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Ionising Radiations

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(0543) 480077 (direct).

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OPINION

Ionising radiations and the management of risk

On the night of 25 April 1986 engineers renewed their attempt to carry out a test with reactor Unit 4 at Chernobyl. This plant had a full operating power of 1000 MW, and operation below 500 MW was normally forbidden due to the inherent instability of the reactor at low power. Notwithstanding this, the test was to be carried out at 200 MW. However that night, because of the particular design characteristics, the operators had difficulty in controlling the reactor at such a low power. But they did eventually bring it under control, temporarily as it turned out, at the excessively low rate of 60 MW. This meant the reactor was operating in an unsafe regime. Compounding their foolhardy action the operators had deliberately and in violation of rules withdrawn most of the control and safety rods from the core, and switched off some important safety systems. At 01 23 the following morning the instability of the reactor led to a sudden rise in steam pressure which was impossible to control. There was a catastrophic explosion.

The disaster was caused by the ignorance, arrogance, indifference and stupidity of the operating team. These would seem to have stemmed from bad management and poor safety policies. There was indeed a cavalier attitude to the risks. One lesson which can be taken from Chernobyl is the utmost necessity of having the right attitude to safety. We must all be safety aware; and we must act in accordance with our informed knowledge of how to deal with particular hazards. Many may yearn to go back to the good old days when the world was apparently non-nuclear. Paradise regained! But the world is radioactive, at one time only naturally and now also artificially. Many may want to distance themselves from radioactive materials - it is far too bothersome applying the required safety precautions; I'll use a video instead. But that would be a mistake. We should as teachers be passing to children safety consciousness - teaching that hazards should be met and can be dealt with by care rather than fear.

More and more the management of risk is seen to impinge on the work and lives of individuals. With the introduction of the Ionising Radiations Regulations 1985 we as teachers will have to manage our own work with radioactive substances in a more careful and professional manner than before. Perhaps the curriculum should reflect these changes. What should it include on radioactivity? I suggest three themes: (1) a description of the basic principles; (2) an appreciation of quantities and the scale of effects; and (3) an understanding, based on intelligent caution rather than fear, of the practical problems posed by living with and managing risk.

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EDITORIAL

Hiccups, hiatus and hernias

Bread and butter services

It seems to me far too soon since last I apologised for delay and apparent decline in the SSSERC publishing and advisory services. The collective conscience of Centre staff demands however that we say something about our current inability to turn round routine enquiries as efficiently as once we did or to produce this 'Bulletin' as often as we would like. We therefore apologise to Scottish EA readers and to our subscribers for the late appearance of this bulletin issue. We also apologise to those of you who have had to wait for replies to technical and other enquiries.

At the risk of upsetting many of our readers I have to be honest and say that to a large extent our current problems took root in the teachers' dispute. If most teachers no longer voluntarily take on work in support of national developments, but still expect to receive support materials, then it follows that others must take up the load. I do not wish to detail here the arguments against relying on part-time involvement by teachers and for more professional full-time support for development work. Our views are already on record. The majority of science and technology teachers know where our sympathies lie.

At present we are trying to provide support operations in a curricular no-man's land. We are being asked to do more and more but with the same staff and only notional increases in facilities and funding. Sounds familiar? If teachers can decide that quarts can no longer be expected from pint pots then so may we.

To the heavy workload from technical support for Standard Grade this year we have had to add major Health and Safety tasks. The results of our work on one such task are indicated in the "Safety Notes" and "Physics Notes" of this issue. The results of our efforts in support of Standard Grade will appear over the next year or so.

The professional and support staff make up the same small team of eight that carried the pre-dispute workload. Despite untold, unpaid, overtime there are not enough hours in the working year (and no, we do not have school holidays!) for us to cover everything now demanded of the Centre. The inevitable result is a decline, hopefully temporary, in the standard of our essential services.

Jam tomorrow?

Things will, I believe, get better. I am hopeful generally in the wider context of resources for science and technology education as well as more specifically for the medium and long term activities of SSSERC. In the wider field the lobbying has been going on for a while and is already producing the beginnings of results. As for the Centre, we too have been fighting our corner. There is now every prospect, within a year or two, of a wider ranging and much improved SSSERC service from a bigger staff team.

One additional post, long needed, would be another specialist qualified in biology. Currently the Director happens also to be the only staff member so qualified. Biology is covered part-time in between representing and running the Centre as well as editing the 'Bulletin' and other publications. Now you know why the 'Biology Notes' section gets shorter and appears less and less frequently.

The snag is that re-organisation effort is internalised effort with no immediately tangible product. Temporarily it actually worsens the service as seen from outside. So, meantime, add us to the list of all those other agencies - such as BT and BR - who plead for sympathy and patience. You have my word that in our case we really are "getting there" and that, barring our privatisation, we will actually arrive.

* * * * *

INTRODUCTION

Double jeopardy

Do you ever wish you had never started something? That 'Opinion' article on learning outcomes, published in Bulletin 156 and the follow up editorial in Bulletin 157 have haunted us like some ghost from 'Ruddigore'.

One less than tenuous connection here is - we have committed that most cardinal of sins - that we have upset the 'G&S' buffs. This is a powerful fraternity, a major socio-political force to be respected. Worse still, we upset them on not one but two counts. In the 'Editorial' in Bulletin 157 not only did we mis-quote, we also mis-attributed. The librettist, of course, was Gilbert - the other one wrote the music. Sorry! number one.

What Gilbert (not "and Sullivan") actually wrote for the libretto of "Pirates of Penzance" was "A startling paradox" and "a most ingenious paradox" but not, as we mis-quoted, "a veritable paradox". Sorry! number two.

It was Randal Henly of Mount Temple School Dublin who, quite rightly, ticked us off. Editor of "Science" the official journal of the Irish Science Teachers' Association and ex 'G & S' chorus 'girl', he claims the necessary authority on two counts.

The correspondence on both articles is now closed - please!

Saturday mornings

As promised in Bulletin 157, Saturday morning opening has begun again after the Summer (the what?). We opened on the 5th and 12th of September and will also open on the first two Saturdays of October, November and December. As always, the beginning of January will be a little hazy - watch this space for details.

Cost Index

We just missed the deadline for getting the May figure into Bulletin 157. The index, set at 100 in May 1974, stood at 379 in May of this year. The percentage increase for the six months from November 1986 to May 1987 was approximately 2.4%. The year on year figure for May '86 to May '87 was 3.9%. For the umpteenth time we have to stress that this index covers a basket of consumables only. It yields no information on trends in capital item prices nor does it reflect increased costs because novel equipment is required for new courses.

Surplus Offers

Conditions of Sale

Your attention is drawn to the 'Conditions of Sale' which are set out at the beginning of the "Equipment Offers" section of this bulletin issue. We have decided that we can no longer do as British Rail and go on referring folk to rules and conditions published in the dim and distant past (in our case in Bulletin 116).

We have recently noticed a marked increase in mis-directed payments and in enquiries related to orders and delivery. This we put down to new science teachers who never saw a Bulletin 116, as well as to old ones who did but have forgotten. Please look at and note our conditions and instructions for payment. They are designed more for your convenience and benefit than they are for ours.

No Comment

Signs from the Times Educational

Creativity - what, a cheek?

"A final note to record one of the more acute observations of the festival. Crichton Smith suggested (this is the old days surely?) that "in Scottish education anything creative is known as impertinence". [1]

Consultation -

a Diogenean definition

"...issued a document for consultation; which being translated means: "Here's what I'm going to do; you've got seven weeks in which you have no chance of stopping me" [2].

References

1. From a report on the 11th St.Magnus Festival in Orkney, Neil Munro, 'Jotter', Times Educational Supplement Scotland, 26th June 1987].

2. Alistair Fulton's Diary, TESS, 4th September 1987].

* *

Comment

Signs of the educational times

Shown to us recently by an Adviser was a cartoon. We cannot, out of courtesy, identify the adviser or - for fear of action over copyright - reproduce the cartoon. We can however describe its visual gist and give a cleaned up version of its caption.

Picture, if you will, a tonsured and begowned cleric seated before a beautiful, yet incomplete, page of illuminated manuscript. He is berating a brother but senior monk with the words:

> "Deadline, what deadline? Nobody told me anything about any ...... deadline!"

and

Seen as a graffito just before the A1 trunk road enters Berwickshire:

> "Keep Scotland Tidy! Leave all your rubbish in England".

* * * * *

CLEAPSE Guides

We have recently received the following new or revised publications from our sister organisation CLEAPSE School Science Service:

L40b "Kits for Biology & Biotechnology: Further Items". Kits for tissue culture, isolated leaf protoplasts and illustrations of genetic engineeering are reviewed and safety aspects discussed.

L76 "Ideas for Practical Open-Ended Investigations". A bank of 150 ideas for GCSE.

L77 "Handicapped Pupils and Practical Science". Adaptations which can be made to furniture, equipment and practices to help pupils with motor difficulties*.

L177 "Buggies & Turtles". The context is computer control and usage in secondary schools.

ELE "Electrical & Electronic Equipment: Commercial Repair and Maintenance". Gives the names and addresses of repair firms, prices etc. (Some of the information may not be relevant to Scottish schools). [Revised].

Copies of these guides may be borrowed for one month on application to the Director of SSSERC.

*Footnote: **L77** We are pleased to see the publication of this CLEAPSE Guide on handicapped pupils and practical science. We are currently compiling a wider list of references and contacts which we hope to publish in Bulletin 159. This will cover assistance for the visually impaired as well as those with motor difficulties.

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VELA Booklet

Adrian Watt, of Edinburgh Academy and the Scottish VELA Users' Group, has produced a small volume on "Demonstrations & Experiments using VELA". To date this has had a very limited print run. We have Adrian's permission to loan out an inspection copy to interested teachers and advisers. Contact our Development Officer, Ian Birrell.

