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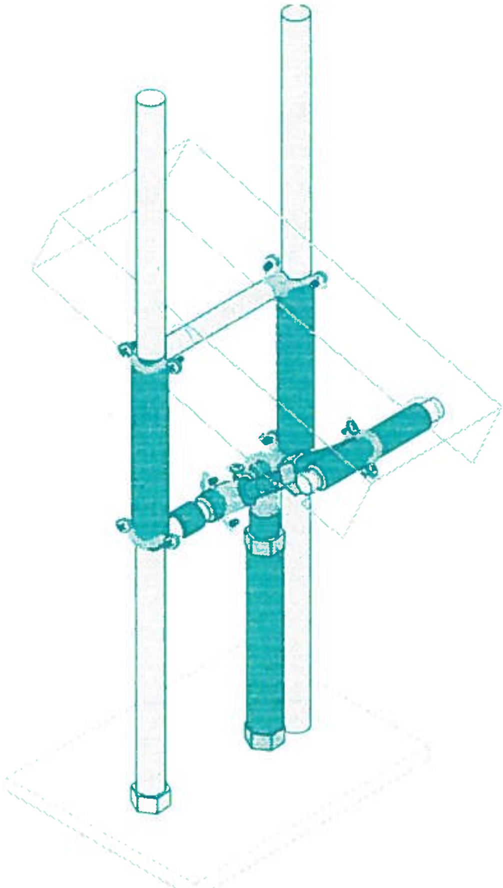

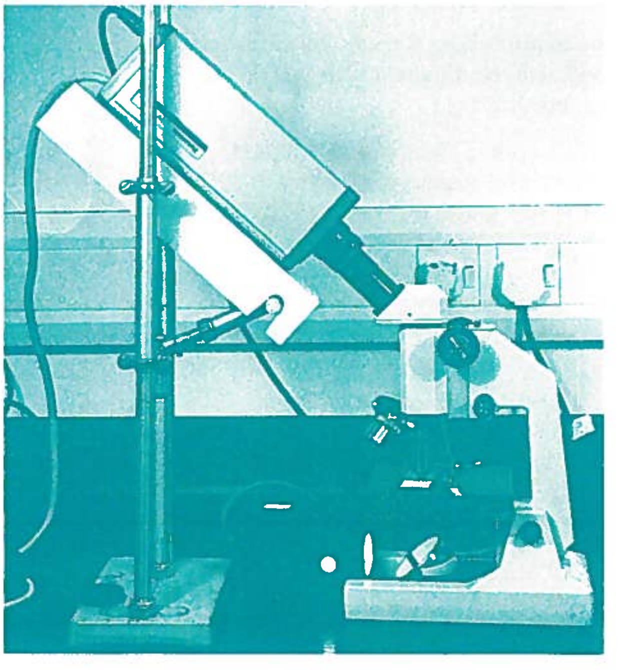

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Opinion I

Ravings

A Jumbo jet uses about 10 tonnes of fuel an hour - about 30kg, or 10 gallons, for each passenger - to travel about 450 miles. Thus the fuel consumption is comparable to each passenger going a similar distance by car - one car each. Cars carrying passengers are considerably less wasteful! Buses, ships, and especially trains are incomparably better. The Jumbo is the *least* profligate aircraft. Airlines pay considerably less for their fuel than motorists - the cost of a plane ticket is usually less than the value of the share of the fuel used, at forecourt prices. Considering the overall cost including damage to the environment, motorists pay too little - how much more so, airline passengers? What about financing the UN with a tax on plane fuel?

The Sun is 1.4 million km in diameter, and 150 million km distant. Thus its diameter subtends a little over half a degree of arc (about the same as the moon, 3,500 km in diameter and 380,000 km distant). A mirror of metallized plastic film in orbit at an altitude of 1000 km would need to be 10 km across to give a full reflected 'second sun' to a single point on the Earth's surface. If it were 20 km across it could shine fully on a 10 km disc of the Earth. If it were orbiting at a greater altitude it would need to be correspondingly bigger. It would be difficult, but perhaps not impossible, to arrange such a mirror to rotate in such a way that it illuminated the same area for some time[1]. This could warm cold regions, lengthen growing seasons, or provide light at night - some of these applications could use the 'part suns' provided by smaller mirrors. Similarly, while between the Earth and the Sun, they would produce a shadow and a cooling effect - if there were sufficient numbers of them, they could have an appreciable effect on the climate, and perhaps be used to counter the greenhouse effect.

Of course for the shadow and cooling effect you don't have to do anything as exotic as putting a mirror in orbit. How about laying a sheet of aluminized plastic over a few thousand square kilometers of the Sahara? This would reflect a considerable quantity of energy back off the Earth's surface, and from just where it is most unwanted. Would the local reduction in air heating be enough to cause a local weather effect - even rain? Already the Sahara is not completely rainless; the reduction in evaporation should at least allow the water table to rise. If the area covered had a hole in the middle, located at a low point in the topography, an oasis should develop there - or an existing one extend itself. Anyone got £25,000,000 for our first 5000 km^2 project? That's only a 40 km radius circle - about one two-thousandth part of the Sahara. If our price is about right, covering 10% of the Sahara would cost the people of the Earth about £1 each. It would be only fair for the richer countries who produce most of the carbon dioxide to contribute proportionately; the UK contribution would be about £5 a head. If the UK funded the suggested demonstration project, it would cost us 50p apiece.

Governments (and large companies) frequently do dafter, more expensive things for less reason. Is it so daft, anyway? Try asking your pupils. If you can, suspend your own disbelief. At the very least, try not to show it.

There's lots of scope for pupil ideas and investigations, and with luck, a bit more excitement than some of the humdrum stuff engenders. The learning outcomes are a little unpredictable, but they should be scattered all over Science and Technology. Perhaps you can even get the Mathematics and Geography staff involved.

[1]If so it would presumably also be possible to have two or more trained on the same area for a real hot spot.

INTRODUCTION

Summer opening

As usual, the Centre will remain open on weekdays right through the Summer break. Official opening times will be 9 a.m. to 5 p.m. Also as in recent years we will be suspending Saturday morning opening until after the Summer holidays. The last Saturday on which we will open (9 a.m. to 1 p.m.) will thus be the 8th of June. Thereafter we will be open the *first two* Saturday mornings of each month starting on the 7th of September.

Centre staff will be taking leave on a rota basis. With the loss of the last of the Joint Support Activity Project staff as from the end of June (see below), there are in any case fewer of us to person the barricades. If you wish therefore to see any particular, specialist member of staff you are advised to write or telephone and make the necessary arrangements before you visit.

Cheerio, Clive!

At the end of June we will say our farewells to Clive Semmens, Senior Project Officer (Information Technology) in our erstwhile TVEI Joint Support Activity Project team. He is the last to jump ship. He also has the distinction of not only serving out his full contract term but of having survived us core staff loonies for an extra month or two. This only shows that he is almost as daft as we are.

Clive is leaving us for the real world and starts a new post in a school next session. The sad part is that he is going to a school in London. That we see as an important loss to the Scottish system of a very considerable talent - of a polymath[1] even.

It is a major independent school which he is to join. Perhaps we here in Scotland have something to learn from it and others like it. Clive joins the school as *Director of Information Technology*. His responsibility is not for any specific subject silliness such as *Computing Studies*, but for managing IT applications right across the curriculum and throughout the school. If he does that for them only half as well as he has done it for us over the last two years or so - whatever they're paying him - they got a "triffic"[2] bargain. Unfortunately their gain is our and Scottish science and technology education's loss.

Errata

It's a while since we had a thorough going grovel but I can see sackcloth time has come round again. Our apollogies[3] firstly for a number of minor but annoying, typographical errors in Bulletin 169 (They annoyed me anyway, mostly it was I who either made or missed them [Ed.]).

Secondly, our humble, grovelling apologies to Philip Harris for an editorial error (yes - me again!). The author of the article on Dataloggers in the last issue had it right and in my Spring gambollings I rewrote that bit so as to hand readers the wrong end of a wrong stick. The Harris *Universal Interface* is just that - an interface. It is not a datalogger neither also nor only. Harris have also written to reassure us that even though other folks' sensors and serial leads can be plugged into their Universal Interface they are confident that no harm will result to either. Sorry!

Thirdly to Unilab for an error in that same "Equipment Notes". Apparently we gave at least them the impression that we judged them idle for not writing or rewriting enough Arc interfacing software. We are assured that Grapher has now been fully Riscossified. We also accept that Unilab does not "farm out" software development to djb. djb write software off their own bat, and some of it is included in the Unilab catalogue. In our defence we would point out that we did use the word "seems" in both contexts.

A final "Sorry!" also for the too liberal use here of footnotes (and all those comments in parentheses [Ed.]).

Reason - excuses

We have had three or more years intimate contact with various manifestations of the Training Agency and its acolytes. The latter include not a few projects and agencies of the school of DTPing[4] wherein sixteen acronyms per paragraph represent the epitome of good, plain English[5] and where everything is laid out in three or more narrow columns. These are invariably left and right justified to death. Even "epitome" becomes "epi- tome"!

We are happy to have survived intact (at least I think we are *in- tact* [Ed.]). We're just cell[3]- ebrating, that's all.

1. "polymath" - one who learns number theory off by heart as part of an Open University mathematics course. Hence that well known expression in octal - "Bits of 8, bits of 8!"

2. "triffic" - useless value judgement terminology, as employed in various reviews of Monty Python publications prepared by M'ssrs.Cleese and Idle*, or of SCET activities by SCET staff, past and present (for good examples see some recent issues of the TES Scotland). We were informed that Clive Semmens was "triffic" mostly by Mr**. and Mrs.C.K. Semmens*** of Cameron Toll, Edinburgh. (*No relation, **also no relation and ***absolutely no relation whatsoever).

3. The double "ll"s are deliberate. Of late I have been feeling sorry for all those discarded double consonants. Where are they to go, now that we don't seem to need them any more for hardening vowel sounds. I have decided that wherever possible I will find a home for them here in the SSERC "Bulletin".

4. "DTP" - desk top publishing, a term which implies editorial skills and knowledge of publishing techniques. It currently holds the record as the most rapidly established misnomer of the late twentieth century.

5. A number of such areas of educational activity were recently subject to comment and criticism from the Campaign for Plain English. Personally, I want to state here and now, fully and frankly and without fear or favour that, at the end of the day, I just love to death that Prince Charles as well as that gadgie Shakespeare - and not necessarily in any of that order. Who was that guy Dunbar by the way - didn't he hold the record for the most hours of sunshine?

No comment

"In the week the world marvelled at the skill of British scientists who turned a .... female mouse into a genetically correct male, it may be pertinent to refer to an instruction recently issued to IBM branch offices in Hong Kong.

"Mouse Balls: If a mouse fails to operate,...or performs erratically, it may need a ball replacement. Because of the delicate nature of this procedure, replacement of mouse balls should only be attempted by properly trained personnel. Before proceeding, determine the type of mouse balls by examining the underside of the mouse. Domestic balls will be larger and harder than foreign balls. Foreign balls can be replaced using the *pop-off* method. Domestic balls are replaced using the *twist-off* method. It is recommended that each replacer have a pair of spare balls for maintaining optimum customer satisfaction."

(As quoted from IBM literature in the issue of "Scotland on Sunday", published on the 12th of May 1991).

Comment

"When everything is measured in monetary terms organisations like ours, which give pupils' and teachers' needs a higher profile than pounds, are an endangered species."

John Evans quoted in the "TES Scotland", 10th May 1991.

(John Evans is Acting Director of *Resource* the Doncaster based IT development project some of whose products we particularly praised in "Equipment Notes" in Bulletin 169. *Resource* is currently threatened with closure by the end of August this year. This is because of the withdrawal of education authority funding.)

Safety Notes

Shell suits - again

In Bulletin 169 we gave a preliminary warning about the possible fire hazards which might come from the wearing of the presently fashionable Shell suits in practical rooms and laboratories.

Since then we have received some more samples of material and replies from the sportswear manufacturers whom we contacted. These samples we have tested both for ease of ignition and rate of flame spread. For those tests we used a simplified version of methods described in British Standards BS 5722 [1] and 5438 [2].

Essentially our test procedure was as follows: A horizontal bunsen flame was applied to the foot of a 300 mm length of vertically suspended cloth. The times both for the sample to catch fire and for the flame front to reach the 300 mm mark were noted. For most samples the outer skin or Shell became well lit in 3 to 30 seconds and the times for the flame front to reach the top varied from 12 to 30 seconds.

