system is a compressor, driven by an electric motor which compresses atmospheric air thus raising its pressure. Some of the electrical and kinetic energy used to do this becomes potential energy 'stored' in the air, some is converted into heat energy.

In most cases the compressor stores air by forcing it into a reservoir or receiver. This high pressure air may then be released as required. After filtration and pressure regulation the stored air is controlled by means of a valve or valves which regulate the supply of air to working cylinders. The cylinder is the means by which potential energy stored in the air by the compressor is converted to linear motion with sufficient force to do significant, useful work.

Compressors

For realistic project work with small scale, pneumatics components of the type actually used in industry two types of compressor are suitable for use in schools and non-advanced FE. These are the reciprocating type and those using the rotary vane principle.

Reciprocating types

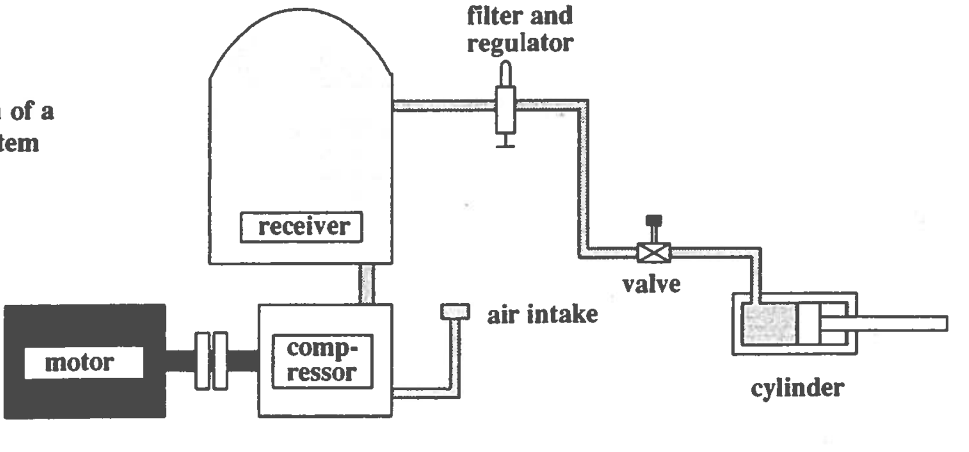
Reciprocating models recommended by us (see Table 1) have noise levels similar to those of typical domestic refrigerators. They are thus quiet enough to be operated in the classroom. The 50 litre receiver should give an adequate supply for 8 to 10 pupil work-stations. A receiver is a reservoir storing air at a higher pressure (7.5-8 bar) than the supply to the components (2-3 bar). This helps to give a pulse-free, smooth supply to working components. Note that throughout this article quoted pressures are always relative to atmospheric pressure and not absolute figures. Thus the working relative pressures of 2 to 3 bar quoted above are 3 to 4 bar absolute.

Because the reciprocating compressor is not designed for continuous running, a design including a receiver allows for off-load use of compressed air so preventing over-heating and ensuring a longer life for the motor unit.

Rotary vane compressors

Rotary vane compressors are designed to run continuously. They do not require a receiver (although one is recommended if the compressor unit is to be operated in the classroom). The models we recommend will service up to 10 work-stations. The major disadvantage of compressors of this type is their noise level, which is typically much higher than that of reciprocating types. For the comfort of staff and pupils it is best where practicable for such a compressor to be sited outside the classroom.

Fig.1 - Block diagram of a pneumatic system



Supplier	Model	Receiver volume (l)	Weight (kg)	Noise level (dB)	Guide price (£)	
Amprotech	75/25/VSS	25	40	55	420	Reciprocating compressors
Amprotech	75/50/HMS	50	60	56	680	
Bambi	75/250	25	41	55	440	
Bambi	150/500	50	72	56	700	
Junair	6-X	25	30.5	40	550	
Junair	12-50	50	55	40	850	
Hydrovane	5 PURS	50	61	60	450	Rotary vane compressor

Table 1

Note that work-station to receiver capacity ratios are roughly as follows:

2 to 3 stations - 15 litre receiver

3 to 4 stations - 25 litre receiver

6 to 8 stations - 50 litre receiver

A rotary vane compressor will require more frequent maintenance than a reciprocating model. It will, effectively, require routine servicing. The cost and frequency of such work should be discussed with suppliers before deciding on purchase and placing your order.