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Ionising radiations

The element of risk

The risk of fatality in humans following a massive dose of radiation to the whole body can be precisely predicted [1]: the probability of death ranges from about 1 per cent within 6-8 weeks following a dose of 2 grays of x- or gamma irradiation to 99 per cent following a dose of 5 grays. What is far less certain is the risk from the delayed effects of radiation, and especially from very small doses. The National Radiological Protection Board (NRPB) have recently issued advice [2] based on evidence also recently published [3] which quantifies that risk. They consider "that effective dose equivalents up to 50 μSv per year, i.e. 1 per cent of the annual dose limit to members of the public, are insignificant as far as the individual is concerned. This level of individual dose rate corresponds to an annual risk of harm to the individual of about 1 chance in a million."

By comparison the annual dose from natural background radiation in the United Kingdom commonly lies in the range 1000 to 10000 μSv.

We have recently estimated by calculations the probable whole body doses resulting from typical practical sessions with school-type sources. These reveal the somewhat comforting news that likely doses are extremely small - up to around 0.1 μSv per experiment. These calculations will be published shortly and made available to schools in the new SSSERC document [4] described below.

From this exercise and the NRPB prognostications it looks as though the element of risk from carefully conducted schoolwork is insignificant and unquantifiably small.

We trust that this is reassuring.

Announcement of new regulations

In 1985 the Health and Safety Commission published a set of regulations [5] with which all work using ionising radiations must comply. These requirements should have been met by mid 1986.

We apologise for the delay in advising you in how to comply with the regulations, but the preparation of our advice has necessarily been very time consuming since many agencies have had to be consulted.

What should shortly be appearing in schools is a circular [6] from SED to replace Circular No. 689, which up to now has laid down the rules of conduct for work in schools with ionising radiations. The main appendix of this new circular is titled

"PROCEDURES FOR THE USE OF IONISING RADIATIONS IN EDUCATIONAL ESTABLISHMENTS"

Because of the Health and Safety at Work Act 1974 however responsibility for health and safety now rests primarily with the employers and, interestingly, but not primarily, with employees. SSSERC has therefore been engaged in drafting notes on behalf of Scottish EAs as employers; these notes provide detailed guidance on how to comply with the Ionising Radiations Regulations. They are called

"PROTECTION AGAINST IONISING RADIATION IN SCIENCE TEACHING

Explanatory notes on local rules for teaching establishments (SED Category C only)"

or the 'Explanatory Notes' for short. Category C refers to the SED classification based on level of work. There are three Categories, A, B and C, ranging from high to low level work. We think it unlikely that any school will seek approval for work in a Category higher than C.

There will thus be dual control: by the SED through their new Circular and associated Procedures, and by the employers, mainly we expect, through the SSSERC Explanatory Notes.

In addition, individual employees have a duty to take care of their own safety and that of others. The principle underpinning current health and safety legislation is self-enforcement; the onus is placed on employees to act in compliance with regulations and to cooperate with their employer to this purpose.

What are the changes?

In general

The present management of radioactive substances presumes that school sources are of a low enough activity that the risk of harm is insignificant. It may well be true that the risk is trivial in most instances, but the premise should not fudge the issues. How do we know what the risks are? How can we, with any integrity, say "tut-tut" whenever SSEB has a minor incident at Torness or Hunterston while we conduct practical work in an unquantifiable, and therefore ignorant, manner?

There is therefore to be a more rational control of radioactive substances. Where necessary, quantitative estimates of of the dose should be made. Thereby the risks can be assessed and managed.

In particular

Local Rules Every school must have a written statement of rules of conduct. These should be terse and pithy. A skeletal set of local rules has been prepared by SSSERC and will be sent to you.

The Explanatory Notes is your reference manual to which to turn for detailed advice.

Responsibilites Employers must set up a system of responsibilities and duties.

Radiation Protection Supervisor Each school must have one. The duties are those which are at present carried out by the principal teacher of physics - to manage the storage and use of radioactive substances.

Radiation Protection Adviser An appointee of the employer who is to be available for consultation to both the employer and employees. In most parts of Scotland the science adviser has this post.

Notification The Health and Safety Executive (HSE) must be notified of any site where radioactive substances are used. SED will normally notify HSE on your behalf.

Dose estimations You are required to estimate the dose received during any practical work. However for most types of work estimates have been done for you. They are summarised in the Explanatory Notes.

In our opinion CSYS Physics project work is the only instance where further calculations may have to be done and a record of estimations kept.

Open sources The keeping of thorium compounds is prohibited - they are usually fine, dusty compounds and it would be technically impossible to comply with the new contamination limits. Thoron generators must be disposed of; look to your EA for eventual direction on when and how to dispose.

The keeping of other open sources is also in general prohibited. Note there is one important exception, this being small quantities of uranyl nitrate.

Radioactive decay This should be studied using an open uranium source in the prescribed manner. The nuclide whose decay is monitored is protactinium-234.

Disposals Additional detail is given.

Leakage tests The Regulations try to ensure that there is very little risk of dispersal of radioactive material. So wherever practicable, sources should be of the sealed rather than open kind. But such a policy depends on the integrity of the sealed source. You will therefore have to carry out a simple check for leakage on certain sealed sources held - once every 26 months.

Storage The dose rate at the exterior of the store must not exceed a certain limit - the siting of your store may have to be reconsidered.

Contingency plan There should be a scheme of what to do and who to contact in the event of an incident.

Accounting You will have to take a regular stock check - once a year may be sufficient.

Records Records should be kept of acquisitions, disposals, accounting, logging of use, and leakage tests.

Units Any records must use SI units.

These are the main changes. They are an extension of present good practice and we believe that, on the whole, teachers will welcome them.

References

[1] Biological Effects of Radiation: J E Coggle: International Publications Service, Taylor & Francis Inc.: New York:1983: ISBN 0 8002 3075 2

[2] Small radiation doses to members of the public: ASP7 NRPB: Chilton: 1985: (HMSO): ISBN 0 85951 240 1

[3] Fleishman,A B: The significance of small doses of radiation to members of the public: NRPB-R175: Chilton: 1985: (HMSO): ISBN 0 85951 241 X

[4] Protection against ionising radiation in science teaching - Explanatory notes on local rules for teaching establishments (SED Category C only): SSSERC: 1987

[5] The Ionising Radiations Regulations 1985: HMSO: ISBN 0 11 057333 1

[6] Procedures for the use of ionising radiations in educational establishments: SED (to be published as an appendix to a new circular)

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Electrical Safety

Transmission line models

Your attention is drawn to the "Physics Notes" of this issue where certain safety features important in the design of such models are discussed. This matter has been the subject of a recent HSE circular to Scottish Regional and Islands Councils as Education Authorities.

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Bunsen flame profiles

Abstract

The temperature profiles of a bunsen burner flame are examined by the following methods, listed in ascending order of complexity and sophistication:

- variation in the colour of steel as it is heated to different temperatures.

- the voltage output from a type K thermocouple displayed either directly on a high impedance voltmeter, or via an amplifier circuit for a more direct temperature reading of 1 mV/°C.

- using suitable software, the thermocouple output voltage is logged against time through the analogue port of the BBC micro. The thermocouple is made to traverse a bunsen flame at varying levels, thereby building a series of temperature profiles.

- the displacement of the thermocouple during any traverse can be concurrently logged with temperature. With suitable software, displacement versus temperature graphs are produced. The use of a position transducer to measure displacement eliminates errors from uneven traverse speeds.

These experiments satisfy learning outcome '24' in Topic 5 'Fuels' of the proposed Standard Grade Chemistry course.

Introduction

Teachers have long told children that the hottest part of a bunsen flame is found at "the tip of the blue bit" and that there is "a cone of unburnt gas" below. The temperatures in a flame are then directly related to the 'completeness' of combustion.

Traditionally, proof of these 'facts' has been provided by using matches placed across the bunsen nozzle or metal objects placed in various parts of the flame. Children however, are not always totally convinced. Witness the usual methods of heating an object:- bunsen nozzle too close, air hole too wide or use of a yellow flame.

The following techniques aim to provide quantitative or convincing qualitative evidence for temperature variations, and therefore completeness of combustion, in a bunsen flame.

Wire or gauze profiles

If a single, stainless steel wire or wire gauze is placed horizontally in a bunsen flame (Fig.1), flame temperature may be estimated from the following colour/temperature chart. The gauze is preferable as a complete temperature cross-section is then obtained for any level.

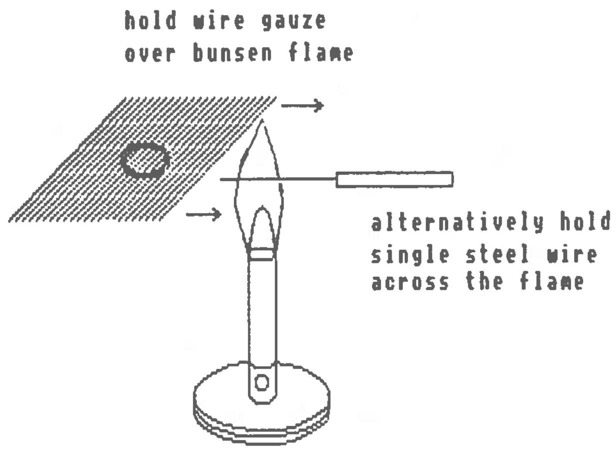


Fig.1.

temperature (°C)	colour
565	brown red
600	dark red
700-730	blood red
740-800	cherry red
825	bright cherry red
900-955	bright red
980	yellow red
1250	white

Table 1

This method has the twin merits of being both directly observational and closely related to industrial practice. The above table was abstracted from a fuller steel industry version giving hardening temperatures and colours for carbon steel.

Type K thermocouple

If two different metals or alloys are joined together, the electrical (contact) potential across the junction may show linear variation with temperature. Such a device is called a thermocouple. A type K thermocouple consists of nickel-chromium (Chromel) wire in a junction with nickel-aluminium (Alumel) wire. Our design (Fig.2) shows the thermocouple wires (0.5 mm) in a ceramic connector block attached to a metal lid from a glass jar. [1 m lengths of Chromel and Alumel wire are available from SSSERC, as Item No. 615, price £2. See the Surplus Equipment section of this Bulletin].