One particularly loosely woven lining, of which we only had one test sample, ignited in less than 1 second and reached the top in 12 seconds. On some samples the flame ran extremely rapidly, only for the sample to self-extinguish as burning blobs of molten polymer fell off and thereby snipped off the burning front from the sample.

For clothing in general there is no laid down standard for this sort of test as to what constitutes a pass or a fail. It is recognised by the British Standards Institution that the grading of fabrics according to their relative flammability under any particular test method could be both misleading and dangerous. BSI point out that the design both of garment and fabric, not solely the basic flammability of the materials used, can affect the degree of hazard of any particular product.

However, one published standard on the flammability performance of sleepwear does require that the flame front does not reach the 300 mm mark in less than 25 seconds. You will see from our results that many of our Shell suit samples performed worse than any night dress which would meet such a standard.

For comparison we also tested such a strip from an old cotton labcoat. It fared little better, the flame running the length of the 300 mm strip in 20 seconds! The saving grace of the heavy cotton was that, although it was ignited in about the same time as the synthetics, the initial rate of burning was less ferocious and it is unlikely that cotton would form molten blobs which then stick to the skin.

Recommendations

Shell suits should not be worn in laboratories, workshops or other practical rooms with similar access to sources of ignition.

We reached this conclusion on grounds other than simply ease of ignition and rate of flame propagation:

a. The *composite nature* of these garments; unlike the outer shell, the lining on the suits examined burned fiercely and did not self extinguish by pieces falling off thus isolating the flame front from the unburned remainder. Thus the lining may keep the shell burning even when bits of the latter drop off. The general flame front is therefore more likely to be sustained.

b. The *full cut* and *generally loose* nature of most of these garments. Because of these general design features loose cuffs or open jackets may easily contact a flame.

c. A *chimney effect* whereby loose garments on a body act rather like a flue with the convectional draught greatly accelerating the rate of burning. This follows from (b) above and taken with (a) leads to us the conclusion that shell suits in practical rooms present significant risk of serious burns.

d. In their replies to our enquiries, manufacturers have echoed our recommendations that this particular type of leisure garment is not suitable for use in laboratories or similar practical areas and should not be worn there.

References

1. BS 5722 "Flammability performance of fabrics and fabric assemblies used in sleepwear and dressing gowns", British Standards Institution (BSI), 1984.
2. BS 5438 "Flammability of textile fabrics when subjected to a small igniting flame applied to the face or bottom edge of vertically orientated specimens", BSI, 1989.

Old glass stills

Before the days of the deioniser, glass still pots for the production of distilled water were more commonly seen in school preparation rooms. There remain a significant number in use and some of them have been around a long time.

Recently we heard a report of a glass still pot wearing so thin that it fell apart. Examination of the broken fragments revealed that erosion over a decade of use had reduced wall thicknesses in places to 0.015 mm! Admittedly this still was in a university medical laboratory and had put in longer working hours than would similar equipment in a school. However even regular cleaning and descaling operations would not have readily revealed such cumulative thinning of the chamber.

The main danger from such a mishap would be scalding from the boiling water cascading down from above. Often such equipment is mounted on a shelf half a metre or so above bench level. This not only tucks it out of the way and saves space, but also allows the freshly distilled water to be gravity fed to storage aspirators at bench level.

We would make two recommendations:

Firstly, such stills should be positioned no higher than necessary to achieve a reliable gravity feed and certainly not above or close to anyone's workspace.

Secondly, if you have an old still which has received a good deal of use over many years, it would do no harm to consult the manufacturer as to the recommended working life of the glass vessel. In some cases that may prove difficult since the original supplier may have moved or no longer be in business. As always, in any cases of such difficulty, we would be pleased be assist SSERC members and subscribers.

Technical Articles

DIY video in biology

The use of an inexpensive camera mounted on a school-built stand for demonstrations at both the micro- and macro scale is described.

Introduction

We last wrote on this subject in Bulletin 154 [1]. There we discussed the use of commercially available video equipment across all three sciences.

Recently we were invited into Woodlands High School in Falkirk to look at a DIY system jointly developed by the Principal Teacher of Biology and the Senior Science Technician. So impressed were we with this set-up that we have since had it on extended evaluation loan.

We have also exhibited the system at a number of teachers' meetings and at each of these it was favourably received. In particular teachers were impressed with its relatively low cost, its flexibility, in that it can accommodate different types of microscope stand, and the emphasis it places on projection of pupil prepared materials.

Uses

Microscopy

One intention behind thc design and construction of this DIY system was to allow for the video projection of, or recording from, pupil prepared materials. This explains some of the apparent complexity of the stand and its adjustments. The intention was to allow any of the school's microscopes which happened to be in use by pupils to be accommodated on this rig.

This was so that if any student were to prepare a particulary good wet mount - especially with tricky techniques such as root squashes - then their microscope could be quickly transferred to the video set up and the specimen seen by the whole class. This is exactly the approach we have tried to encourage over the years, not only for video-microscopy but for all forms of microprojection. Commercial, prepared microscope slides shouldn't be so projected - there are better ways of ensuring that all the students get to see particular anatomical or histological features [2].

Recordings

The type of security camera used may be connected directly to a monitor or via a video cassette recorder (VCR) to a monitor or television. The insertion of a VCR into the system brings other possibilities.

One application tried with great success by Woodlands High was with microscopic examination of living protozoa. Cultures of *Amoebae* or *Paramecia* are notoriously tricky to maintain long term in schools. In addition great good fortune is needed to observe, first hand, clear examples of vacuolation or phagocytosis. Often when 'H' grade or CSYS students at Woodlands are engaged in this kind of work a video system with VCR is set up handy.

Any particularly good specimens or observations are then recorded. This insures against the possibility that cultures may expire before the next class meets or that such observations cannot be repeated. Of course, these *Blue Peter* or *Delia Smith* techniques (this is one we prepared earlier!) should not be taken too far - else we might as well go straight to commercially prepared material.

Macro-video

The camera and mount can also be used with a VCR and large screen monitor for work other than that requiring microscopes. The system may be so used for any small scale operation or manipulation of apparatus or specimens where otherwise a whole class of pupils would have difficulty in seeing what was going on.

Overview of the system

The system is shown (Fig.1) in use with a microscope of the modern type with a fixed limb, inclined eyepiece tube and stage focusing mechanism. Provided that a security camera with a 16 mm lens of the type shown is used, no special adaptors are needed for the optical parts of the system. The microscope eyepiece is simply left in place and the camera focused on the image at the eyepoint or *Ramsden disc*.

It also happens that the internal diameter of the 16 mm video lens assembly is only just greater than the RMS standard eyepiece external diameter. This type of video lens thus sits nicely over a standard eyepiece. With any reasonably accurate positioning of the camera lens stray light is thus excluded.

The camera

The camera illustrated is a monochrome security camera by Panasonic which uses the now outdated vidicon tube technology. Many such cameras have already or are currently being replaced by more compact, modern designs which employ CCD or *video-chip* detectors. They are thus quite a few such cameras around on the second hand market. Even second hand vidicon colour cameras are becoming readily obtainable although, obviously, these command higher prices.

Woodlands High School obtained a fully reconditioned second hand model for £180 from a local company. In contrast a new CCD colour camera suitable for micro-projection is about five times that price[1]. Since they bought that second hand example, prices for vidicon cameras have held steady or even fallen.

1. Beware new, but cheap, security systems now obtainable complete at under £200. Their resolution, at less than 200 lines per screen, is insufficient for this application.

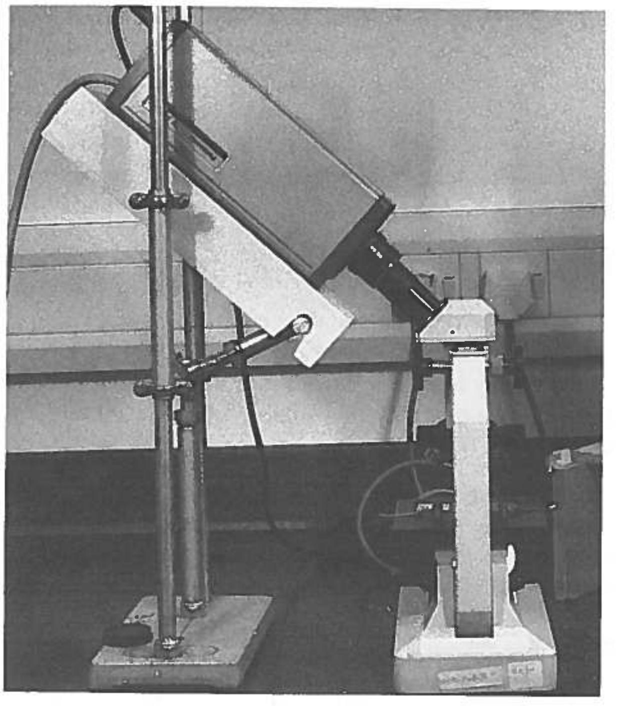


Fig.1.

Illumination

Any standard microscope illuminator will do and *in extremis* we have even employed mirror lighting and a daylight source. Use of a good quality sub-stage illuminator or proper external microscope lamp obviously improves matters. This is especially so where such lamps are fitted with iris diaphragm or other field stop to allow contrast control and the removal of glare.

It is in this sphere that the disadvantages of the vidicon tube cameras become obvious. Unlike the video-chip or CCD based devices which are replacing them, vidicon tubes react badly to sudden changes in intensity of illumination. This is seen as an effect known as *white-out* where the image may disappear entirely for a short time until the tube recovers[2]. Besides being much smaller devices, video chips have the added advantage of not suffering from this effect.

The mechanics of the system

The stand

This is simply an adapted laboratory stand fitted with various tubes and threaded rods which provide adjustments to allow for the use of microscopes of differing working heights and styles.

2. With very intense sources such as direct sunlight or quartz-halogen lamps the effect may be permanent when it is known as "burn-out".

It is basically in the form of a two-runged ladder with the top bar or rung providing a fixing around which one end of the camera platform may rotate. The position of the bottom rung not only determines the overall height of the camera but also provides a means whereby the camera angle may be altered to suit diferent eyepiece tube angles or other modes of use.

Detailed description

Figure 2 provides a line drawing of the system with a magnified view of the more complicated adjustable bits. We are sorry if what follows reads, at least first time through, like those awful instructions for assembling *knock-down* furniture.

Unfortunately such tortuous description seems unavoidable. This is just one of those devices that are very easy to understand if you see and handle the real thing but which defy succinct verbal description.

The basic frame

The base of the lab stand is drilled and tapped with a thread to take a second, 12 mm, rod (*R2*) mounted parallel with that normally fitted (*R1*).

Another, tapped hole is provided in the retort stand base about one third of the way in from the original rod. This hole is fitted with a third, short rod, (*R3*) over which a metal tube of 13 mm internal diameter can be slipped to act as a spacer (*S1*).

With spacing rods of various lengths it is possible to adjust the rig to take different models of microscope. It can thus accommodate either the modern, fixed limb type as illustrated or stands of the more traditional type with an upright eyepiece tube.

DIY camera platform

The camera itself is bolted onto a section of plastic trunking as used in electrical installation work. To suit this particular camera a section ca. 260 mm long, 100 mm wide and 50 mm deep was used. Obviously these dimensions may vary for different models of security camera.

At about 100 mm in from the end away from the lens end, holes were drilled in this plastic section to take a 12 mm dia. rod (*PR*). Threaded at both ends this mounting rod is fitted with two pipe clamps (*C1 & C2*) which slip over the main uprights and rest on the tops of spacer tubes *S2* and *S3*.

This whole camera platform is free to rotate about the rod *PR*. However two *U-shaped* cut-outs, centred about 25 mm in from the lens end of the platform, provide limits to that rotation. In these cut-outs are fitted the ends of the *T-piece* which rotates about the horizontal bar (*H*) [see below].

Changing camera angle

A horizontal bar (*H*) is fitted, by means of pipe clamps, (*C3 & C4*) to two 13 mm i.d. steel spacer tubes (*S2 & S3*) which set the distance between the camera platform's mounting rod (*PR*) and this same horizontal bar.

Now, for the clever bits: Two more pipe clamps, (*C5 & C6*) are each fitted with short lengths (ca. 25 mm) of 15 mm i.d. copper pipe which sleeve the horizontal bar *H*. They are thus free to rotate around it.