Siting

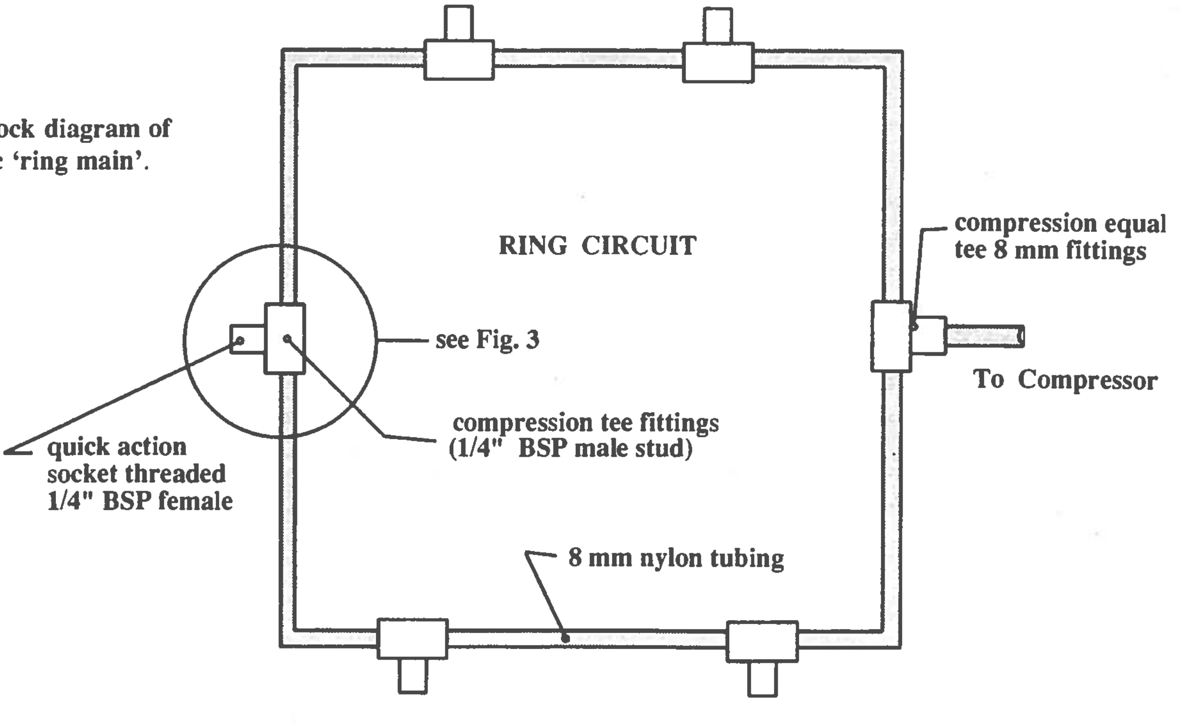
If you wish to site the compressor in a technology teaching room or have no practicable choice then we advise you to buy a reciprocating type with a receiver. If there is a suitable location outside the teaching room or rooms and it is practicable and affordable to lead a main air supply into the teaching areas then either type of compressor is acceptable. Whichever type and model is chosen it must be sited to ensure an unrestricted flow of air at the compressor intake. Remember to discuss with your supplier any detailed requirements for the fitting of water vapour traps or coalescing filters (see Safety Warning below).

Installing air-lines

When planning an air supply circuit it is essential to ensure an adequate supply of air is available at all points of the system. Air lines from the compressor should be of a large enough diameter to prevent a pressure loss at work-stations. With narrow tubing this may well occur when all the stations are in use and air flow requirements are at a maximum. Tubing of 8 mm diameter is advised for air supply lines, this gives an adequate flow rate for up to 10 work-stations. Sharp bends in the tubing should be avoided.

The installation should be on a 'ring main' system, fed from a T-piece at the compressor (Figure 2). This

Fig.2 - Block diagram of a pneumatic 'ring main'.



gives an arrangement whereby both ends of the supply can be connected at the compressor, and reduces the risk of having insufficient pressure at the furthest work-station outlets to operate any pneumatic components.

Air outlets at workstations should also use a T-piece arrangement with a quick action, push fit socket.

It is best to avoid crude routeing arrangements where pipe is merely run around the room walls and held in pipe clips. A much safer and neater job results when the piping is led in plastic trunking or behind a bulkhead (see Figure 3).