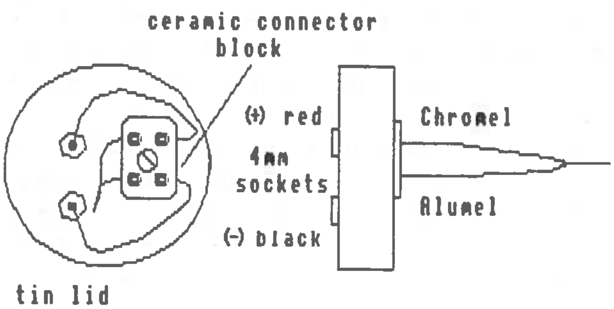


Fig.2. Thermocouple mount

Meter display - indirectly calibrated

For accurate measurements a thermocouple should have a 'cold' or reference junction which is held at a constant temperature (usually at 0°C). In this present application the main interest is in relative temperatures. An accurate reference junction is not strictly necessary. In effect our reference here is room temperature. The thermocouple is directly connected to a high impedance voltmeter or multimeter. Table 2 shows the approximate voltage outputs (mV) expected over a range of temperatures.

temperature (°C)	output (mV)
0	0
100	4
250	10
500	21
1000	41
1200	70

Table 2

Such a thermocouple and meter combination may thus be used with a calibration graph or table to investigate temperatures in various regions of a flame.

Our previous work with simple copper/nichrome thermocouples had shown that the size and physical nature of the junction including the quality of the contact between the dissimilar metals could affect the performance of the sensor. Trials on the type K nickel-chromium/nickel-aluminium device however revealed no significant differences in output between 2, 4 or 8 turns of wire in the junction or between junctions which were merely twisted hand-tight or were twisted with pliers. This is encouraging in that such devices can seemingly be reliably and easily made up without recourse to hammer welding or other additional procedures. Indeed there is no reason why students might not make up their own thermocouples from lengths of 0.5 mm diameter wire. We would recommend that they use 10 cm of each wire with 4 turns in the junction making them 'plier tight'. This gives a junction of adequate size and security.

Meter display - calibrated

Direct connection without intermediate signal conditioning is acceptable for qualitative use or for quantitative applications when interfaced to a computer where calibration can be software based (see below). It is more convenient however, especially for stand-alone use with a meter, if circuitry is provided which gives a direct and simple relation between thermocouple output and temperature. A design for such a circuit is given in the "Instrumentation Notes" of this bulletin (see page 13).

Our experiments at the bench showed that type K thermocouples, with junctions made in a variety of ways, all had a sensitivity at room temperature of about 40 $\mu V°C^{-1}$. A simple d.c. amplifier circuit with a gain of, say, 25 will provide an output of 1 $mV°C^{-1}$. Digital multimeters typically have a resolution of 100 μV. Such a circuit can thus provide a sensitive, direct reading thermometer suitable for a wider range of applications than that outlined here. It will also find uses in the new Standard Grade Biology and Physics courses. See "Instrumentation Notes" in this issue for the technical details.

Use with a microcomputer

The unamplified voltage output from a type K thermocouple provides an adequate signal for input to the on-board analogue to digital converter of Acorn BBC microcomputer models. This opens up a number of interesting further investigations on flame temperatures.

Simple flame traverse

With suitable data logging software it is possible to calibrate the voltage output from the thermocouple in degrees Celsius and a graph of temperature against time displayed.

The Philip Harris 'Datadisc' data-logging software provides such facilities and was used to obtain the graphs displayed as figures 4, 5, 6 and 8. The thermocouple is connected to channel 1 of the analogue port of a BBC Model B, B+ or Master, using the SSSERC diy analogue port connector (Bulletin 140) or Philip Harris 'Datadisc' 4-channel connecting box (Fig.3). [Cat. No. A29015/4, £54.75 incl. software].

The voltage output from the thermocouple is essentially linear over the range from room temperature (ca. 20°C) to that of the hottest bunsen flame (ca. 1000°C). Note however that the displayed temperatures are approximations, because a constant reference junction is not used.

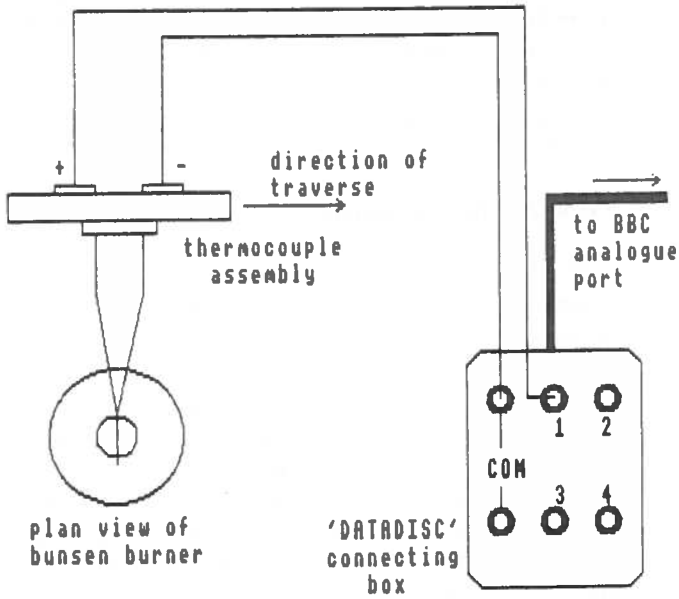


Fig.3.

The calibration steps involve keying in two reference temperatures at the extremes of the range to be measured whilst the thermocouple and is held at those temperatures and its output voltage input to the analogue port. If desired the two calibration temperatures can be checked with a proprietary type K thermocouple and signal conditioning box as available from Jenco Electronics (Cat. No. TVC-1K, £49). Channel 1 of the analogue port is calibrated to convert voltages into °C, from room temperature to the hottest flame temperature.

Once the thermocouple has been calibrated by software means it can be manually traversed steadily through the flame. A graph can then be displayed where the Y axis is temperature and the X axis is time but where time is roughly related to position in the flame.

The real-time display of temperature vs. time may show a very small apparent variation in plotted temperature vs time. Do not panic. Software of the Datadisc type will look for the maximum and minimum voltages and will automatically rescale. It will display a more pleasing graph once the data has been so processed. Such a graph is shown as figure 4.

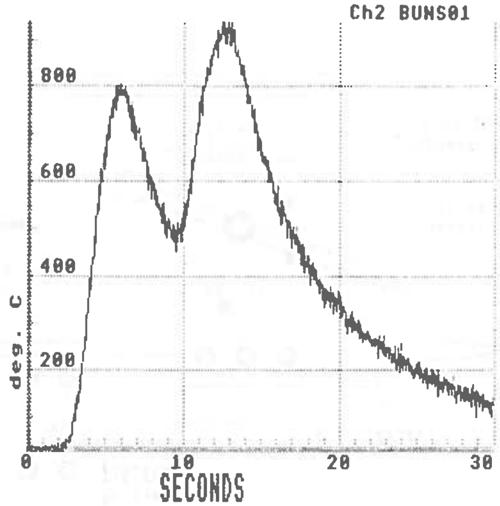


Fig. 4.

Smoothing data

A few school level data-logging packages allow some mathematical operations on raw data. The Harris Datadisc package is one which provides the facility to smooth raw data to remove some of the effects of noise and general signal degradation. The smoothed data can then be plotted on screen. Figure 5 shows a graph using the same raw data as that for figure 4 but here the data has been smoothed using one of the mathematical utilities on the 'Display Options' menu of Datadisc.

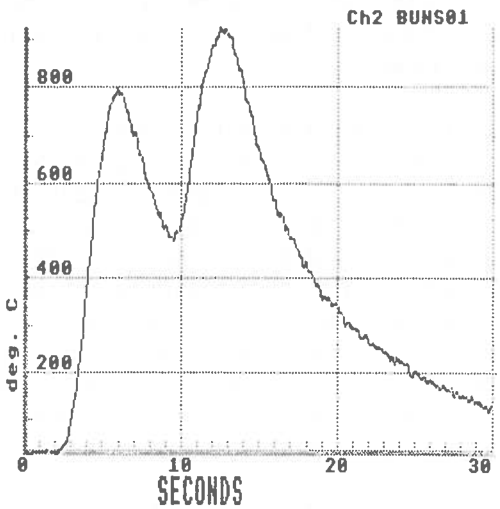


Fig.5.

Multiple recordings

If the software allows superimposition of graphs, traverses at different heights in the flame can be displayed concurrently. With Datadisc, for example, if the recording conditions are not changed the software automatically puts the first recording on to another channel before the next traverse is attempted. This can be done for up to four bunsen traverses each at a different height all displayed on the same graph (temperature vs. time, Fig.6). Note that peaks may occur at different positions on the graph unless flame traverse times are consistent.

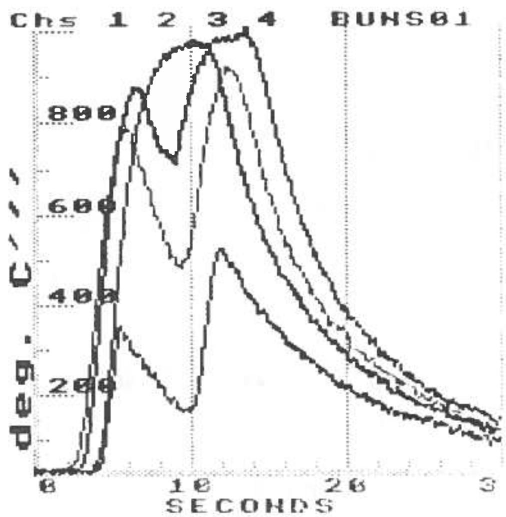


Fig.6

Analysis of graphs

In figure 6 it can be readily observed that the lower the level of traverse across a blue flame, the greater the extent of dip in temperature across the flame centre. There is a greater volume of unburnt gas there and combustion is less complete. The two outer temperature peaks decrease as the traverse level approaches the bunsen nozzle. Observe that the right hand peak generally indicates a higher temperature. This is because the thermocouple does not cool to the reference temperature as it passes through the unburnt cone of gas. Note also how the two peaks merge as the tip of the blue flame is approached and combustion nears completion.