C5, nearest to the main upright rod *R1* is tapped to take a short 12 mm nut and bolt assembly *(B1*). This provides both attachment for the other end of spacer tube *S1* and by means of its bolt also provides one of two means of fine adjustment of camera height.

C6 similarly is fitted with a short threaded rod or bolt and nut. On to that is fitted the *T-piece* made up from a 12 mm threaded rod or bolt with a nut (*B2*), 13 mm i.d. tube, and yet another pipe clamp (*C7*).

The ends of the top, horizontal, arm of this T-piece fit into the cut-outs at the lens end of the camera base. Camera angle is thus roughly determined by the overall length of the vertical of the T. Finer adjustment is achieved with the nut and bolt at *B2*.

For a vertical camera

Should the ends of the horizontal of T-piece be removed from the camera platform cut-outs, then the whole T-piece assembly can be swung down out of the way or be removed entirely. The camera base will then swing down until its cut-outs rest instead on the bottom bar, *H*.

The camera is then mounted vertically and can accommodate a microscope of the more traditional type with an upright eyepiece tube. Alternatively the vertical camera position may be needed for certain types of non-microscopic demonstration (see above under "Uses").

Depending on the height of the traditional microscope, or on the nature of the *macro-* application, longer spacer tubes may be required at *S1*. The Woodlands rig possesses two such extra spacers - one 220 mm and the other 320 mm long.

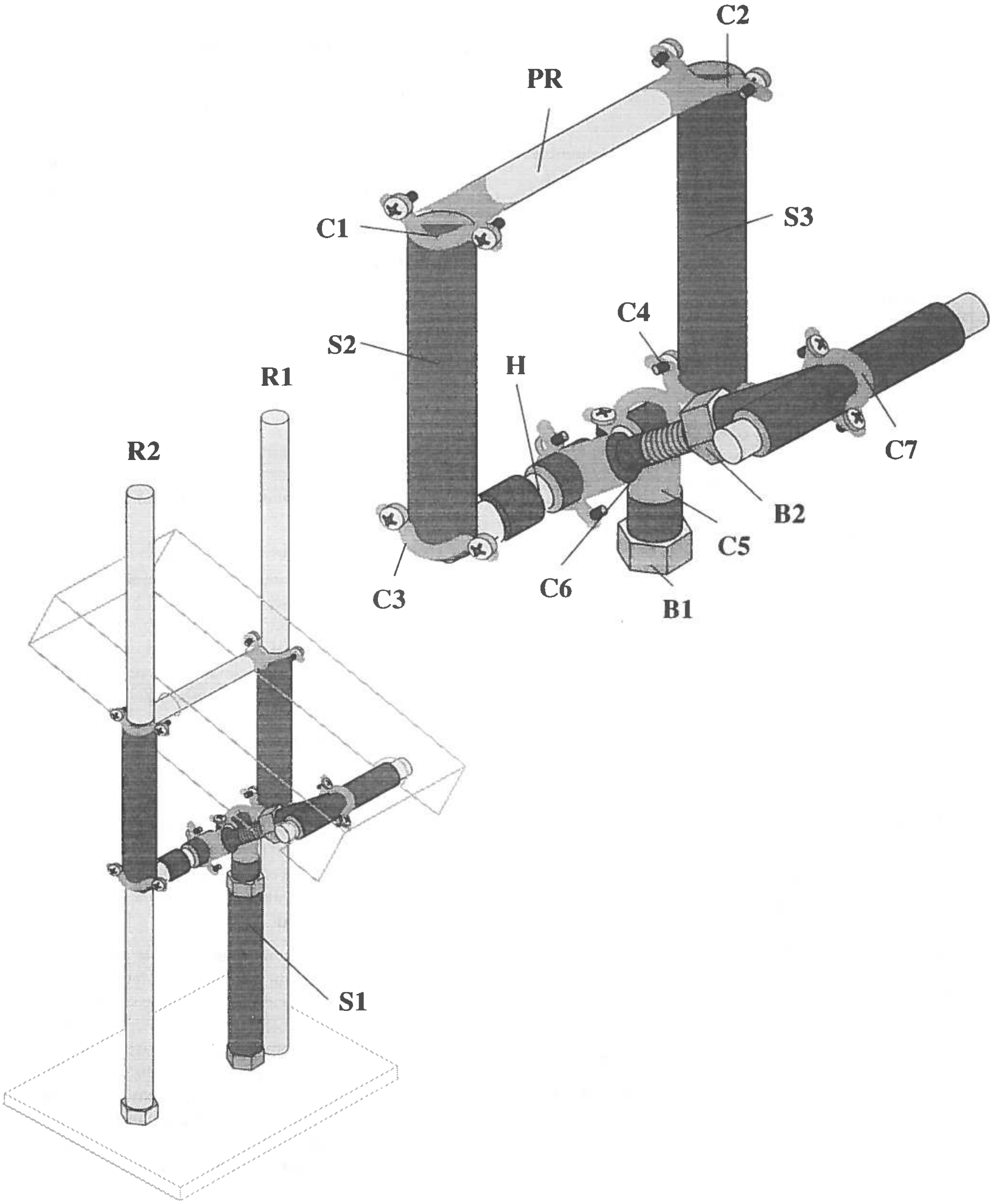


Fig.2 Modified stand and camera platform with magnified view of adjustment arrangements

Parts and sources of supply

For stand and camera mount

12 mm diameter metal rod (or clamp stand spare)	K.R.Whiston
13 mm i.d. metal tubing (e.g. Whistons $^5/_8$" 18 g)	K.R.Whiston
pipe clamps	local plumbers' merchant or DIY store
15 mm copper pipe	scrap or as above
plastic trunking	local electrical wholesaler

e.g. City Electrical Factors (or see "Yellow Pages")

Tools

Access will be needed to suitable taps (for threaded holes) and dies (for putting threads on the rods) and you will need a hacksaw somewhat beefier than the typical *Junior* model. Here's a chance to get cross-curricular. Scientists reading this should ask the technical department for help. Any technologist readers could make the necessary offer!

Camera and monitor

Secondhand cameras and monitors are from time to time advertised in specialist magazines, for example in "Electronics World and Wireless World" by companies such as "Display Electronics". Alternatively an approach to a local security company or alarm system installer may well pay dividends (see "Yellow Pages").

Acknowledgements

We are extremely grateful to Mr. Ian Cochrane, Principal Teacher of Biology and to Mrs Olive Robb, Science Technician of Woodlands High School, Falkirk both as the source of this design and for their assistance with our evaluation and description of it.

References

1. "Video equipment in science teaching", SSERC, "Equipment Notes", Bulletin 154, November 1986.
2. "Microprojection and CCTV microscopy", SSERC, "Biology Notes", Bulletin 140, April 1984.

Technical Articles

Higher Grade Chemistry

First ionisation energies

The article describes the use of two types of thyratron valve, in measuring the first ionisation energies of the *inert* gases argon and xenon. Experimental procedures are described and constructional details given.

Introduction

Those parts of any syllabus in the physical sciences which deal with atomic structure tend to be mostly theoretical and a bit short on illustrative practical work. Unit 5 of the revised Scottish Examination Board's Chemistry syllabus at the Higher Grade is no exception in this respect.

At school level, emission spectroscopy is one fruitful area in which to look for suitable practical activities. The measurement of first ionisation energies of inert gases is another.

Acceptable values for the first ionisation energies of argon and xenon are obtainable by using thyratron valves, albeit not in the way originally intended by their manufacturers. The results of such measurement support and illustrate the general principle (see Learning Outcome 12 in H grade Unit 5), that electrons more distant from the nucleus of a larger atom are more easily removed.

Principles of measurement

Thyratrons, thermionic valves filled with inert gases such as argon or xenon, are still commercially available as are valve bases designed for educational use. The electrodes with which these valves are fitted (see Fig.1) happen to provide convenient means by which voltages may be applied across these gases and the currents which result may be measured.

Electrons *boiled off* the heated cathode are attracted towards the anode by the potential difference applied between that cathode and the grid/anode combination. When they have sufficient energy to eject other electrons from the atoms of argon or xenon with which they may collide, then the current flowing between the cathode and grid/anode increases sharply. This increase in current is so marked in the case of xenon that it will strike an LED (light emitting diode). For xenon a red LED can therefore replace a milliammeter in the measurement circuit.

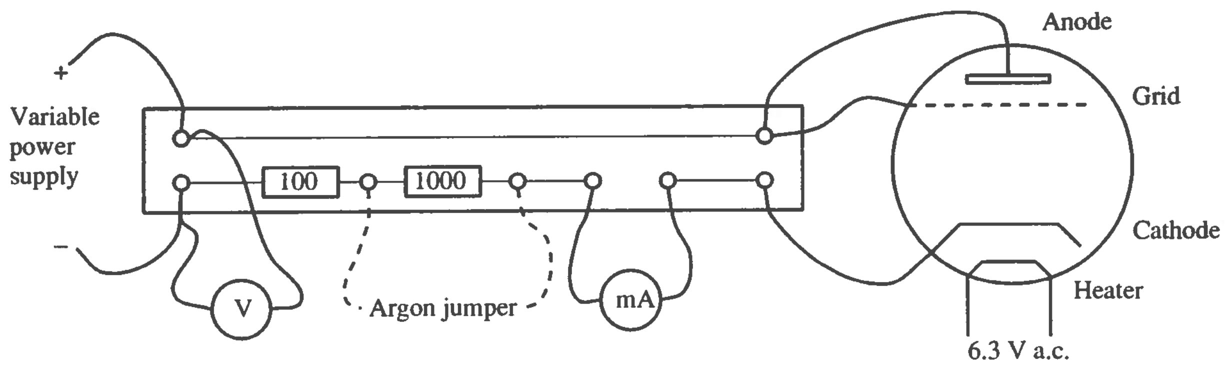


Fig.1.

Development work

Our more recent development work has had the twin aims of:

- reducing the voltages which have to be applied to the grid in order to observe the effect described above (in other circuit designs up to 60 V d.c. may have been needed);

- simplifying and clarifying the connections to the valve electrodes, heaters and measuring circuitry so as to ease the business of setting up the experiments and measurements.

We also took the opportunity to adapt the method to provide a facility for datalogging and measurement by graphical means using *Dataplot* software from Harris.

Practical details

Apparatus

For the various measurements described in this section of the article we employed one of two versions of a customised connector box together with commercially supplied valve bases and power supplies. Technical information on these aspects is provided at the end of the article (see page 11).

Procedures

Direct measurements - simple method for xenon

The relevant circuit is given as in Figure 1. - the version without the shorting lead labelled "Argon jumper". Using this with an EN91 xenon filled valve, we gradually increased the voltage applied across the valve electrodes and with a milliammeter noted when the current began to increase and the voltage at that point. This voltage when the current suddenly starts to *avalanche* should be close to 12 V for xenon.

An even simpler method is to replace the milliammeter with a red, miniature, light emitting diode (LED). Merely note the value of the applied voltage when the LED strikes. This should occur at between 13 and 14 V.

The LED will drop about 1.5 V across itself when it lights so that must be subtracted from the observed voltage. In our measurements we found that such an LED consistently struck at 13.9 V. Allowing 1.5 V for the LED gives a figure of 12.4 V which is within 2.5% of the generally accepted figure for the first ionisation of xenon of 12.1 eV.

Graphical method

Unfortunately this simple, direct method using an LED does not work for measurements on argon filled valves such as the type 884. This is because with argon the current does not suddenly avalanche from a neglible value as it does for xenon (Fig.2).

With argon it is necessary to draw a graph of the cathode current (I_c) against the applied voltage (V_{app}). You may then extrapolate this graph back to an intercept on the horizontal axis (Fig.3) and read off the voltage at which ionisation of the gas first occurs.

Although this method is only really necessary for argon it will also provide greater precision with xenon filled valves. Such graphs may be plotted manually or with the aid of a microcomputer with an analogue interface and suitable software (see below).

Another requirement for measurements on argon is to substitute a lower value of protective resistance limiting the grid current. A simple of way of doing this is to set up circuitry which includes two series resistors for a higher level of protection suiting a xenon filled valve and then to use a jumper lead to short out part of that series to cater for argon filled valves.

In our circuits (Fig.1) for use with xenon an 100 ohm resistor is placed in series with another of 1 kilohm. For argon we shorted out the 1 K reducing the overall protection to about 100 ohms.