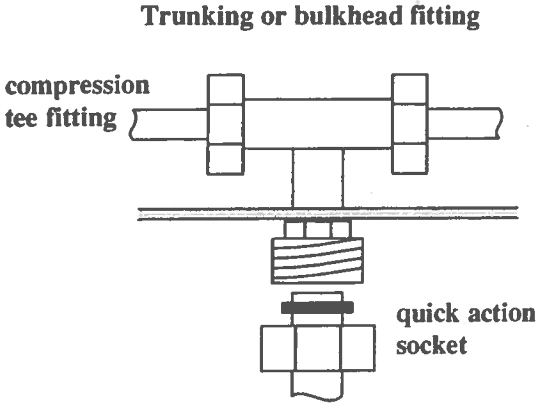


Fig.3 - Detailing at ring outlets

Other compressors - for low pressure, lower power

Both types of compressor described above are intended for use with components which are miniature by industrial standards but which still possess sufficient power, and are reasonably safe, for serious applications at school level. There are however some specialised pneumatics teaching kits designed to operate at extra low pressures. Suppliers include Fischertechnik, LEGO and Testbed. Such kits require the use of other, suitable, types of compressor.

A special compressor is available from Fischertechnik to power their pneumatic kits. A satisfactory and inexpensive substitute is a diaphragm aquarium pump. Details on using such a pump with a reservoir can be obtained from SSERC.

Pneumatics kits from Testbed Technology are potentially useful particularly because they were deliberately designed to integrate with some of the Testbed/Unilab electronics systems boards. These Testbed pneumatic components can be powered from a simple hand-operated compressor and air reservoir, which works on the same principle as garden sprayers.

Routine maintenance

Ensure that the air receiver is drained at the end of each day's use. The compressed air in the receiver becomes heavily laden with moisture and if allowed to remain in the receiver it will eventually cause serious corrosion.

If the compressor is in the same room as computers or other electronic equipment care should be taken when emptying air from a receiver at the end of a working day. The air released will be at 8 bar above atmospheric. It will expand rapidily spreading a fine moisture laden and oily mist over the contents of the room. This can be overcome by venting to the outside, or using a water trap, i.e. a pipe from the receiver to a water filled container, making sure the escaping air is slowly bubbled through the liquid. This latter method is time consuming (see also the Safety Warning given below).

Inspection and longer term maintenance

Manufacturers of compressors carry out strenuous testing of receivers and ancillary equipment. They generally issue a certificate of proof of testing with each machine. Education authority insurers may examine compressors and receivers during routine examination of plant and equipment.

The Factories Act 1961 recommends that inspection of receivers be carried out by a competent person at least once every 26 months. This is echoed in B.S. 4163 [2] and in the DES "Safety in Practical Studies" booklet [3] which interprets the requirement as once every two years.

Safety Warnings

Using inappropriate compressors

There have been incidents in schools where some plastic kit components have been blown apart when used with industrial compressors. In view of such accident histories it is strongly recommended that such plastic pneumatic components *shall not* be operated from industrial compressors.

Compressors and COSHH

The oily aerosols produced by compressors when air is released were referred to in the section on routine maintenance. These suspensions of atomised oil will remain in the air for some considerable time after their release. For technical reasons some makers still use mineral oils in certain compressors. Others may use synthetic oils which have a less unpleasant odour, but are not necessarily present in the air at lower concentration.

It has been recently brought to our attention that in some schools where compressors have been getting significant use there have been problems with oil released into the air also from valves and cylinders. There have even been reports of staff teaching the course suffering from headaches, and of other staff complaining of fumes.

These reports reinforce our advice to fit coalescing filters at the outputs of compressors. Such a filter will reduce significantly, but not entirely, the amounts of any atomised oil entering the atmosphere of the room.

In an ideal world only dry, or oilless, compressors would be used in schools but such types are very much more expensive than lubricated models. Proper filtering seems to offer a more cost-effective solution, except perhaps where usage is exceptionally heavy.

Pressure gauges

We have a number of pressure gauges (see surplus list, page 44) reading between 0 - 4 bar above atmospheric (0 - 55lb/sq") and feel they could be a useful addition to pneumatics kits. We have noted below a few of the more obvious uses, but we will be happy to hear of any others. The good ones we will pass on through the Bulletin.

A number of gauges strategically placed at workstations will provide convenient visual indication of pressure levels.