So far we have done little that could not have been carried out, with less fuss and expense, on other transient recorders such as a chart recorder, VELA or a storage CRO.

Temperature against displacement

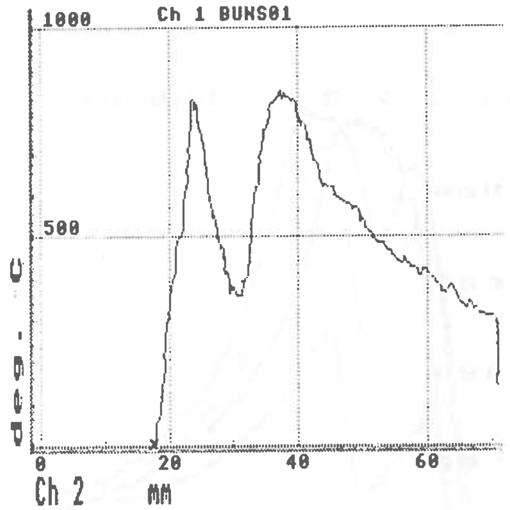


Fig.7

If a position transducer is available e.g. Philip Harris (Cat. No. C67770/2, £48.75), more consistent results are possible. Temperature and displacement vs. time are logged. (Figure 7). An 'X-Y' plot of temperature vs. displacement can then be produced (Figure 8.). This eliminates the distortion of graphs (see figures 4 and 5) because of manual flame traverses of uneven speed.

'Grapher' software for use with the Unilab interface also provides such an X-Y plot facility but in 'real time'. Additional calibration steps will be needed because the relation between voltage output from the position sensor and the actual limits of the traverse has to be established. This is in addition to the relation between temperature and thermocouple output.

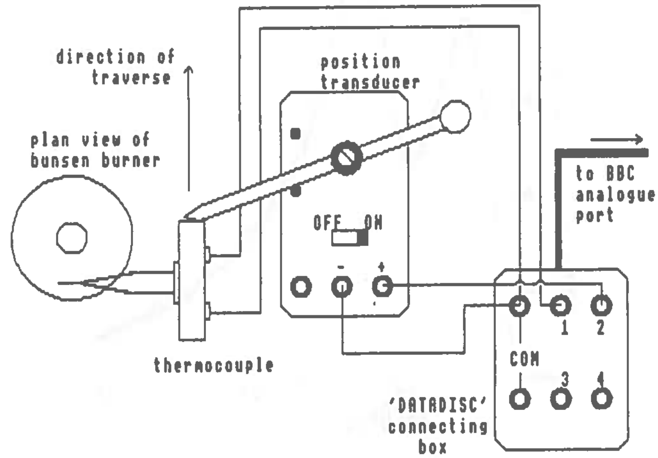


Fig.8

Again a simple two set-points calibration is usually all that is required for displacement units (e.g. mm). The computer will need to 'know' the voltage output from the position sensor at each end of the traverse across the flame.

Further work

Using the outlined techniques, the field is open for investigational work, possibly even at Standard Grade Credit level. Such work could include examination of a yellow bunsen flame, varying the air hole position, altering the nozzle shape, candle flames etc.

There must also be a sixth year project lurking here! The thermocouples are not particularly expensive and it would not be impracticable to arrange for a triple array to pass concurrently through a flame. Each thermocouple would be set at a different height. All three temperatures could be 'X-Y' plotted against displacement for immediate comparison on the same graph. For the ultimate how about a three dimensional model - an X-Y-Z plot of flame temperature vs. horizontal displacement vs vertical displacement?

* * * * *

An amplifier for a type K thermocouple

The type K thermocouple described in Chemistry Notes has a sensitivity of about 40 μV/°C. By applying the signal to an amplifier with a gain of 25 you can boost the sensitivity to 1 mV/°C (Fig.1). If the amplified output is measured by a digital multimeter on 2 V setting then, forgetting about the decimal point, each digit corresponds roughly to one degree celsius.

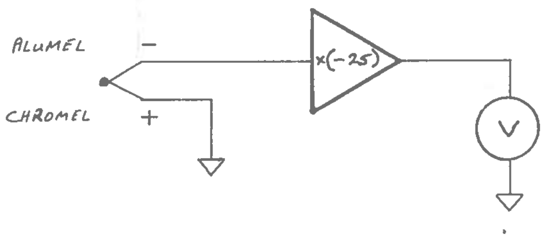


Fig.1 - Schematic diagram - thermocouple linked to amplifier

An inverting amplifier which does this task is shown below (Fig.2). A non-inverting amplifier might be preferable; but the type shown fits in with the amplifier in Unit 4 of Standard Grade Physics.

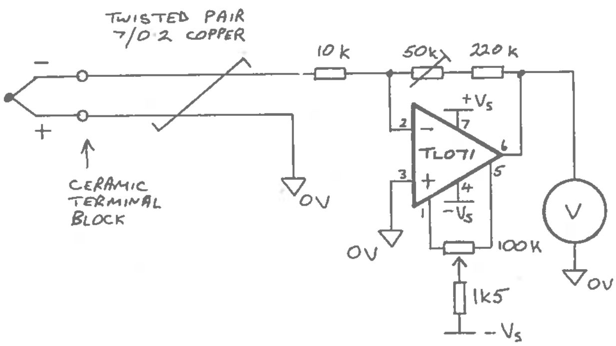


Fig.2 - Circuit diagram - thermocouple linked to amplifier

The alumel wire joins to a copper conductor, which connects via a 10k resistor to the inverting input. The chromel wire joins a copper conductor, which connects to the 0 V rail of the circuit. The thermocouple is thereby referenced to the temperature of the surroundings; the output will be offset by that amount. If the thermocouple is used to measure very high temperatures then any offset will be no more than a few per cent of the reading. With this arrangement the sense of the output is positive whenever the thermojunction probe is warmer than the surroundings.

The amplifier should be powered by a dual rail regulated supply, anywhere between + and - 4 V to 15 V. A pair of 9 V batteries in series is suitable.

Once the circuit has been constructed the setting up procedure, after applying power and connecting a digital multimeter on 2 V d.c. setting to the output, is:

(1) keep the thermojunction probe at room temperature; adjust the 100k offset null pot till the the reading on the voltmeter is 0.000 V (it may be, with your meter, that the zeros are blanked out).

(2) place the thermojunction in a hot bath, which might be boiling water or molten aluminium at its freezing point; adjust the 50k gain pot till the reading corresponds to the temperature of the bath minus room temperature.

The device should now be ready for use.

The prototype we built performs quite well; after correcting for room temperature any disparity between its output and the output from a commercial type K instrument was found to be within 10°C up to 1000°C.

Components

Item	Supplier	Cat.no.	price
type K thermocouple wire, one metre per pair	SSSERC	615	2.00
2-way ceramic terminal block (5)	RS	425-156	3.08
TL071 op amp	RS	304-245	0.61
50K preset pot	RS	186-766	0.43
100K preset pot	RS	186-772	0.43

* * * * *

Radioactive decay experiments using protactinium-234

Replacement of thoron generator

In secondary schools the thoron generator has been the standard source used for studying radioactive decay. The use of this generator is now to be prohibited (see Safety Notes). This is because thorium compounds, in the solid state, are typically very fine powders; there is therefore a significant risk that the dust may leak from the bottle. It may then either contaminate surfaces, or be inhaled. The new HSE Regulations set very low contamination limits for thorium compounds. It would be technically impossible for schools to continue to work with these compounds and comply with the Regulations.

The protactinium generator which is described in the Explanatory Notes (see "Safety Notes" pp 5 - 7 in this issue) should be used as a substitute for studying radioactive decay.

Physical description

The radionuclide we look to as a substitute is protactinium-234, which has a half life of about 70 s. This is a product of the uranium-238 decay series, part of which is shown below:

U-238 - Th-234 - Pa-234 - U-234 - Th-230

The method of isolating Pa-234 uses a solution of a U-238 salt, uranyl nitrate, in concentrated hydrochloric acid, to which has been added a less dense, water-immiscible, organic liquid such as pentyl ethanoate. Protactinium forms into a complex acid which is soluble in this organic liquid; some uranium may also dissolve; but thorium does not. When the liquids are shaken together the organic solvent selectively extracts or milks the protactinium. On being allowed to resettle, a physical separation into two layers occurs, protactinium being in the upper layer (Fig.1).

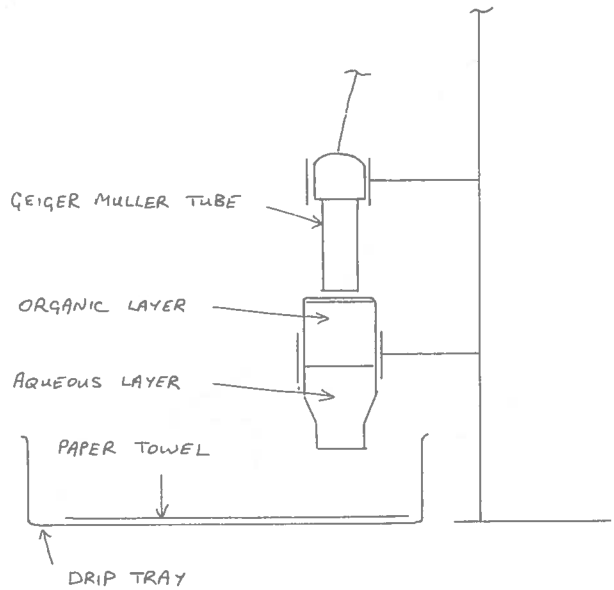


Fig.1 - Monitoring the decay of Pa-234

Several factors combine to ensure that this nuclide exhibits unobscurely its own half life:

(1) thorium nuclides remain in the lower aqueous layer - radiation from Th-234, which is beta, has a peak energy of 0.19 MeV and will scarcely penetrate the flask; radiation from Th-230 is alpha and will not be emitted from the flask either;

(2) both uranium nuclides U-238 and U-234 concentrate mainly in the aqueous layer; they are both alpha emitters;

(3) protactinium-234 is a beta emitter with an energy spectrum going up to 2.3 MeV, which is sufficiently high for the radiation to penetrate both the walls of the flask and some of the liquid in which the source is sited;

(4) the immediate parent of further protactinium nuclides is sited in the bottom layer; radiation from freshly born protactinium nuclides cannot penetrate through from the bottom layer to the counter.