Again measurements of acceptable precision can be made by this means. For argon filled valves the intercept typically occurs at values of applied voltage of 15 V or so. This is acceptably close to published values for the first ionisation energy of argon of 15.7 eV.

Datalogging

If suitable protection can be arranged for the analogue inputs of a microcomputer and means found whereby current can sensibly be measured then, with suitable software, graphs of I_c against V_{app} may be constructed as the experiment proceeds rather than plotted afterwards from a table of results.

Protection

One of the parameters to be logged is the voltage applied across the valve (V_{app}). For xenon filled, EN91, valves applied voltages need not exceed 18 V or so, but up to about 22 V will be needed for type 884 argon valves (see Figs.2 & 3).

The measuring range of the analogue ports of Acorn microcomputers is however only 0 - +1.8 V (although protection is provided up to 5 V or so). In order to be able to measure the applied voltage (V_{app}) without damage to the computer it is necessary to feed to the analogue port only a definite fraction of that voltage [1]. The way to ensure that is to use a potential divider circuit. This is achieved in our design by connecting the signal ground or zero volts directly to the negative side of the supply to the valve electrodes with V_{app} as measured by the computer being tapped off from a potential divider circuit of 10 K and 560 R as shown in Fig.4.

A maximum V_{app} of 20 - 25 V as actually applied to the valve is more than enough to give a reasonable length of graph for back extrapolation. However if your power supply is capable of delivering 35 V or so, then tailor the voltage divider to tap off no more than 1/20 of the voltage actually applied to the valve. As you can see from the relevant figure, we settled for a fixed value voltage divider. This is less flexible in some ways than using a potentiometer. It does however possess two advantages. The first is simplicity in use. The second is that it removes the danger presented by a potentiometer that someone may adjust it wrongly and apply too high a voltage to the computer input.

A combination of 10 kilohms and 560 ohms gives an output of +1.6 V when the power supply is feeding +30 V. Modern analogue connecting boxes usually contain diodes to guard against reversed polarity as well as resistors protecting against over voltages. Nevertheless it is good practice to use a multimeter to check the polarity and magnitude of any voltage signal before plugging the latter into such a four channel connecting box.

Measuring current

Analogue to digital convertors can only really measure and capture voltages. In order to *con* a microcomputer into logging current it is necessary instead to measure the voltage dropped across a suitable value of resistor in series in the signal line. (See Fig.4 where the 22 ohm resistor to the left of the negative rail is the relevant component).

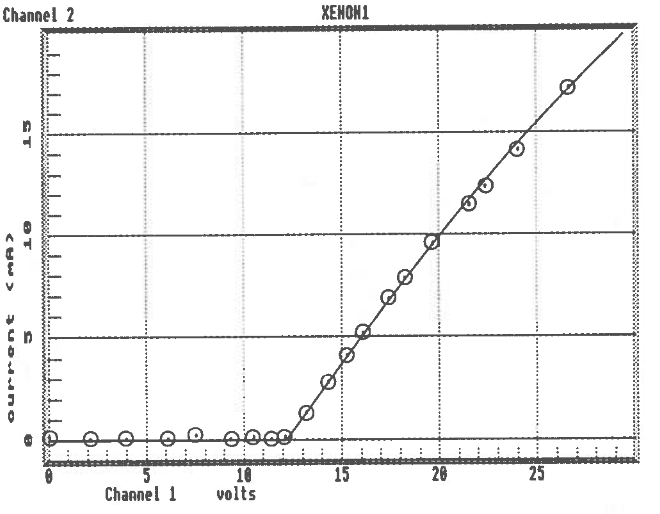


Fig.2 - results for xenon

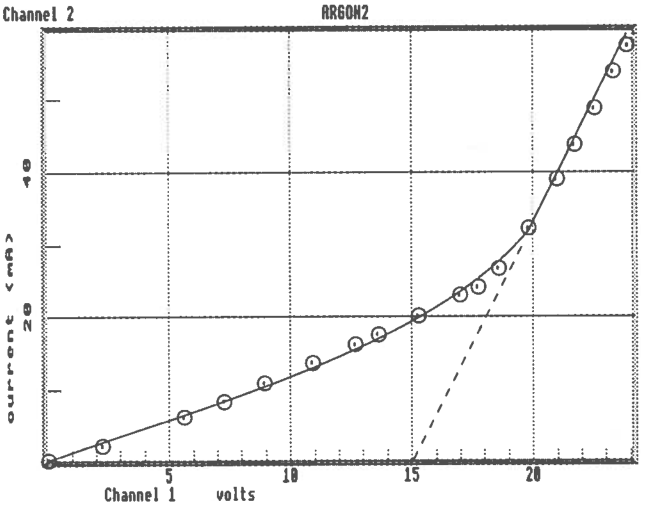


Fig.3 - results for argon

A signal proportional to current, but essentially voltage based, is then fed to the analogue port of the computer. This is conveniently done with a four channel connecting box, either of commercial origin or of DIY construction. This signal may then be calibrated by software to read in the desired units of current such as, in this case, mA.

Again to prevent damage to the analogue port this signal should not exceed 1.8 V. Trial and error showed a resistor of 20 to 30 ohms to be a compromise which will do for both valves. In practice a 22 ohm resistor rated at 2.5 W was used, though you will get away with a half watt rating if you don't hold the higher currents - about 50 to 60 mA - needed for the argon valve, for too long.

Dataplot from Philip Harris provides simple and suitable software for automating the graph drawing. As V_{app} is incremented stepwise a press of *F0* (function key zero) per step will plot a point at each equivalent intersect of I_c/V_{app}. Once graphing is ended then graphs may be saved, printed out as hard copy etc. (*Dataplot* also has a number of other special features such as the facility to edit data points etc. - see reviews in [2]).

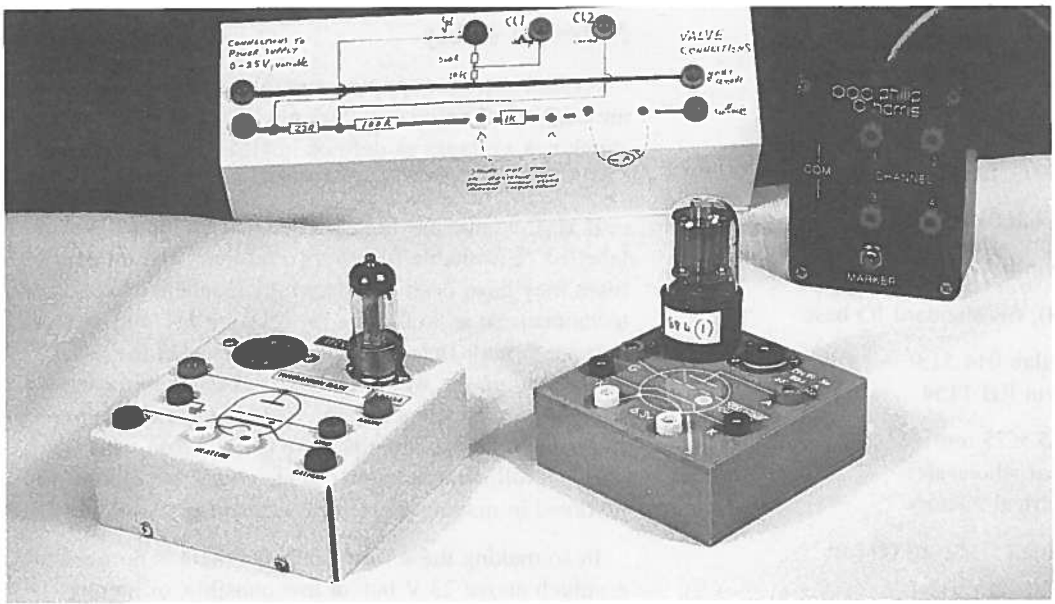


Fig.4

Apparatus

In addition to showing typical commercial examples of a valve base and 4 channel analogue port connector box, Figure 4 also illustrates our own DIY box which provides:

- the necessary connections onward to the commercial valve base and to either direct measuring devices (meters or LED) or to analogue channels on a BBC microcomputer;

- limiting resistors to protect the grid, other resistors set up as a potential divider for voltage (V_{app}) measurements or in series to provide a voltage proportional to valve current (I_c) and

- drawn on the top of the box with a permanent marker pen, a circuit diagram come schematic layout.

Constructional details

Dimensions and positions of sockets are not critical; we used a 250 mm length of plastic trunking 75 mm wide which gave a generous separation of sockets but all could be accommodated in much less space.

The setting up of the circuit is greatly facilitated by;

- colour coding of sockets and 4 mm plugs on leads, with different colours for the valve heater; anode/grid; cathode and various measuring circuits;

- the positioning of outlets and inlets so that the leads to power supplies, meters, valve and interface do not have to cross over and, as shown,

- marking on the top of the of the box the circuit and the positions for connections to meters, power supply, etc.

Figure 5 illustrates a simpler version of our DIY box. This lacks the outputs to a microcomputer analogue connector and simply allows for direct measurements and manual plotting of graphs.

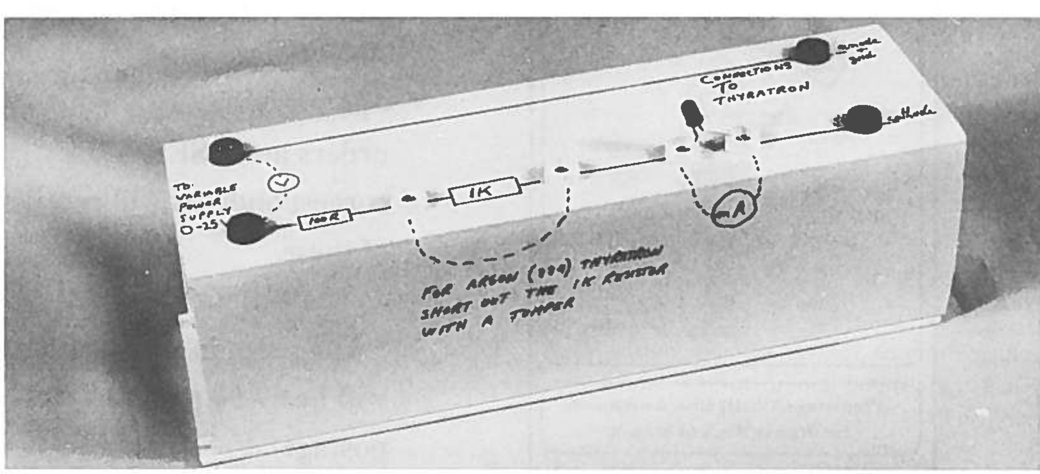


Fig.5

Components etc.

thyratron base	Unilab 014.507	£11.47
Irwin	EA1154	£23.55
thyratron, xenon (EN91), fits B7G base:		
	Unilab 014.512	£2.71
	Irwin RA 115A	£8.79
thyratron, argon (884), fits standard IO base:		
	Unilab 014.513	£8.85
	Irwin RB 1154	£8.45

electrical trunking (75 x 75 mm)
Local electrical wholesaler
e.g. City Electrical Factors

4 mm sockets:	Farnell ca. £3.00 for:	
	4 red, 149-416	
	4 white 149-550	
	3 black 149-546	
resistors:	Farnell	
1/4 W 560 ohm	SFR-25-560R	<£0.02
1/4 W 10K ohm	SFR-25-10K	" "
1/2 W 1K ohm	MFR4-1K	<£0.03
2.5 W 22 ohm	W21-22R	£0.47
2.5 W 100 ohm	W21-100R	£0.47

power supply, continuously variable, 0-25 V d.c. with 6.3 V a.c outlet for valve heaters

Harris	P70170/7	£227.19
(0-35 V d.c. 20 mA max and 0-350 V d.c. 60 mA max)		
Unilab 022.108		£56.26
(0-150 V d.c. 50 mA max.)		

Notes on safety

Available power supplies suitable for this experiment are capable of delivering currents in excess of 5 mA at shock risk voltages as defined in HSE Guidance Note GS23 [3].

If HSE advice has been heeded, such supplies will be labelled "Unsuitable for use by children" and internal fuses may have been withdrawn by teachers or technicians so as to disable the relevant HT outlets as a normal, default state in storage. However in the usual interpretation, the word "children" is taken to mean pupils under 16 years of age. With suitable supervision and some other safeguards there is no reason why students following a Higher grade course should not be involved in making these measurements.