When connected to signal ports of control valves and to cylinder ports they can be used to demonstrate when pressure is applied and when it is removed. Or again to show the build-up of pressure in a time delay circuit.

The gauges can also be of use in showing the relationship between Force - Area - Pressure, e.g. increasing or decreasing the diameter of the cylinder or the applied pressure.

In-service courses

SSERC has run a number of successful in-service courses on pneumatics. These have been for different EAs and have either provided technical training for regional or divisional trainers or were introductory courses for teachers or for technicians on setting up, using and maintaining pneumatic systems.

The Centre already has a number of bookings for technology courses for the 1990-91 session but, given sufficient demand, would consider offering further courses on pneumatics. Enquiries to the Director, SSERC, in the first instance please.

References

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Equipment Notes

CCAP Culture Kit - a review

Background

In 1989 we completed evaluation of an early version of this culture kit which uses algae and protozoa to support practical work in microbiology and biotechnology. Because of disruption from our move to new premises we had to discontinue the maintenance of our cultures. To a large extent this work with algae and protozoa then got overlooked.

The advent of the revised Highers and Sixth Year Studies has reminded us of this useful material produced by staff of the Culture Collection of Algae and Protozoa (CCAP) and available from the Institute of Freshwater Ecology (IFE). The kit is supported by the Shell Education Service, the Society of General Microbiology and the British Phycological Society.

Description of kit

The culture kit contains:

- 8 cultures of algae and protozoa selected by CCAP from a wider list
- concentrated culture media
- 3 background readers one general and two on different culturing, isolation and identification techniques
- Teachers' Guide
- 8 illustrated workcards.

It is available to schools at the special price of £25-00 including postage and packing from the IFE address on the inside cover of this bulletin issue. Grants have been available in past years which further reduce the net cost to EA schools to £15 per kit. The cost to Universities and other H.E. establishments is £36-00. Please enquire of the IFE if you wish to confirm current prices. Note also that the kit is sent minus the cultures which follow after about four weeks. This arrangement is to allow time to read the literature and prepare media etc.

Results of our evaluation

For Standard Grade

We first looked at the kit for possible applications in the Standard Grade Biology course. Certainly there are a good number of such potential applications - particularly for Topics 1, 2, 3 and 7. Examples of apparently relevant activities in the kit include work on predator/prey relationships with protozoa, immobilisation of microalgae, useful products from algae (e.g. the natural red pigment astaxanthin) and photobehaviour.

After trying out several of these practical exercises we concluded that Standard Grade was not an ideal level for much of the work. Whilst many of the exercises went fairly smoothly and produced useful results, some of the techniques were a little too demanding and beyond Standard Grade except possibly at Credit level. Some require a fair amount of preparation time from technicians.

The other snags we found were to do with providing a suitably well-lit, yet relatively cool, site for maintaining the cultures. One or two of the activities were beyond even our resources. If we lacked the necessary equipment then it is unlikely that thesc experiments would be routinely attempted in typical Scottish secondary schools.

For revised Higher and CSYS

We are of the opinion though that the kit is a useful resource for more advanced work at Higher and as a basis for SYS project work. At that level it would undoubtedly find a range of applications which would not be restricted solely to the microbiology related topics. Many of the activities illustrate important biological ideas and simply happen to use micro-organisms to do so.

Video

A video has now been produced to complement the kit. This is entitled "Microbial Engine : Algae and Protozoa - Ecology to Biotechnology". It costs £19-95 plus £1-39 post and packing (net of VAT) and is available from the IFE. From the description given to us it looks potentially useful for various bits of the Standard Grade and Higher courses, particularly the ecology and biotechnology related topics. It covers subjects such as the role of algae and protozoa in sewage treatment and in general ecological processes as well as looking at the production of useful products from algae. As yet however we haven't viewed a copy. Teachers should therefore make their own further specific enquiries as to content and depth of treatment.

Summary

At a time when the range of microbiological practical work available to schools has been somewhat restricted by Health and Safety considerations, this kit provides timely support. With its use of selected algae and protozoa, species without any known health hazards, it extends the range of interesting microbiological practical work which may be carried out in schools.

The kit may well find some application at the Standard Grade but its real potential would seem to be for use at the Higher and SYS levels and possibly even for one or two SCOTVEC modules.