The protactinium decay is monitored by a Geiger tube placed close to the top of the containing flask.

These liquids can be stored, mixed together, in a sealed flask for a period of many years provided that the flask is made of a chemically inert material such as PTFE or its substitute PFA. Apart from during its preparation and disposal there is very little likelihood of contamination. The protactinium generator can therefore be regarded as being effectively a sealed source.

Acquisition or preparation

To avoid teachers having to work with an open source we suggest that these generators might be obtained from commercial suppliers, or prepared in local science centres.

Should however you want to prepare your own generator you should first find out from your Radiation Protection Adviser whether your employers will allow you to do this. If they do then you should follow the instructions which we give in the Explanatory Notes. Making your own generator is technically simple, but requires care.

Experimental method

The Explanatory Notes should be consulted for details of storage, carrying, handling and work. It will suffice to say here that any work must be conducted over a prepared drip tray.

Decide how you are going to mount the protactinium generator after it has been shaken and inverted. We found that a second, large flat-bottomed flask makes a suitable stand - it takes less time placing the generator in this than in a clamp-stand. Set up a Geiger tube facing downwards at the appropriate height.

Once ready to begin, hold the generator firmly in one hand and shake gently, inverting several times, for a period of about 15 seconds. Then mount the generator inverted, position the Geiger tube immediately over the base and start recording the count over 10 s periods. Do all this smartly.

If the scaler has an automatic reset then use it. If this facility does not exist then the sequence is:

0-10 s	count
10-20 s	record reading and reset
20-30 s	count
30-40 s	record reading and reset
etc.	

Continue for about 6-8 minutes, by which time the count rate will be close to background.

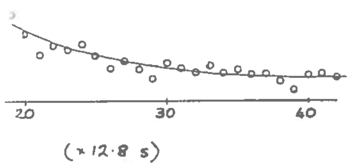
You will now have to determine what the background count is. This should be measured with the generator still sited below the Geiger tube - background in this experiment has a contribution from other nuclides in the generator. Therefore nothing should be moved between recording the decay and measuring background. Wait till about 10 minutes has elapsed since shaking the generator. By this time the activity from Pa-234 in the top layer will be about 0.2% of its original level. Then measure the count over the next 100 s to obtain background. Or instead of this, you could monitor the count rate continually after shaking till the rate levels off, say after 10 to 12 minutes. Typical values are:

background alone	= 3 counts $(10\ s)^{-1}$
background plus quiescent count from generator	= 10 counts $(10\ s)^{-1}$

Obviously the decay curve is offset by the second value of 10 counts $(10\ s)^{-1}$.

A graph of count rate versus time is shown in Figure 2. The recording instrument was the S-Range Digicounter P67410/8 from Harris, which has an automatic reset; it counts for 10 s, holds for 2.8 s, then resets. The time axis is therefore in divisions of 12.8 s. The graph has not been corrected for background; it can be seen that it tends towards a count of 10 $(10\ s)^{-1}$.

The procedure can be repeated indefinitely as protactinium-234 is in secular equilibrium with the parent of the decay series, uranium-238.



curve of Pa-234

ng

ld be automated using a data
Details on this particular
d in "Experiment with VELA",
d from DATA (Scientific).
ation include using a
terface such as the Unilab
e called Teller (reviewed in

If your scaler does not have the facility to output electrical pulses then you may like to try this tip from Adrian Watt, who teaches at The Edinburgh Academy. Adrian suggests taping a small microphone to the loudspeaker or (we suggest) clicking mechanism of the counter and taking the microphone signal to the Pulse Input of VELA.

Growth of a radioactive product

Further investigative work which you might like to do could be to study the growth of fresh protactinium-234 in the aqueous layer immediately after milking off this nuclide to the organic layer.

The half life of protactinium-234 is very much shorter than that of its parent, thorium-234. After shaking and separating the liquid into two layers the growth of protactinium-234 in the aqueous layer should therefore rise exponentially to its maximum value, when equilibrium is attained.

It should be possible to monitor this growth to equilibrium in the aqueous layer by positioning the counter beside the base of the upright flask immediately after shaking. As explained earlier, protactinium-234 is the principal contributor of radiation from the flask. After a period of 8 minutes, or 7 half-lives, the protactinium nuclide should have returned to within 99% of its equilibrium concentration in the aqueous layer.

*   *

H.T. Transmission lines

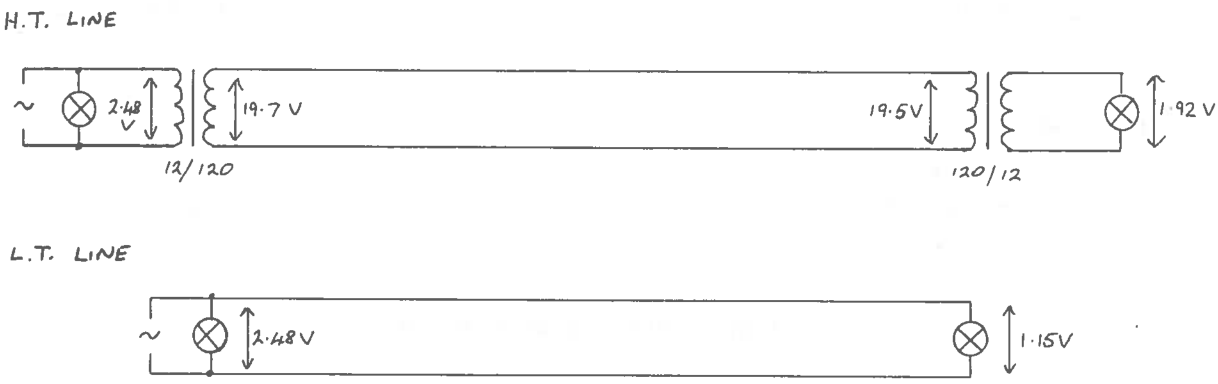


Fig.1 - 20 V transmission line

We have for some time been concerned that many teachers demonstrate the working of the National Grid at voltages which are potentially lethal. This seems an unnecessary risk when the electrical principle can be adequately shown at voltages low enough to be harmless. The Health and Safety Executive are also concerned. In a recent circular to Directors of Education they instruct that such demonstrations with uninsulated conductors may continue provided that the voltage does not exceed 50 volts a.c. r.m.s.

This restatement might sound repetitive; but it follows good pedagogical practice - "What I tell you three times is true!" There are safe ways and risky ways of doing experiments. Always try to cover your bum.

The limiting voltage

What are the limits of safety? Usually the risk comes from the magnitude of shock current - but because of the difficulty of accurately assessing the magnitude of a current which has caused a fatality, it is voltage, which is more readily assessable, which is used in safety limits. Fordham Cooper [1], the former HM Electrical Inspector of Factories, gives the following threshold shock voltages at 50 Hz a.c. The voltage values are r.m.s.

minimum threshold of severe pain	20
minimum threshold hold on volts	20 to 25
minimum threshold of death	40 to 50

In statutory codes the limit set is thus usually 50 V a.c. r.m.s. at 50 Hz.

In exceptional circumstances however, fatalities have occurred at voltages as low as 25 V a.c. r.m.s. We therefore advise that, whenever possible, pupils under 16 should not undertake practical work with uninsulated electrical conductors at voltages in excess of 25 V a.c. r.m.s. at 50 Hz.

If a teacher uses an H.T. transmission line at a voltage much in excess of 25 V a.c. r.m.s., that is between 25 V and the upper limit of 50 V, then we suggest that this should be by demonstration only.

We therefore offer you two designs: (1) one for pupils to use, where the H.T. voltage is well below 25 V (Fig.1); and (2) one for demonstration only, at 50 V (Fig.2).

wire:	length 1 m, type constantan 28 s.w.g., Griffin ECW-280-210H
lamps:	2.5 V, 0.2 A, MES
transformers:	
20 V line	20 VA, 240 V to 12 V, RS 207-144
50 V line	20 VA, 240 V to 9 V, RS 207-510