In so making these measurements there is no need to go much above 23 V but an irresponsible, or merely careless, student fiddling with controls might do so. One bit of good general advice is for the circuit to be set up, and any subsequent alterations made, only when the power supply is switched off, unplugged and disconnected from the apparatus so as to render all *safe and dead*. Even with students over 16 there should be close teacher supervision.

References

1. "DIY Computer Interfacing Part III", SSERC, "Technical Articles" Bulletin 169, April 1991.
2. "Interfacing - the datalogger cometh", SSERC, "Equipment Notes", Bulletin 169, April 1991.
3. "Electrical Safety in Schools (Electricity at Work Regulations 1989)", Health and Safety Executive, General Series 23, September 1983, revised February 1990, HMSO, ISBN 0 11 885426 7.

Opinion II

Rantings

Most of our work on equipment evaluation is kept private - necessarily so because of the confidential nature of our discussions with manufacturers. However schools should be well aware of the outcome of this work: in the form of equipment lists to accompany the SEB syllabuses, and in the Bulletin's Equipment Notes.

The Centre is controlled and, currently, largely financed by local authorities. Our evaluation service is wholly and only for the purpose of being able to give good advice to schools. Certainly the manufacturers and suppliers also benefit - though sometimes they may swear at us - from getting test reports and advice, for which of course they do not, and cannot, pay since we cannot serve two masters. They benefit indirectly.

Our test procedure starts with obtaining, often on loan and at no cost to the Centre, the equipment to be looked at. If there is a risk of harm to the user, we normally check for compliance with British Standards. For instance every item of mains electrical equipment is so checked, and the same applies to other fields. Where features don't impinge on safety, for instance the output characteristics of a power supply as opposed to its HT insulation system, we usually devise our own tests rather than work with British Standards, if indeed any could be found that are relevant. We then report on our findings to the manufacturer, and ask for his comments.

The responses we get can sometimes be disturbing. Clearly we would like the manufacturer to say: "We accept your findings and will modify our product accordingly". Some do. But too many don't! We get replies like: "Our company has been making this product for twenty years, and it hasn't killed any pupil yet!" Some question the probity or applicability of British Standards, and doubt whether their products should comply with them. There are reasons for such attitudes which we understand. Sometimes British Standards are outdated in that they cannot allow for methods of manufacture or design improvements which weren't available when the Standard was drafted. In addition no manufacturer wishes to unnecessarily increase his costs and lose any competitive edge. Those who offer that latter reason may also argue that this is in the best interests of the customers who are thereby protected against unnecessary price increases.

Too often these days such arguments look to us more like excuses for inertia and sloppiness rather than sound reasons for refusing to act to correct faults or improve designs. There is also the question of the overall impression given by such British manufacturers to customers and to those who represent their collective interests. With such haggling and wingeing what many seem to undervalue is the right of the customer to ask for goods to be manufactured to a reasonable standard - sometimes a standard of safety. The Centre is a collective voice of Scottish schools in this regard. We represent customers!

One manufacturer's response received last year is especially noteworthy, and so it's quoted in full - all one sentence of it - in reply to a report on one of the very few soundly engineered microscope lamps we have recently tested:

"We note your instruction, and add our type reference number, the lamp wattage and the earth bond mark to the illuminator from next shipment."

From a manufacturer that believes that the customer may often be right - a Japanese manufacturer!

Equipment Notes

Portable appliance testers

In this article we report on portable appliance testers, which are used in maintenance tests on portable electrical apparatus. A description of the tests is included.

Introduction

The objectives of this article are to describe the tests which would be carried out as part of routine maintenance of portable electrical apparatus, and to summarize the results of a technical evaluation of some fourteen portable appliance testers (PATs). The statutory requirements for such testing are also discussed.

Scope

Sufficient information is given so as to explain the purpose of portable appliance testing, and no more! The report is not a guide to fault finding, or routine maintenance. Nor does it describe the remedial work which may be necessary to repair defects.

The evaluation reports are primarily based on bench tests carried out in the Centre. However one Irwin tester included in the summary has not been seen by us, but we presume that it closely resembles the other Irwin tester we have examined. One of the Edgecumbe PATs has only been examined outwith the Centre and has not therefore been as thoroughly inspected as the others in the report. It should be obvious from the summary where testing has been incomplete.

The survey is believed to cover the complete market as of March 1991 with the exception of some models of PATs from Clare. It was thought sufficient to test no more than three instruments from that company.

The survey has not separately included 110 V versions of the standard 240 V models.

Context

The major part of portable appliance testing consists of a series of visual inspections and checks. The use of PATs in a routine maintenance programme is of lesser importance, although none-the-less necessary, than the series of visual inspections.

Statutory requirements

Regulations

The Electricity at Work Regulations 1989 [1] made under the Health and Safety at Work Act imposed general requirements on employers with respect to electricity at work. These included under Regulation 4(2) "as may be necessary to prevent danger, all systems shall be maintained so as to prevent, so far as is reasonably practicable, such danger".

This is the only reference to maintenance in these Regulations. The need to carry out routine electrical tests on apparatus is seen as a necessary requirement. However the Regulations shy away from explicitly specifying what actual tests should be performed. The HSE Guidance on Regulations [2] refers to other published sources for technical details of tests which might, or might not, be applicable. These other sources include the series of guidance notes and booklets published by the HSE and HSC on safety, including electrical safety. They also include British Standards and *The IEE Wiring Regulations*.

We understand from correspondence with the HSE and from discussions with an HSE Factory Inspector that the employer is expected to be sufficiently competent to decide what tests to apply, and what test limits to set. The onus is therefore for the time being at least placed on the employer to decide for himself what testing to carry out, and what test limits to apply.

This must not be intrepreted to mean that the HSE is disinterested in testing, or in whether testing is carried out. They are very interested. Their main concern for the present is in getting employers to set up routine maintenance programmes rather than fuss over the details of such programmes.

HSE Guidance Notes

GS23 [3] provides a guide to tests which might be carried out on portable apparatus in schools. Its specifications are merely guidance, not legal requirements, or definite instructions. It specifies:

- checking earth bond resistance with a test current of at least twice the fuse rating; two pass conditions are given: either the resistance should be less than 0.1 Ω, or 0.5 Ω for loads fused at 3 A or less; and

- checking insulation with a test signal of 500 V a.c. minimum, but does not specify what the pass condition should be.

The latest edition of Guidance Note PM32 [4] now too includes a copy of the typical routine checks for portable apparatus that appears in the Appendix of GS23. It also advises "For Class 1 apparatus earth continuity tests using a substantial current capable of revealing a partially severed conductor, and insulation tests, should be carried out as described in the relevant British Standard for the apparatus".

We are therefore being advised to use either the above tests from the Guidance Notes' appendices, or tests from British Standards.

British Standards

Whilst these are not concerned solely with electrical safety they contain sets of tests on earth bonding and insulation and specify pass conditions. Many of the tests and test limits found on portable appliance testers relate to British Standard tests. Some correspond exactly. Some bear a rough correspondence. Some bear no correspondence at all.

British Standards are arrived at by consensus rather than solely from the best advice of technically competent experts. They are in general highly regarded as being the best, acceptable standards to work with. They are seldom ever definitive. Most Standards are periodically corrected, amended, or revised.

There is no standard specific to electrical apparatus in schools. Other standards whose scope is wider than school apparatus are made use of [5] [6].

Earth bond test

The term 'earth bond system' refers to all electrically conducting parts bonded to earth by the earth conductor. In practice it has to include the earth conductor in the flexible cord connecting the apparatus to the 13 A socket outlet.

The test measures the resistance between the earth pin on the 13 A plug and other parts of the earth bond system (Fig.1). To comply with British Standards the resistance between the earth bond terminal of the appliance and any other part of the earth bond system must have a resistance not exceeding 0.1 Ω. The resistance of the flexible cord is not included in the measurement. However it is usual for practical reasons to assume that the flexible cord is also part of the earth system of apparatus and to include it in the test.

conductor being damaged from the overheating which this current causes, the period the current is applied should be limited to 5 s at most.

The power source in the PAT delivering the test current is very low voltage a.c., typically 6 V. Therefore the earth bond test operator is not at risk of electric shock, but the sparking which the large current can cause at a poor earth connection - usually at the test probe - can be alarming.

Many PATs also provide for testing at the less stressful level of around 6 or 8 A. Some apply the same pass condition of 0.1 Ω, but others use weaker limits of 0.25 Ω, or even 0.5 Ω. We question the worth of these secondary tests and test limits. They fail to discriminate between standard and sub-standard earth bonding. All that less stringent testing achieves is to show that sub-standard wiring is indeed sub-standard.

We therefore think that all apparatus should be tested at 25 A for 3 s if fitted with a 3 A fuse. Otherwise the test period should be 5 s. The pass condition should be 0.1 Ω, including, for practical reasons, the flexible cord.

Multiple testing

In addition to testing that the conducting enclosure is properly bonded to earth, it is also necessary to test certain other parts of apparatus. It must not be taken for granted that conducting fitments will be adequately earth bonded even although the enclosure has been found to be so. Very often a layer of paint or varnish will insulate one part from another and cause parts which should be earth bonded to fail.

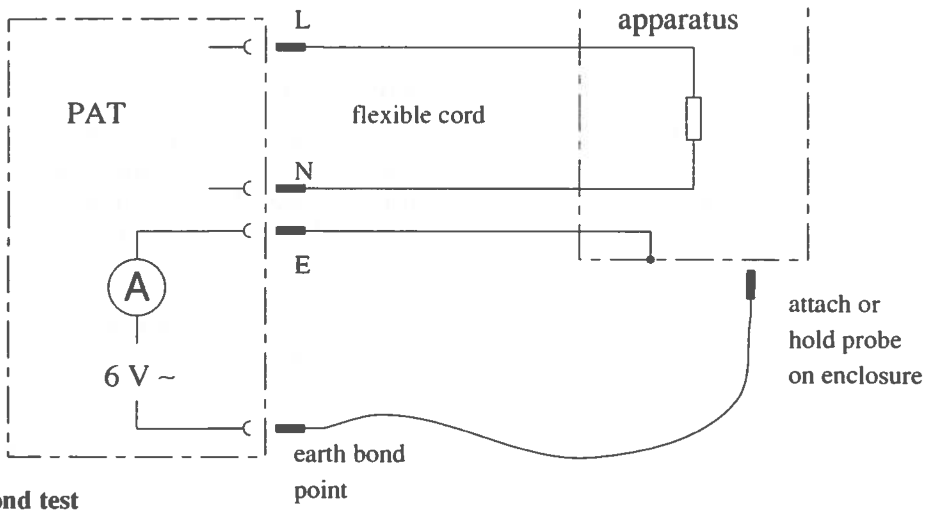


Fig.1 Earth bond test

The test must be deliberately stressful so as to burn out and thereby fail a grossly under-rated earth conductor or badly made connection. Other conductors which are only a little under strength and register a fail are not burnt out by the test. By rule of thumb, the test current should be nominally twice the fuse rating.

To be able to test to this BS pass condition, a PAT must be capable of delivering a current of at least 25 A into a load resistance of 0.1 Ω. To prevent an earth

We therefore recommend separately testing the following parts:

- each part of the enclosure, if in separate parts, e.g. lid and base;

- metallic switch if it forms a conducting path to the interior of the enclosure;

- any screw fastening the isolating transformer (one screw only);

- metallic carrying handle which is part of the earth bond system;

- any other significant parts which might be gripped.

Minor parts need not in general be tested. Apart from the first test, which should be to the frame chassis or enclosure, a test period of 1 s is normally sufficient for all secondary parts.

To prevent the procedure becoming unduly long, the PAT must be able to carry out earth bond tests in rapid succession. Several models do not allow for this.

Insulation test

Unlike earth bond testing, which needs to be stressful, insulation testing should preferably not be so. The amount of stress is dependent on the magnitude of the test voltage. Too high a voltage can permanently damage an insulation system, and can place the test operator at risk of electric shock.

We therefore think that the test voltage in routine testing should be limited to 500 V.

GS23 suggests that the 500 V test signal should be a.c. There is no corresponding BS type test. Indeed as far as we can find out, the reason behind a.c. being specified in the Guidance Note is that a.c. is easier to generate than d.c. We don't think that this is a good reason! Possibly this has something to do with the inability of the Guidance Note to specify what the test pass condition is?