Trade News

LJ Systems

The company markets a range of control equipment that may have uses in Technological Studies, at Higher and Standard Grade, and in the Short Course, Robotics. The robot arm with conveyer belts, known as EMU, and the microprocessor trainer, known as EMMA, were both used in a workshop at the Launch Conference of Higher Grade Technological Studies. They both survived the onslaught of some fifty teachers: most comments were favourable.

The company plan to offer their three-axis milling machine, which at present can only be controlled with the IBM, to schools, with software written for the BBC. The selling price is expected to be around £800.

The mill with robot arm, conveyers and microprocessor trainer could be suitable for modelling a work cell.

Opitec

Opitec is the marketing arm of Durr Technik, an East German company, and offer a range of kits and components which are very competitively priced.

Their range of propellors is particularly interesting. In addition to pre-built props they also sell a kit version consisting of hubs, blades and screws with which props in a variety of number of blades can be constructed. This should be of specific interest to teachers of Standard Grade Physics.

The company also stock a range of models in kit form, mainly using wood as the construction material. These should interest teachers of Technological Studies.

MJP Geo Packs

New to us is the firm of MJP - Michael Jay Publications - suppliers of a range of equipment and materials for environmental studies. Products supplied by this firm include:

- sand, soil, sediment and pebble sampling and analysis equipment;
- river sampling and analysis equipment;
- meteorological equipment, including anemometers, barometers and a 4 channel computerised weather station;
- biogeographical and geological surveying equipment.

Also described in the MJP catalogue are slide sets, OHP transparencies and computer software. Copies of the catalogue are available from the address given on the inside cover of this bulletin.

Oscilloscope repair

The firm of Mendascope specialise solely in the repair and recalibration of all makes and models of oscilloscope, including obsolete models. If you engage their service they uplift and inspect your instrument and issue a free estimate. Repairs would then, on your approval, be carried out.

Mendascope maintain a library of service manuals and can supply photocopies of many now hard to obtain.

Change of address

We have notification from Clandon Scientific Limited that they have moved to new premises. Their new address can be found on the inside cover. Their telephone number remains unchanged.

Ross and Lamont

I am told that when the keepers travel out by helicopter for their monthly inspection of the Flannan Island Light they find that the door that they are scrupulous to lock on each departure is unlocked.

One of our great national mysteries was the disappearance of the three keepers before the days of automation altogether killed off the practice of permanent keepering. One of our other great national mysteries is the firm of educational manufacturers, Ross and Lamont.

Where are they? What has become of them? If any reader can help with our enquiries we would be very grateful. Failing that any poem submitted on the subject, in the style of W.W.Gibson, will be considered for publication.

Surplus Equipment Offers

General Conditions

In general this offer is subject to the conditions laid down in Bulletin 158 (October 1987).

New Lines, new stock

Listed below are a small number of items newly added to our stock. Please note that there will be an additional charge for any postage costs.

Item 710	Sonic switch and motor assembly. 1st sound starts the motor, 2nd sound reverses the direction of rotation and a 3rd sound stops the motor. Driven by 4 AA cells (not supplied).	45p
Item 711	Regulator, 6.2 V, 100 mA (pre-cut leads)	10p
Item 712	Smoke pellets by Brocks. For testing local exhaust ventilation (LEV) - fume cupboards (containment) and extractor fans etc.	
	Large (each)	50p
	Small (each)	40p
Item 713	Solar cell and motor assembly (new stock)	£3-50
Item 714	Sign "Radioactive substance" to BSI spec. ca. 145 x 105 mm, semi-rigid plastic material. Suitable for labelling a radioactive materials store. With pictogram and legend.	£2-10
Item 715	Pressure gauge, ca.40 mm o.d. case, 25 mm deep and 33 mm dia. dial reading 0-4 bar (i.e. above atmospheric). With rear fitting for 1/8 B.S.P. Suitable for use as indicator for pneumatics circuits in Technological Studies.	75p
Item 716	3-core cable with heat-resisting silicone rubber insulation, 0.75 mm^2 conductors, can be used to re-wire soldering irons as per Safety Notes, Bulletin 166. per metre	£1-35

Standard Stock

We still have stock of most of our standard items as listed in earlier issues of the Bulletin (162 to 164 inclusive). Orders and enquiries are invited for such items. We are also always pleased to receive ideas and suggestions for other items which you might like to see us add to our stock. A full list will again be published in Bulletin 167, which will be published early in the Autumn term.

S.S.E.R.C.
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