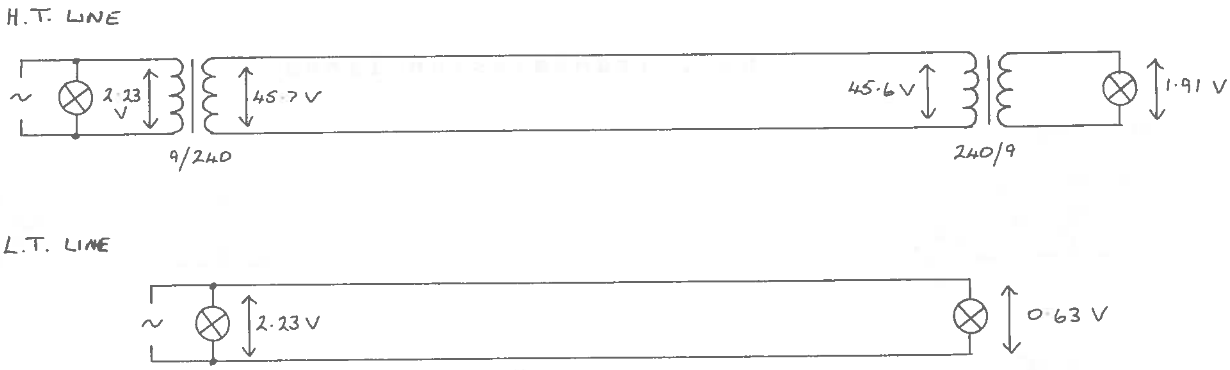


Fig.2 - 50 V transmission line

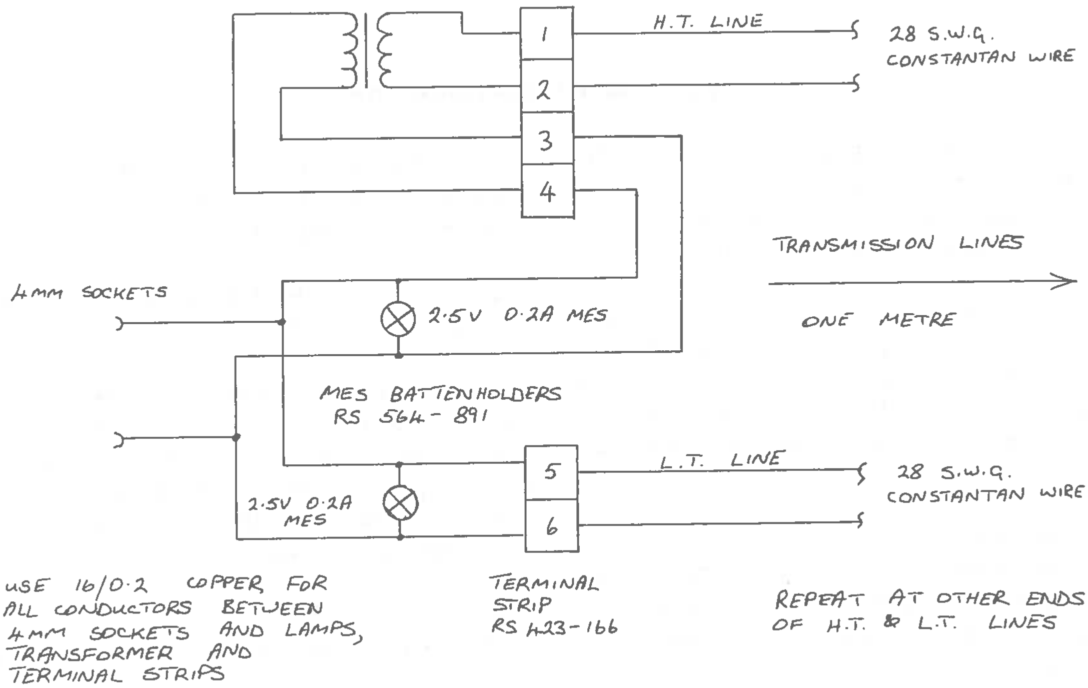


Fig.3 - Electrical connections at input end

The conductors in the transmission lines use resistance wire so as to produce a significant power loss in the L.T. line. The type is 28 s.w.g. constantan wire. As this does not solder well we recommend using terminal strips at the ends of the transmission lines. These should be mounted one metre apart on a baseboard. The other components should be interconnected using 16/0.2 insulated copper wire, with solder joints (Fig.3).

The 20 V H.T. line suffers from an appreciable power loss, chiefly in the transformers, but we think it shows the electrical principle adequately. If any reader can devise a scheme which is noticeably better we would be pleased to hear of it.

Reference

[1] Electrical Safety Engineering: W.Fordham Cooper: Butterworths: London: 1978: ISBN 0 408 00289 1

Introduction

A ring main model should show that if appliances are wired in parallel there can be an appreciable voltage drop across cables which transmit power from appliance to appliance. When the ring is made any voltage drop in cables becomes insignificant.

The models below are developments from the one published way back in Bulletin 33. In that original one, nichrome wire was used to conduct current from appliance to appliance - these new models use copper conductors.

In the first model we have lamps to represent appliances. "Hey!" I hear you say. "Since when were domestic lighting circuits wired as a ring?"

"OK! It's a poor model," I reply. "Then try Model number 2; it has heating elements instead of lamps."

"That's more like it," you say, "but why persist with Model number 1?"

"Because Model 1 illustrates the electrical principle beautifully. With Model 2 we found it hard to standardise the heating elements - they all glow differently. And they have great inertia at switching. In any case, with any model at all, you must expect it to work so far, and no more. In using models you always have to allow for those features they misrepresent."

So there you have it. We offer two models - they are both good buys; the choice is yours.

Model 1 - with lamps

This has seven MES lamps mounted in battenholders round three sides of a 50 cm square baseboard (Fig.1). The conductors are 10/0.1 copper wire - we think it important that copper is used. The lamps are rated 1.25 V, 0.25 A. For best results the supply voltage should be around 1.25 to 1.3 V. Under these conditions, if the switch is open there will be a gradation in brightness from normal to very dim. But if the switch is closed, thus completing the ring, the lamps will all be uniform.

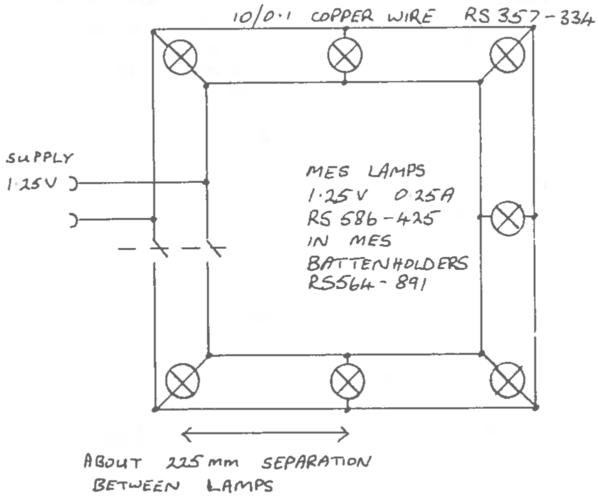


Fig.1 - Model with lamps

Model 2 - with heating elements

This has six home-wound heating coils mounted about 25 cm apart on a baseboard measuring 60 cm x 30 cm (Fig.2). Each coil draws just over 2 A at 8 V. Therefore the total current required from the supply is about 13 to 14 A, which standard L.T. supplies are unable to meet. This may however be provided by using a large battery, or by connecting two continuously variable d.c. supplies in parallel. If using the second method the current from each supply should be monitored by ammeters; if the readings differ the voltage outputs should be adjusted till the difference disappears. Both supplies should be switched on and off simultaneously. Do not attempt to connect a.c. outputs in parallel - you run the risk of coupling them out of phase. Suitable supplies with continuously variable d.c. outputs rated to 8 A include Model EJ0032 from Irwin and Model 022.106 from Unilab.

The heating elements are made by winding 14 turns from a 32 cm length of 28 s.w.g. nickel-chromium wire, such as ECW-440-210T from Griffin. A former should be used since it is important that the turns sit snuggly together, otherwise they may glow non-uniformly, or not at all. The turns should be wound tightly and neatly round the former such that adjacent turns lie touching one another. Take care that the turns do not overlap - overlapping wires tend to short-circuit, overheat and fuse.

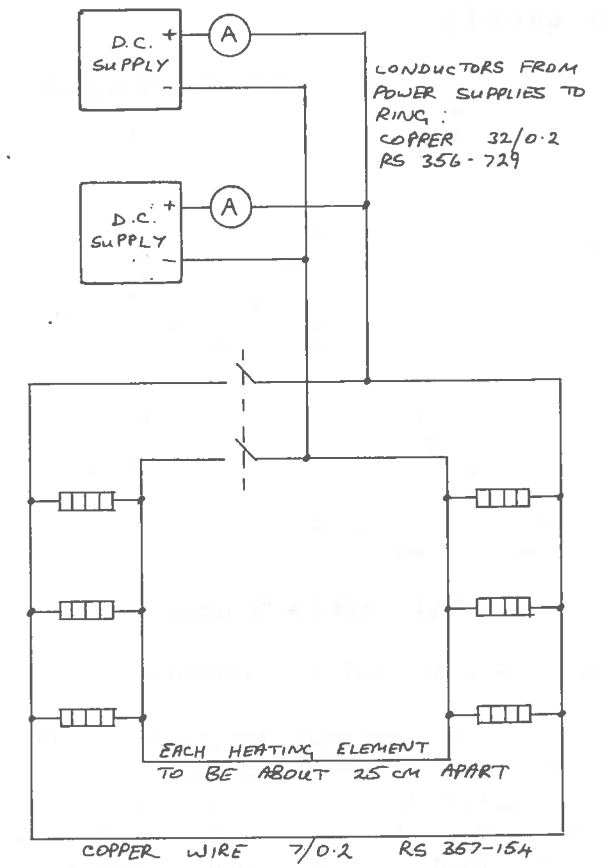


Fig.2 - Model with heating elements

A former can be fashioned by cutting off lengths from the ceramic former of an old fire element. Suitable dimensions are: length 17 mm, diameter 6 mm. Once the 14 turns of wire are wound tightly round the former the length of the coil should be about 7 mm and the diameter, 7 mm also. One free end of wire should be taken through the centre hole of the former (Fig.3). The wire ends should then be doubled back by about 5 mm and fastened to a ceramic terminal block (RS 425-156). This should be mounted on an L-shaped bracket, which might be cut from sheet aluminium, each arm of which is 30 mm long. The wire is sufficiently stiff to be able to support the weight of the coil and former, which therefore stands in air.

Copper is again used for the conductors between heating elements - this time it should be 7/0.2 wire. But current should be fed from the power supply to the ring circuit through thicker gauge, such as 32/0.2.

The elements should be uniformly spaced around the baseboard so that there is a 25 cm length of copper conductor running from one to another.

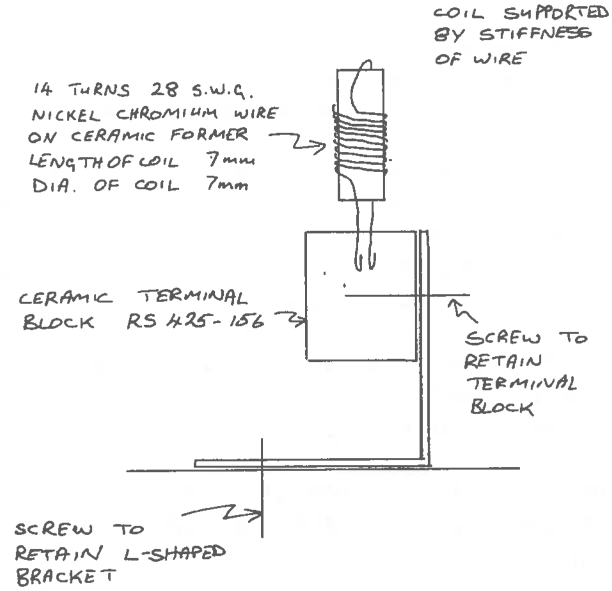


Fig.3 - Heating element

Because this is a model the double pole, single throw, switching action should be obvious. The switch should be an old fashioned knife type, such as ECK-720-050K from Griffin. Such open switches are allowable at the low voltages employed here. It may however be more convincing to a pupil if the switching action were done by inserting a pair of jumper leads.