Having recognized the muddle, most PAT manufacturers have sidestepped a.c. and standardized their insulation test on 500 V d.c., at which there is a BS type test of insulation resistance. As far as we can judge, electrical reasons point to a d.c. test being preferable to a.c., these being:

- the relative simplicity of carrying out resistance rather than impedance measurements;

- the relative simplicity of using the minimum acceptable values for insulation resistance adopted by BS, namely 2 MΩ for Class 1 and 7 MΩ for Class 2 apparatus;

- avoidance of spurious failures caused by capacitors connected between the live pole and earth in some apparatus;

- avoidance of dielectric stress caused by applying 500 V a.c. across certain components which might be susceptible to damage.

Possibly the one sound reason in favour of a 500 V a.c. test is that it tests with a signal that closely resembles, but is more demanding than, the operating voltage, 240 V a.c.

There being no BS type test at 500 V a.c. you the user and they the PAT manufacturers have to decide what the pass limit is. The nearest BS test is one at 250 V a.c. This sets a pass condition for leakage current to earth at 0.75 mA, or 0.75 mA per kilowatt, whichever is greater, with a maximum of 5 mA for the appliance as a whole. If this is scaled up by the voltage ratio 250:500, it becomes 1.5 mA for most laboratory apparatus. The Harris tester adopts this pass condition. Clare is the other manufacturer of PATs which test at 500 V a.c. They have set their pass condition empirically at 5 mA. Experience has shown that almost all apparatus whose insulation is sound passes under this limit.

Because the HSE have so far been unwilling to issue firm advice on insulation testing, the Centre is adopting for the time being a liberal policy towards this test. Some PATs are a.c.; some d.c. As with the morals of our age, anything goes in certain quarters! The test can be either a.c. or d.c. The pass conditions we recommend are:

(1) on 500 V a.c., a leakage current not exceeding 5 mA a.c. at 50 Hz, or

(2) on 500 V d.c., an insulation resistance not less than 2 MΩ.

How it's done

The test is carried out through the three core flexible cord connecting the apparatus under test to the portable appliance tester. The live and neutral conductors to the apparatus being tested are commoned within the appliance tester and a 500 V signal is applied across them and the earth conductor (Fig.2). The on/off switch on the apparatus clearly must be in the *on* position for this test to be meaningful.

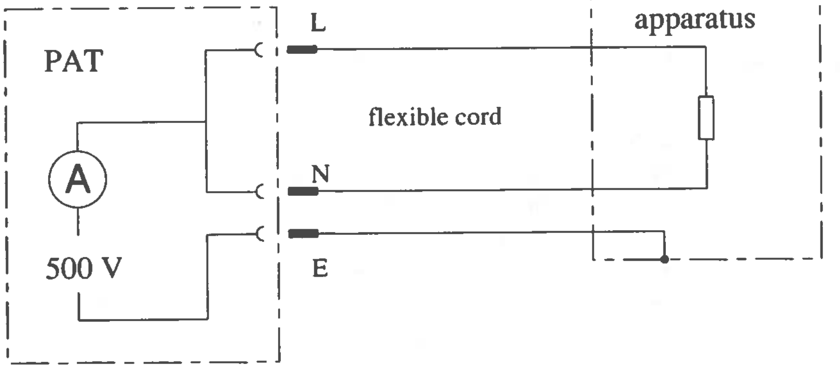


Fig.2 Insulation test, Class 1 apparatus

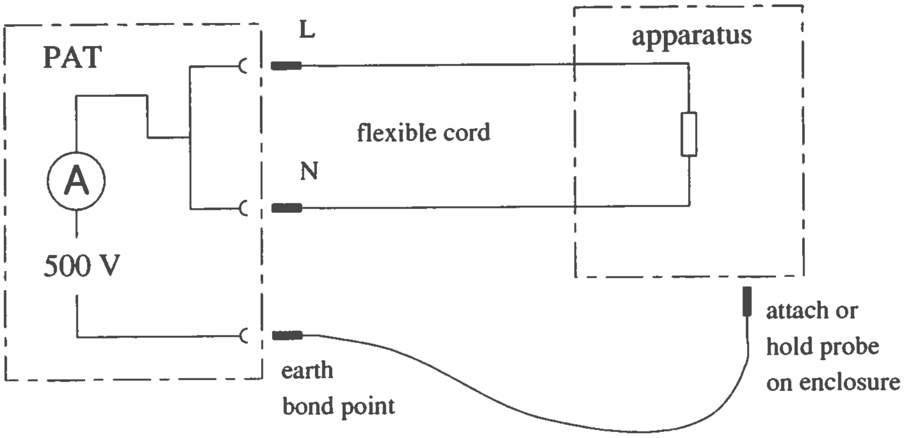


Fig.3 Insulation test, Class 2 apparatus

To test Class 2 (all-insulated and double-insulated) appliances, it is necessary to hold the flying lead from the earth terminal on the PAT firmly against that part of the appliance's enclosure whose insulation seems most vulnerable and carry out the test (Fig.3).

The PAT measures either the leakage current to earth, if the test is a.c., or the insulation resistance, if d.c. The test period should be 5 s minimum.

Risk to operator

If the earth bond and insulation systems of the appliance under test are both defective the enclosure of the appliance becomes live at 500 V with respect to earth. Any operator touching this enclosure is then at risk of receiving an electric shock.

Because of this risk, all but one of the PATs we looked at have been designed so as to limit the short circuit current which the insulation test can deliver to about 5 mA. We have checked this feature.

One manufacturer, Clare, has incorporated a safety interlock. This ensures that the insulation test voltage cannot be applied unless the earth bond test registers a pass. Also, it automatically switches off the insulation test voltage should the earth bond system fail during this test.

The operator should never touch the appliance under test except by gripping the earth bond test lead connected to the PAT, which is then completely safe. In those PATs in which the tests are carried out sequentially under manual control, such as on testers made by Megger, the operator must not carry out an insulation test without first ensuring that the earth bond system has passed.

Other tests

The two standard tests are earth bond and insulation. All the PATs we saw do these two tests. However some models we looked at carry out further tests whose purposes are described here.

Flash test

This is another test of insulation, but at a higher voltage than the standard test described above. Class 1 appliances are normally tested at 1250 V a.c. applied across the conductors in the flexible cord (Fig.2). Class 2 are tested at around 3750 V a.c. This is applied between the commoned live and neutral conductors within the apparatus enclosure and an insulated probe which is held against the exterior of the enclosure (Fig.4). Some variation in specifications of flash test voltages is found from one model of PAT to another.

The PAT measures the current leaking through the insulation system. The pass level is typically a few milliamps - 3 mA or 5 mA dependent on model of PAT.

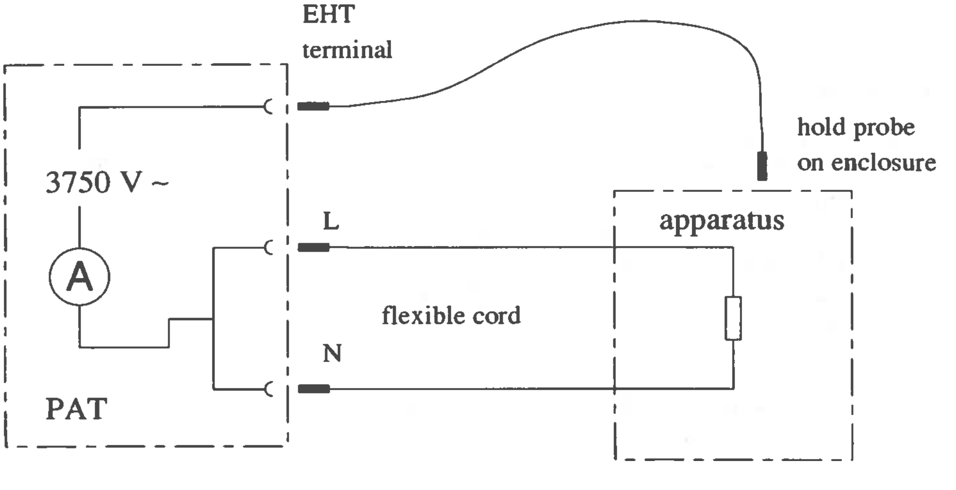


Fig.4 Flash test, Class 2 apparatus

The flash test is deliberately stressful. Because of the harm that it might do to an insulation system, it should not be carried out frequently on apparatus. The risk of serious harm to the operator is contained by protection measures within the PAT to prevent the short circuit current rising much above the pass level current. Although a shock is unlikely to be lethal, it could well be very painful (5 mA at 4 kV is not my idea of kicks!).

Because of these risks, we question whether schools should carry out flash tests. Do the risks not outweigh the benefits? We have only two instances in our test records of the last five years, of apparatus passing an insulation resistance test at 500 V d.c. and subsequently failing a flash test at 1500 V a.c. One was on apparatus under development which, because of a multiplicity of design faults, never reached production. The other was on apparatus in regular use which, because it was designed to Class 1, was reasonably safe provided its earth bond system remained intact.

We therefore for the present, and until we get evidence to the contrary, recommend that schools do not flash test apparatus. Such tests are more appropriately carried out under specialized conditions, such as in regional technician centres where apparatus is sent for repair.

Load and operation tests

As the nomenclature for these tests is not standardized, you have to look carefully at the test specifications to see what they are.

By *load test* we are referring to a test voltage at extra low tension, typically 6 V a.c., applied across live and neutral to measure the power rating of the apparatus. Its usefulness is that it can help to prevent the explosion which might occur were the test carried out at 240 V on apparatus with a direct live to neutral short. There is little need for such a test in schools as this fault condition would make itself evident before the apparatus was withdrawn for a routine maintenance check!

By *operation test*, we are referring to a test at 240 V a.c. across live and neutral with an indication of the power consumption. The measurement of power is useful, but not thought essential in a programme of routine testing. The check that the apparatus works correctly at 240 V is thought essential - but you don't need a PAT to do it!

Earth leakage test

Some insulation systems pass at room temperature, but break down when hot. Apparatus with mineral insulated heating elements such as electric kettles, water baths and some types of radiant heaters are particularly susceptible to this fault condition. Neither the insulation test, nor flash test, pick up this defect, although bad breakdowns would be spotted with sockets protected by a residual current circuit breaker (RCCB).

The earth leakage test checks the integrity of an insulation system at the standard operating voltage. The PAT applies 240 V a.c. across live and neutral and measures the leakage current to earth. The British Standard test limit for Class 1 apparatus is 0.75 mA, or 0.75 mA per kW rated input for each element or group of elements, whichever is the greater, with a maximum of 5 mA for the appliance as a whole.

Few models of PAT make provision for this test. In one model the earth leakage and operation tests are carried out jointly as a single test procedure.

Earth leakage faults are not uncommon. They certainly occur far more frequently than do breakdowns in insulation systems tested at room temperature. In our opinion, earth leakage testing should possibly therefore be carried out routinely in schools on apparatus susceptible to this fault condition. This goes further than the present HSE recommendations, but seems a commonsense decision on the evidence we have.

Other features

Readings displayed

Most PATs use indicator lamps to show the test results, there being separate lamps for the earth bond and insulation tests. Five PATs had meters, allowing test figures to be obtained.

The two so-called benefits of the indicator lamp system are simplicity and cost. However if the time which the obtainment of test value readings saves in diagnosing a fault and fixing it is also considered, the advantage swings the other way. We therefore recommend that if repairs are to be carried out on the premises, the establishment should buy a PAT with a meter.

Link to printer or computer

One Seaward tester has such a provision. The PAT can store up to 1000 results before it's necessary to download. The PAT can therefore be used as a portable tester unencumbered by IT peripherals. We quite like this means of obtaining records. The main snag is that since the relative importance of PAT testing to visual inspections is of the order of 1 to 10 it over-emphasizes that which is of minor worth. Thus you are probably best advised to steer well clear of this provision.

110 V appliance testers

If you have apparatus that operates off 110 V, such as portable workshop tools, you will need to provide for their testing. Some models of PAT have 110 V versions. However the most cost effective solution would be to buy a PAT which has dual provision to test 240 V and 110 V apparatus.

Calibration

If you are to have confidence in the test results which your PAT obtains you must have some means of having your instrument tested and calibrated. An annual or biennial calibration is recommended. Some suppliers operate calibration services. Clare provides a dummy load with which you can roughly self-check your own tester.