For best results the supply or supplies should be adjusted to provide a current of 13.4 A when the switch is open and the elements are in parallel. If this condition is met the following electrical features should prevail:

switch open	supply current	= 13.4 A
	p.d. across 1st element	= 8.5 V
	p.d. across 6th element	= 6.8 V
switch closed	supply current	= 14.5 A
	p.d. across 1st element	= 8.2 V
	p.d. across 4th element	= 7.8 V

If two L.T. supplies are used in parallel then the nominal voltage shown on the controls would be around 11 to 12 V.

Under these electrical conditions, if the switch is open there will be a gradation from the first to sixth element from full bright red to dark red - the uniformity of the gradation being dependent on the care taken in manufacturing the elements. If the switch is closed any gradation in brightness between first and third, and between sixth and fourth will be slight, and probably random.

There is one obvious hazard with this demonstration - getting your fingers burnt. Since the hazard is so obvious and the voltages well below our 25 V limit, physical guarding of the elements is unnecessary.

*   *   *

Jupiter

Those of our readers who venture out at night and whose eyes are not so sodden with light at 589 nanometres that they do sometimes look upwards must have noticed that glorious sight in the night sky - the planet Jupiter, which this autumn shines brighter than any other heavenly body bar the moon. What makes it particularly suitable, now, for viewing is the fact that it is much brighter than normal, brighter indeed than any time since 1975. This is partly because it has reached this year the perigee of its 12 year orbit, and partly because this October it is in opposition to the sun. At midnight from Scotland it stands in the south about 40° above the horizon.

The four major moons of Jupiter can be easily seen through binoculars. And if you observe on successive nights you will find that the relative positions of these moons changes significantly (Fig.1).

The innermost moon Io buzzes round its orbit in 1.8 days. The change in its position may be discerned within a viewing period of a few hours. Of the other three, Europa has a period of 3.6 days, Ganymede 7.2 days, and Callisto, 16.8 days.

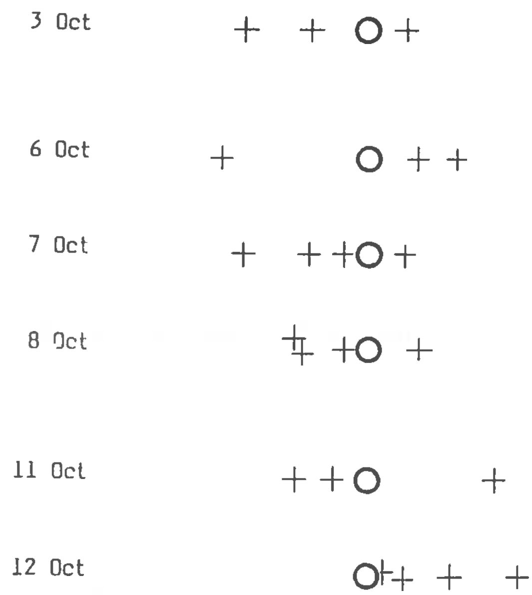


Fig.1 - Moons of Jupiter on successive nights

The moons can be seen with most types of binoculars, including the popular 8 x 30. Such a marking tells us that the magnification is 8 times and the diameter of the objective lens is 30 mm. However for astronomical viewing a larger diameter of objective lens such as 50 mm is better since it lets more light in. So 10 x 50 would be very suitable; and the greater magnification improves the detail that can be resolved. One drawback of increasing the magnification is that the field of view reduces and the objects get harder to find.

The main problem with using binoculars for astronomical viewing is keeping them steady. Some kind of support about head height is required to rest the binoculars on. A wooden post, say 2 x 2, standing at the requisite height makes a suitable stand.

The present position and brilliance of Jupiter provide a good opportunity to start off pupils viewing the night sky.

*   *   *   *   *

Conditions of sale

All we usually say here is that such offers are generally subject to the conditions laid down in Bulletin 116. However, as indicated in the "Introduction" to this issue, a full re-statement of those conditions is overdue. We had tended to forget that Bulletin 116 was published in November 1979 when a significant number of todays young science teachers were at school as pupils. As they say, time flies when you're having fun.

Please keep a copy for reference

1. Bona-fides

The service is underpinned financially by Scottish Regional and Islands Councils as Education Authorities and by subscribing independent schools. Goods and components are therefore offered on the general understanding that they are for bona-fide educational use within a Scottish school, college or resource centre and not for the personal use of staff or third parties. Certain goods may only be sold against official orders in order that the customer institution shall have a record of receipt.

2. Prices

These are quoted net, exclusive of VAT. This is because most transactions will be Category D - transactions between exempted bodies - and are thus outside the scope of VAT. This does not apply to orders from subscribing private or fee-paying schools. They will be liable to VAT at the standard rate.

3. Carriage or postage charges

These are not included in prices. We will post or freight out light items of equipment, materials and components if you request this and give us delivery details. In that case postage charges will be added to the overall bill. We can also arrange delivery by carrier or even by the bus parcel services to some areas. Again any consequent charges will be passed on at cost. We are equally happy to reserve and retain items here at the Centre until you can arrange for them to be collected, either personally or by some nominee who happens to be coming to Edinburgh.

4. Payment

This may be by cash, or by crossed cheque etc. made out to "SSSERC", against a SSSERC issued receipt; or by credit. Normally we will not accept credit sales for orders totalling less than £5. This is because of disproportionate administration costs.

For credit sales, an Advice Note will be issued with the goods. This effectively doubles as a delivery note and will detail the items, their prices and your official order number if available. The Advice Note must be checked against the goods and then passed on to the school administrators. The issue of that note will, in due course, automatically trigger the production of an Invoice (usually at the end of each calendar month). That invoice will only quote the SSSERC advice note number. It will not necessarily detail every item nor name the person in the school who bought it. If the advice note has not been put into the administrators' hands there may be trouble and inconvenience at both ends of the system.

If for some reason you wish to pay a debt after the issue of an advice note but before the arrival of an invoice, you must do so in plenty of time to allow us to prevent the preparation of that invoice. Such payments therefore should come here to the Centre. Once an invoice has been prepared it enters the great Lothian financial computing mill and we lose direct control over the process. Direct payment to SSSERC after the issue of an invoice wastes everyone's time. All we can do is pass on your payment to the Lothian system.

Once an invoice has been received payment should therefore be made against it to the Regional Collection Office of Lothian Regional Council (our host authority) and not to SSSERC. Detailed instructions for payment are printed on the invoice and should be followed closely if needless telephone calls and correspondence are to be avoided.

5. Health & Safety and other liabilities

As a supplier we have certain duties laid upon us by the Health and Safety etc. at Work Act (HSAWA) [Part 1, Section 6]. Because of the nature of many of the goods that we sell, it is not always "reasonably practicable" for us to take direct responsibility for the "Safety in use" of some items. Many of the things which we supply are components, some passive and some active such as motors or fans. A few items are sold as sources of such components or for spares. Whilst we can take direct responsibility for the inherent safety of the component itself and give information and guidance, the actual final use to which many items may be put is outwith our control. The responsibility for safe installation and usage then devolves upon the purchaser under other provisions of the Act.

The above statement is not intended as a disclaimer. We cannot avoid our responsibilities and duties under the HSAWA or those involving public liability. We wish only to make it clear that there is a point at which our respons -ibilities end and those of a purchaser begin.

* *

Ballot Items

Items 600 to 611 inclusive are new stock. All are **subject to our ballot procedures.** Entries should preferably be submitted on a postcard and with an indicated order of priority. Delivery on successful bids for items 607 to 610 inclusive will require submission of an official order following notification of allotment.

Item 600	Ilford HP5, 35 mm, B/W film, 200' roll in can	£6.50
Item 601	Safelight, Kodak filter 2 (deep red) suitable for indirect darkroom lighting	£5
Item 602	Ilfospeed bromide print paper Grade 2, 12 x 16", box of 50 sheets.	£6
Item 603	As above but 16 x 20"	£6
Item 604	As above but Grade 3, 16 x 20"	£6
Item 605	Kodabrome print paper, N3,IIRC, (resin coated), 12 x 16", box of 50 sheets.	£6
Item 606	As 605 but F1 grade.	£6
Item 607	Camera, Pentax SLR, 35 mm,with 55 mm, F1.8 standard lens (screw fitting Pentax thread) and case.	£45
Item 608	Camera lens, 300 mm, F6.3 by 'Takumar' (fits Item 607), with case.	£30
Item 609	Camera lens, 300 mm, F4, by 'Takumar', multi-coated type, with case (again Pentax thread).	£30
Item 610	Camera, Voigtlander 'Vito' CL, 35 mm, F2.8, 55 mm lens, (not SLR), with case.	£20
Item 611	Magnifier, x8, folding pocket type with quality metal mount housing a 20 mm diam. aplanatic lens.	£3

End of ballot section.

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Non-ballot stock items

Please note that items are not necessarily arranged according to the item number. They may be grouped because of similarity of application or for other reasons. Often the item number serves only for stock identification by us in making up orders.

Motors, encoders and fans

Note that items 373, 417, 589 and 594 (next page) are all small, precision d.c. motors. They are of ironless rotor and permanent magnet construction. They are amazingly precise and efficient and may be used in applications calling for precision movement, low power or low electrical noise or very high speeds.