Test result summary

Provisions, specifications and tests are tabulated overleaf. Specific comments on each model of PAT are given below. Full test reports are available on request to the Director of the Centre.

Bridage Earth Insulation Tester

The Bridage tester does not set the appropriate earth bond test level, nor can it do an insulation test at 500 V.

Other unsatisfactory features are the overheating of the transformer, the drift of the insulation test voltage, the absence of protective measures to prevent insulation test high voltages being applied to equipment that has failed the earth bond test, and the absence of instructions.

Clare Electrical Safety Tester V152/M888

The V152/M888 Clare tester satisfactorily provides earth bond, insulation and flash tests. Insulation testing is at a.c. The safety interlock provision is good. We like the sample Test Log which places visual inspections before electrical safety tests in order of importance.

Clare Electrical Safety Tester V154

The V154 Clare tester satisfactorily provides earth bond, insulation (a.c.), flash and operation tests. Both earth bond and operation test results are metered. Other, general comments are as for the previous Clare model.

Clare Electrical Safety Tester V341

The V341 Clare tester satisfactorily provides earth bond and insulation (a.c.) tests. Other, general comments are as for the previous two Clare models.

Edgecumbe Metrohm

The Edgecumbe Metrohm is not, in its present form, suitable for testing portable, school apparatus. It has two failings. (1) The earth bond test period, at 30 s, is unreasonably long under automatic operation and could result in damage to conductors. (2) The insulation test limit is not the requisite value, namely 2 MΩ. Further to these failings, the appliance tester is relatively expensive for what it offers, namely pass/fail indications of two tests only.

Edgecumbe Metrohm PAT

Because the Metrohm PAT carries out its test operations in automatic sequence, it cannot make multiple earth bond tests in quick succession. This failure is an operational weakness. The insulation test short circuit current is 9 mA and is considered hazardous. The Metrohm PAT is relatively expensive for what it offers, namely pass/fail indications to four electrical tests.

Harris Electrical Safety Tester

The appropriate earth bond test of Class 1 equipment is 25 A nominal at 0.1 Ω. The Harris Tester does not deliver a sufficiently large current to test to this level.

Another unsatisfactory feature is the presence of 50 V a.c. between live and neutral combined and earth during periods when testing is not being carried out. The output is therefore never dead, not even when the test button is not being depressed. This feature is however thought not to be dangerous.

Since completion of our PAT evaluation programme Harris have withdrawn this product from the market. It is now being re-designed.

Irwin Earth Bond and Insulation Tester EA0799

This PAT does not carry out an insulation test at 500 V and therefore would not be suitable. See next report.

Irwin Earth Bond and Insulation Tester EB0799

This PAT satisfactorily tests earth bonding, but its ability to test insulation is not so sound. The insulation test voltage drops to 100 V d.c. with 70 V a.c. superposed across a 2 MΩ load. This is inadequate.

Megger PAT 2

The Megger PAT 2 satisfactorily provides earth bond, insulation (d.c.), flash, load and operation tests. All tests are metered. We have no hesitation in recommending this instrument if you want the provision for flash testing, although it is rather pricey.

Megger PAT 3

The Megger PAT 3 satisfactorily provides earth bond and insulation (d.c.) tests, both of whose results are metered. It also performs a *continuity test* to establish whether there is a conducting path between live and neutral. A dual version to test both 110 V or 240 V apparatus is available. We have no hesitation in recommending this instrument, although it too is rather pricey.

Megger PAT 101

This is the latest model from Megger. The PAT 101 satisfactorily provides earth bond, insulation (d.c.), flash, operation and earth leakage testing. All tests are metered, although the scale can be momentarily confusing. These facilities, which now include earth leakage testing, make it a potentially more useful tester than either the PAT 2 or PAT 3 from Megger.

Unfortunately, whilst in general being very soundly designed and constructed, the PAT 101 has one electrical feature which is hazardous. When the function switch is set on position 3 (*INSULATION*), the flash probe is live at HV and the lower right hand 13 A socket outlet is live at 2.4 kV. The safety of the operator depends solely on reasonable expectations of the voltages which ought to occur on each electrical outlet on the different switch settings. Because these high voltages are unrelated to the insulation test they are unexpected, and therefore hazardous.

In reply, Megger have written: "Though voltage is present as described by SSERC, note the following:

Manufacturer	Bridage	Clare	Clare	Clare	Edgcumbe	Edgcumbe	Harris
Type	EthInsTr	ElSfyTr	ElSfyFnTr	ELSfyTr	Metrohm	Metrohm PAT	ElSfyTr
Supplier	Eagle	Clare	Clare	Clare	RS	RS	Harris
Stock number	P58-700	V152/M888	V154	V341	610-770	255-654	C67565/1
Price	£140.63	£386	£495	£218	£384.10	£350.00	£135.02
Earth bond test:							
25 A at 0.1 Ω nominal	yes	yes	yes	yes	nominal	yes	nominal
25 A current check	pass	pass	pass	pass	unchecked	pass	fail, 14 A
0.1 Ω limit check	fail, 0.35Ω	pass	pass	pass	unchecked	pass	yes
test period ≤ 5 s	yes	yes	yes	yes	fail, 30 s	yes	yes
rapid multiple testing	fail	yes	yes	yes	fail	fail, 60 s	yes
result indication	unlatched	unlatched	unlatched	unlatched	-	latched	unlatched
Other earth bond tests	no	8.5A, 0.1Ω 10A, 0.5Ω 6A, 0.5Ω	10A, 0.5Ω	10A, 0.5Ω	8A, 0.25Ω	10A, 0.5Ω trip levels 0.2, 0.3, 0.4, 0.5 Ω	10A, 0.5Ω
Insulation resistance test:							
500 V d.c. at 2 MΩ nom.	no, 1000V	no, a.c.	no, a.c.	no, a.c.	no, 0.5 MΩ	yes	no, a.c.
500 V voltage check	fail	-	-	-	unchecked	pass	-
2 MΩ limit check	fail	-	-	-	-	pass	-
Other resistance tests	no	-	-	-	-	500 V, 7 MΩ	-
Insulation a.c. tests:	no	500 V 1250 V	500 V 1250 V	500 V 1250 V	no	no	500 V
Insulation test safety:							
short current ≤ 5 mA	pass	pass	pass	pass	unchecked	9 mA	pass
switch-off on failure	no	yes	yes	yes	unchecked	no	no
Insulation test indication	unlatched	latched	latched	latched	-	latched	unlatched
Flash tests:	no	3000 V 4000 V	3000 V 4000 V	no	no	no	no
Earth leakage test	no	no	no	no	no	no	no
Load test (at low V)	no	no	no	no	no	yes	no
Operation test (at 240 V)	no	no	yes	no	no	no	no
Test values displayed	no	no	analogue	no	no	no	no
Computer link	no	no	no	no	no	no	no
Printer link	no	no	no	no	no	no	no
110 V version	no	no	no	no	yes	yes	no
Dual 110 & 240 V versn.	no	no	no	no	no	no	no
Sequencing of tests	parallel	parallel	parallel	parallel	automatic	automatic	parallel
Calibration service	no	dummy l'ds	dummy l'ds	dummy l'ds	yes	yes	yes
Other comments	isolating transformer overheats	dual 110V/ 240V models available					outlet not dead in off condition
Assessment	C	B	B	B	C	C	C

Manufacturer	Irwin	Irwin	Megger	Megger	Megger	Seaward	Seaward
Type	EthBnd&InTr	EthBnd&InTr	PAT 2	PAT 3	PAT 101	PAC 500	PAT 1000
Supplier	Irwin	Irwin	RS	RS	RS	RS	RS
Stock number	EA0799	EB0799	612-243	253-131	255-856	654-641	254-853
Price	£109.00	£112.00	£570.00	£363.00	£620.00	£132.00	£590.00
Earth bond test:							
25 A at 0.1 Ω nominal	yes	yes	yes	yes	yes	no, 0.3 Ω	yes
25 A current check	unchecked	pass	pass	pass	pass	unchecked	pass
0.1 Ω limit check	unchecked	pass	pass	pass	pass	fail	pass
test period ≤ 5 s	yes	yes	yes	yes	yes	yes	yes
rapid multiple testing	yes	yes	yes	yes	yes	yes	no*
result indication	unlatched	unlatched	meter	meter	meter	unlatched	LCD display
Other earth bond tests	no	8A, 0.5Ω	no	no	4A, 0.1Ω	no	8 A 2 pass limits: 0.1Ω, 0.25Ω
Insulation resistance test:							
500 V d.c. at 2 MΩ nom.	no, 1000 V	nominal	yes	yes	yes	yes	yes
500 V voltage check	-	fail, 100 V	pass	pass	pass	450 V	pass
2 MΩ limit check	-	fail, 5 MΩ	pass	pass	pass	pass	pass
Other resistance tests	no	1000 V	no	no	no	no	no
Insulation a.c. tests:	no	no	no	no	no	no	no
Insulation test safety:							
short current ≤ 5 mA	unchecked	pass	6 mA	pass	pass	pass	pass
switch-off on failure	no	no	manual	manual	manual	no	no
Insulation test indication	unlatched	unlatched	meter	meter	meter	unlatched	LCD display
Flash tests:	no	no	1500 V 3000 V	no	1kV, 2.5kV 1.5kV, 3.75kV	no	1500 V 3000 V
Earth leakage test	no	no	no	no	yes	no	yes
Load test (at low V)	no	no	yes	continuity	no	no	yes
Operation test (at 240 V)	no	no	yes	no	yes	no	yes
Test values displayed	no	no	analogue	analogue	analogue	no	digital
Computer link	no	no	no	no	no	no	yes
Printer link	no	no	no	no	no	no	yes
110 V version	no	no	yes	no	yes	yes	yes
Dual 110 & 240 V versn.	no	no	no	yes	no	no	yes
Sequencing of tests	parallel	parallel	manual	manual	manual	parallel	automatic
Calibration service	self	self	yes	yes	yes	no	yes
Other comments					socket live at 2.4 kV		* available on new model 1000S out shortly
Assessment	C	C	A	A	C	C	B

i. The current is token, less than 5 mA, the level stated by HSE as safe.

ii. The socket not in use is shuttered, access can only be with illegal tool or prod.

iii. To expose the metal tip of the flash gun, the trigger needs to be pulled. The operator needs two hands to operate the insulation test and hence needs two more to operate flash gun and grip to get a slight tingle. Therefore in practice the PAT 101 is safe, even in misuse."

We aren't much comforted by Megger's assurance and will reply to tell them so. In the meantime, we cannot recommend this instrument in its present state.

Seaward PAC 500

The Seaward PAC 500 is a small, compact instrument that is simple to operate and relatively inexpensive. It adequately carries out insulation tests (d.c.), but uses an earth bond test limit that is higher than we recommend.

In reply, Seaward have written: "The 0.3 Ω pass band was designed into the unit to compensate for the ease of use this product gives. As you are probably aware the earth continuity tests associated with safety standards do not include the resistance of flexible mains leads. Therefore to compensate for the lead on the appliance under test an extra resistance of 0.15 Ω was allowed and 0.05 Ω for tolerance. This would still provide a good indication of a product's true earth bond resistance."

Seaward PAT 1000

The Seaward PAT 1000 satisfactorily performs earth bond, insulation (d.c.), flash, earth leakage, load and operation testing. All test values are metered on an LCD display. There is the facility to download results to a printer or computer.

The only significant defect we found was that because the PAT 1000 carries out its operations in an automatic sequence, it cannot, as presently programmed, make multiple earth bond tests in quick succession. This is an operational weakness. We understand from Seaward that they have acted to remove this problem. As from late May, a new version of the PAT 1000, the PAT 1000S, will be available. This has software improvements that will allow up to 15 earth bond tests to be made in succession, but will only store and print the worst reading.

On this basis, the PAT 1000S would appear to be a sound buy.

Verdict

Assessment codes in the Summary Table are:

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

B - satisfactory for use in above

C - unsatisfactory

Best buy?

We prefer PATs to have metered outputs rather than indicator lamps and which measure insulation resistance on d.c. The simplest of the sample that soundly performs both earth bond and insulation resistance testing is the Megger PAT 3 at £363. Of particular interest to some might be the dual voltage version which tests both 240 V and 110 V apparatus (RS 253-973 at £429).

Dispensing with both of these preferences, the Clare V341 is soundly engineered and quite reasonably priced at £218.