Item 214 Motor, 12 V, d.c., by Smiths ex-car industry. Dimens. case 4" X 3" dia. with 1.25" shaft, 0.25" dia. £2.50

Item 215 As above but double shafted with output shaft at either end. £2.50

Item 344 Fan, 12 or 6 V d.c., quiet running, with mounting bracket. Ex car heater. Dimens. fan 180 mm diameter, bracket 200 mm. Needs addition of home-built guard for safe use. £4.00

Item 351 'Model' motor, 'Scalextric' type 3 V d.c., 300 mA off load.Open construction, worm gear output. 30p

Item 373 Precision motor, 12 V d.c.,3.2 mA no load current. Motor will operate off a very low supply voltage (< 1 V) and rotate when drawing as little as 1 mA. Ideal for small scale solar power and similar low power applications. £4.50

Item 378 Encoder disk, 15 slots precision made, 30mm dia. with 4.5mm shaft dia. 50p.

Item 395 Model maker's motor, 3 V, d.c. no load speed & current: 6250 rpm, 350 mA. Stall torque 10g cm . Dimens. 35 mm long and 30 mm dia. with 15 mm shaft 2 mm dia. 40p

Item 417 Motor,precision, 9 V d.c.,with attached 6.3:1 gearbox £5

Item 589 Precision motor, 9 V d.c., power output 2.1 W, no load speed & current 7500 rpm at 5 mA, stall torque 10.6 mNm . Dimensions 22 dia. x 30 mm, plain 7.5 mm shaft, 1.5 mm dia. £3.20

Item 590 Stepper motor, single phase, 5 V manufactured for clock or other timing device. Delicate gearing with 40 tooth plastic wheel as output. Suitable for demonstration or as a method of digital input for control or timing. Uni-directional Dimens. 30 x 25 x 10 mm. Circuit diagram supplied. £1.20

Item 591 Stepper motor, 4 phase,12-14 V d.c., 400 mA, 27.5 R coil. Step angle 7.5 degrees. Powerful motor with 15 mm, 6 mm dia. output shaft. Dimens. 40 mm long, 70 mm diameter on 70 mm square mounting plate with fixing holes at 56 mm centres. Circuit diagram supplied. £4.50

Item 592 'Model' motor, 2.5 to 9 V, d.c., smooth running, speed governor. No load current 30 mA. Dimensions 35 x 40 mm dia. 8 mm shaft 2 mm dia. 60p

Item 594 Precision motor, 12 V d.c., power output 3.8 W, no load speed & current 4900 rpm, 12 mA stall torque 29.4 mNm . 10 mm plain shaft, 3 mm dia. £3.20

Item 613 Miniature d.c. motor, 1.5 - 3 V No load current 320 - 380 mA, speed 8,700 - 14,000 r.pm. Stall torque 16 - 26 g/cm. 28 mm long by 20 mm dia. 5 mm x 2 mm dia. shaft. 40p

Item 614 Miniature d.c. motor, 1.5 - 3 V No load current 235 - 300 mA, speed 7,700 - 13,800 r.pm. Stall torque 20 - 33 g/cm. 25 mm long by 21 mm dia. 8 mm x 2 mm dia. shaft. 40p

Miscellaneous items

Item 596 Orienteering and hillwalking compass by Suunto. With instruction leaflet. £3.25

Item 539 Reaction time switches, set of 3 for use with Harris 'Digitimer'. £2

Item 559 'Worcester' current balance kit components for use by up to 8 students.(Philip Harris P54330/0). £2

Item 526 Gas generator, Kipp's type by Exelo (Philip Harris C41740/6). £5

Item 540 Pond net frame (square) and 1.5 m aluminium handle (without net). £2

Item 542 Animal weighing box attachment for use with Ohaus balance (Philip Harris C13885/2). £3

Item 547 Resistance coils, "unknown value" alphabetic codes, A,C and J, 1% tolerance, (Philip Harris P59220/7, 260/8 and 320/0). £1

Item 561 Model periscope, plastic tube type, (Philip Harris P36590/2). £2

Item 563 Analogue to digital converter module for BBC microcomputer. Original MkI fast A-D with 0-5 V range only but mono- or bipolar. Complete with cassette software. (Philip Harris P89250/1). £5

Item 564 PET interface unit, originally intended for connection to PET user port via an edge connector and multi-way cable. Built-in diode and resistor network for reversed polarity and over-voltage protection. Looks adaptable for use with other computers with a 6522 VIA chip. Recommended only to those with some experience. Box alone worth £4 and cassette software included. (Philip Harris P87220/4). £4

Item 313 Thermostat, open construction, adjustable, range of operation covers normal room temperatures. Rated at 10 A, 250 V but low voltage operation also possible. 60p

Item 380 Thermostat, with capillary 500 mm long. Operates at low voltage but rated 10 A, 250 V. Can be activated by heat from human hand. £1.25

Item 348 Pump, submersible, 12 V, d.c. corrosion-free nylon construction. £5.60

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

Item 419 Humidity switch operates by contraction or expansion of membrane. Ideal for greenhouse or similar control project with items 348 and 344.Rated 3.75 A up to 240 V. 75p

Item 507 Optical fibre, plastic, per metre single strand 1 mm dia. Used for the optical transmission of sound. See Bulletin 140 for one such application. 35p

Item 523 Kilowatthour meter,domestic pattern, digital display (electromechanical) with mounting instructions. £2

Item 593 Underdome bell, 75 mm dia.,3 to 4.5 V d.c. £2.20

Item 429 Metallised polyester film one square metre 12 microns thick (see Bulletin 139 for applications) £1

Item 612 Beaker tongs, metal, <u>not</u> crucible type but kind which grasps the beaker edge with formed jaws. £1.20

Item 615 Wire, for thermocouples, 1 m of each of 0.5 mm dia. Chromel (nickel chromium) and Alumel (nickel aluminium). Makes up into d-i-y thermocouple as described in "Chemistry Notes", this issue. £2

Kynar film items

See Bulletin 155 for details of applications such as force/time plots and detection of long wave infra red radiation.

Item 502	Kynar film, screened, 28 µm thick, surface area 18 x100 mm. With co-axial lead and either BNC or 4 mm connectors (please specify type).	£20
Item 503	Kynar film, unscreened, 28 µm thick, 12 x30 mm, no connecting leads.	55p
Item 504	Copper foil with conductive, adhesive backing, 1" strip. Makes pads for Kynar film, onto which connecting leads may be soldered.	10p
Item 505	Sensifoam, 0.25" thick, 6 X6"	£1
Item 506	Resistor, 1 gigohm, ¼ W	80p

Resistors fixed & variable, components

Item 328	Potentiometer,wire wound, 15R linear, 36 mm dia.	20p
Item 329	As above but 33R.	20p
Item 330	As above but 50R and 40mm dia.	20p
Item 331	As above but 100R and 36 mm dia.	20p
Item 420	5% carbon film, ¼ watt resistors values as follows: 10R; 15R; 22R; 33R; 47R; 68R; 100R; 120R; 150R; 180R; 220R; 270R; 330R; 390R; 470R; 560R; 680R; 820R; 1K0; 1K2; 1K8; 2K2; 2K7; 3K3; 3K9; 4K7; 5K6; 6K8; 8K2; 10K; 12K; 15K; 18K; 22K; 27K; 33K; 39K; 47K; 56K; 68K; 82K; 100K; 150K; 220K; 330K; 470K; 680K; 1M0; 2M2; 4M7 & 10M.	6p/10

N.B. If anyone is interested in purchasing other values in the E12 range between 1R0 and 10M, which are not listed above, please let us know so that we can consider extending our stock list.

Item 421	d.i.l. resistor networks per 10 following values available: 62R; 100R; 1K0; 1K2; 6K8; 10K; 20K; 150K; 125/139R and 1M0/6K0	30p
Item 321	Transistor, BC108, low power NPN	5p
Item 322	Germanium diodes	8p
Item 371	Ferrite rod aerial, two coils MW & LW, dimens. 10 X 140 mm.	40p
Item 511	Loudspeaker, 8R, 2 W, 75 mm, resonant frequency 250 Hz.	50p
Item 354	Reed switch, s.p.s.t., 46 mm long	10p
Item 382	Rotary switch, six pole, eight way wafer.	65p
Item 508	l.e.d.s, red, green, yellow: each or 10 for	5p 45p
Item 510	Microphone with stand, ex-cassette recorder, 200R switched. 900 mm lead with 2.5/3.5 mm combination jack plug.	80p
Item 386	Light dependent resistor, resistance limits: dark 1K - 4K, light 10R - 50R.	55p
Item BP100	Precision Helipots,Beckman mainly 10 turn, many values available please send for a complete stock list.	10 -30p

We also hold in stock a quantity of other electronic components including capacitors, diodes, transistors, etc. To list all of these items would be uneconomical most articles being priced at 5p and under. If you do have requirements for such items please let us know and we will do our best to meet your needs.

*   *   *   *   *

Used Microscopes

Just as we were about to send the copy for this issue to the printer, we had a 'phone call about another offer of microscopes from Finlay Microvision. As before the original source is a University with which Finlay Microvision have done a package trade in and replacement deal.

As a consequence they are able to offer a number of Beck 'Diamax' instruments. These have an 'H' grade or teacher demonstration specification:

> 4 place nosepiece with achromats, x3.5; x10; x45 and oil immersion x90. Variable intensity, built-in illumination. Inclined monocular head with x10 Huygenian eyepiece. Mechanical stage.

The price is negotiable around £150 per instrument depending on condition.

We tested the 'Diamax' model several years ago. It is a quality instrument extremely well made mechanically and of good optical performance. The only small cautionary notes we would sound arise because of that good quality. These models should give years more useful service but should spares ever be needed then they will be expensive. The optics use standard RMS threads but objectives have long barrels and peculiar working distances. Any replacement objectives would have to be obtained from Ealing Beck.

Interested parties are asked to contact Finlay Microvision directly and not to negotiate through SSSERC. Speak or write to Mr. Simon Sharples at the company offices (address and telephone number are on the inside front cover of this issue).

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S.S.S.E.R.C.

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