Moving up the list of provisions, the cheapest PAT which also does flash testing is model V152/M888 from Clare at £386. However if metering and d.c. testing are wanted, there is the Megger PAT 2 at £570, or the Seaward PAT 1000S at £590. This latter also provides for earth leakage testing.

Unsatisfactory models

We are aware that many authorities and schools have already purchased PATs. If you are in this position and find that we have given your instrument an unsatisfactory assessment, what do you do about it?

We recommend that you plan for the replacement of your unsound PAT, but in the meantime go on using it. The summary table, as well as indicating what your PAT's defects are, which you may have to live with for the time being, also shows what the instrument's capabilities and strengths are. Since there are no legal requirements on test specifications, sub-standard testing is better than no testing.

We make no apology either for reiterating (this will be the third time) the relative weight which must be placed on the use of PATs. Although they are important, in that they will pick up faults which might otherwise go undetected, 90% or so of common defects will be found through simple, visual inspections of plugs, cables and enclosures etc.

References

1. The Electricity at Work Regulations 1989, SI 1989/635, HMSO, ISBN 0 11 096635 X.

2. Memorandum of guidance on the Electricity at Work Regulations 1989, HS(R)25, Health and Safety Executive, 1989, HMSO, ISBN 0 11 883963 2.

3. Electrical safety in schools (Electricity at Work Regulations 1989), Guidance Note GS23, Health and Safety Executive, 1990, HMSO, ISBN 0 11 885426 7.

4. The safe use of portable electrical apparatus (electrical safety), Guidance Note PM32, Health and Safety Executive, 1990, HMSO, ISBN 0 11 885590 5.

5. BS 3456 : Part 201 : 1990 Safety of household and similar electrical appliances, British Standards Institution, ISBN 0 580 17335 6.

6. BS 7002 : 1989 Safety of information technology equipment including electrical business equipment, British Standards Institution, ISBN 0 580 17262 7.

Equipment Notes

Grampian Op-amp Board

We have recently had in for evaluation an op-amp board from a company called J J M Electronics, newly formed by a Morayshire teacher. He has written to tell us, "I have been making circuit boards for use in my own department for several years (greatly aided at the start by a technician inspired and trained at a SSERC in-service on electronics construction). My initial motivation for this was dissatisfaction with the equipment available for the electronics option topics in H and CSYS Physics."

How can we possibly be impartial with comments like that? You just have to trust us! Truly, our appraisal had been carried out before we had heard directly from the teacher. The kind comments prefaced his reply to our evaluation report, which is summarized below.

Construction

The board is a single-sided p.c.b., very soundly constructed, with the components and sockets mounted on the top surface (Fig.1).

We like the use of 4 mm sockets for external connections, and 1 mm sockets for internal. This latter feature facilitates the fitment of unmounted 0.25 W resistors, or capacitors, to the board. An excellent arrangement! A technique for making wire links using turned pin DIL or SIL sockets is suitably well explained in the technical notes which the manufacturer supplies.

Educational facilities

The top of board layout strikes a reasonable compromise between the need to permit the construction of many different circuit configurations and yet still be as simple as possible. A very good layout has been achieved. Components are laid out more-or-less exactly as they would be in circuit diagrams. The board is readily suitable for all of the following circuits:

- inverting amplifier
- differential amplifier
- comparator without hysteresis
- current to voltage converter
- summing amplifier
- voltage follower
- differentiator
- integrator

This list includes the complete set of op-amp circuits required by the revised H Grade and CSYS Physics syllabuses.

Listed below are some of the circuits for which the board is not particularly suitable, either because of the need to add flying leads, or mount components in a dog-legged fashion, or inability to fit all the components on the board:

- non-inverting amplifier
- comparator with hysteresis
- logarithmic amplifier
- relaxation oscillator
- active filter

In response, the designer points out that the non-inverting amplifier "can still be built reasonably simply by using a single 4 mm lead to ground R_{in} - not very tidy I admit, but surely no worse than other op-amp boards?"

Technical matters

Two 210° turn potentiometers are provided. These supply variable voltage d.c. outputs, which can be applied to the op-amp inputs. The impedance of one of these pots is 1 kΩ. This is reasonably low. However the 5 kΩ resistance of the other pot is high enough for there sometimes to be appreciable over-loading. This may result in some confusion.

The op-amp on the board is a 741. This is now hopelessly obsolescent and is out-classed by all the rest of the market. However it is sufficient for this need, and cheap.

The absence of markings to show power rails and power connections to the op-amp is approved of. They would only have added confusing clutter.

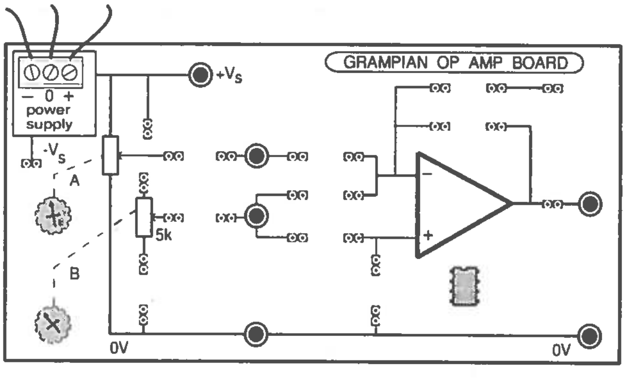


Fig. 1

The lack of an offset-null pot is also welcomed (although p.c.b. tracks have been provided for one to be fitted). Such pots can be confusing to a class of beginners. Also they correct for just one out of many deviations from ideal behaviour.

Activity sheets, etc.

There are accompanying activity sheets for pupils, a workshop manual and teachers' guide - all produced to a high standard. The workshop manual is supplied with the board. We understand that the other printed material is being distributed nationally by TVEI to regional TVEI centres, from where copies should be available.

It's particularly good to see reference in the pupil material to the golden rules of ideal op-amp behaviour, and application of these rules to derive the voltage gain of an inverting amplifier. None of the feedback mumbo-jumbo that is so often used to mis-explain op-amp behaviour in other texts!

There is only one feature that niggles, that is the use of the two potentiometers in out-of-balance bridge circuits. An off-board bridge circuit with fixed value resistors and resistive sensors would have been preferable, reserving the on-board pots for signal inputs.

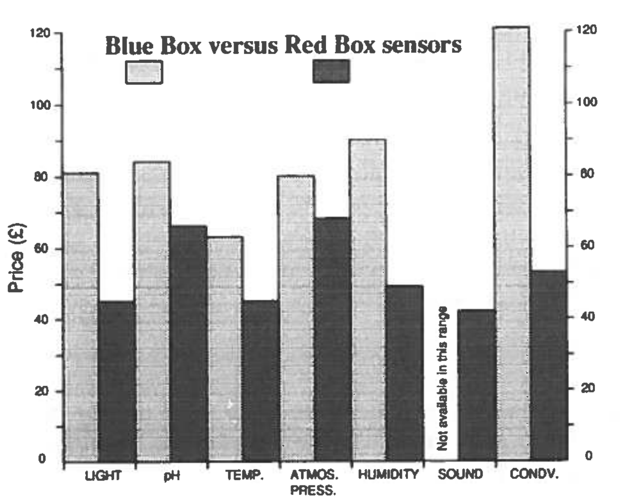
Conclusion

This is an excellent package of hardware and supporting paperwork for use in teaching the behaviour of op-amps. It is immediately relevant to the revised H Grade and CSYS Physics syllabuses. It could also be useful in any other course in or using analogue electronics where some understanding of the circuits listed above is required. That means possible application also in Technological Studies, Electronics Short courses and some SCOTVEC modules.

Relative to other boards, it is generally superior to Unilab's Nuffield Operational Amplifier Board (099.901), to which it is closely related. It is not quite so elementary to work with as is Unilab's H Grade Alpha Kit. It does not provide for input signals as satisfactorily as Alpha, nor does it yet provide for power outputs, which Alpha does superbly, though such provision is under consideration. The Grampian Board is however more versatile and, at £9.35, less expensive.

Sensor cost (£)

Parameter	Philip Harris	Unilab
light	linear sensor (66.06) infra-red filter (15.00)	light sensor (44.40) with filter
pH	pH sensor (44.83) probe (38.81)	pH sensor (37.24) probe (29.00)
temperature	temperature sensor (62.50)	temperature sensor (45.00)
atmospheric pressure	electronic barometer (80.21)	electronic barometer (67.50)
humidity	humidity sensor (89.72)	humidity sensor (49.00)
sound	not available in this range	sound level sensor (42.00)
conductivity	conductivity sensor (53.28) probe (67.37)	conductivity sensor (43.00) probe (30.41)



Equipment Notes

Interfacing latest

OK, what's red and into logging? No, not a Russian lumberjack but a new range of sensors from Unilab. Philip Harris have dominated the sensor market with their excellent 'blue-box' range over the past five years or so. Now in the red corner they would seem to have a fight on their hands. We reserve judgement on their performance until we test them, but on a straight price comparison (see table and bar graph below left) they look good value for money. Unilab say they are the first sensors from a large range which they have planned.

Fig.1 shows the Unilab temperature sensor (sizes are approximate) alongside its Philip Harris equivalent. Each sensor is housed in an aluminium case with plastic end-caps (à la P.H. S-Range). The sides of each box are coloured red. The Unilab sensors feature a 0-1 V output through 4 mm sockets with an internal link which allows the user to change this configuration to ±0.25 V (VELA compatible). Depending on the sensor, they are each powered by either 4 or 6 AA type batteries. Each sensor box has a wee bar-like analogue meter (like the one on the EMU datalogger) which lets you monitor the state of the batteries or monitor the voltage during sensor operation.

Our review of other interfacing devices promised for this issue has proved very time consuming. Publication has been delayed to Bulletin 171 - we hope!

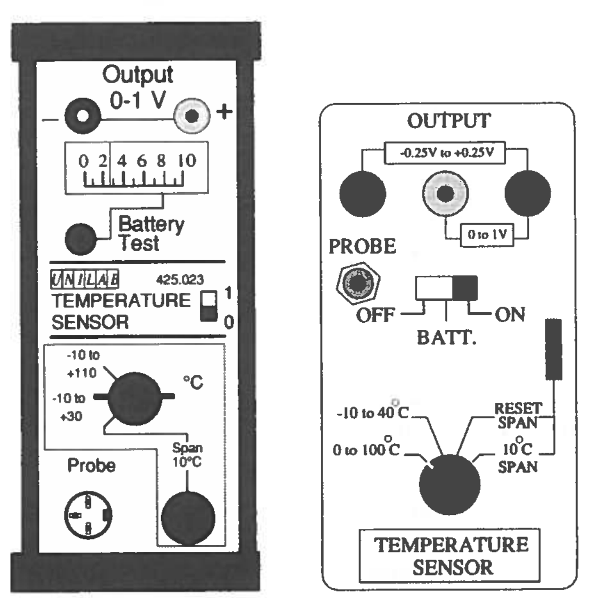


Fig. 1

Opinion III

Ramblings

Cats and technology education

We haven't published many waffley technology pieces. Well, we haven't lately. Recently it seemed that there was far too much competition in the field.

The winding down of our Joint Support Activity Project prompts me however to review and reflect on the types of support we have tried to provide for Scottish technology education. Nearly every such project has both overt and covert aims - hence the ubiquitous jargon of the *hidden agenda*.

Our JSA project has been no different, except that I hope we have managed, until now, to avoid blabbing about things best demonstrated in action and, in the main, better left unsaid.

Latterly we have sensed implied criticism, from high heid yins and others, both within and outwith TVEI, that we have concentrated too much on supporting *hard* aspects of technology. It would seem that we have been inattentive to issues such as technology across and through the curriculum. I suppose we should be grateful that at least somebody from a Central Government agency or department has actually recognised principled prioritized[1] action when they saw it (even if they didn't grasp the principle).

Many readers will know that much of our JSA effort has gone into publishing and training to support SEB syllabuses in *Technological Studies* and *Electronics Short Courses*. In addition the Centre's own core staff have been publishing support material for the sciences which, wherever possible, highlights industrial aspects or applications of science, information technologies and biotechnology. That is what our JSA contract specified.

So setting our priorities does not mean that we aren't interested in strategic, cross-curricular issues. It also doesn't mean that we think technology can only be dealt with effectively in those departments traditionally linked with it. It does mean a difference of tactics and of emphasis.

To put it bluntly: We do not think that cross curricular approaches or technological activity in traditionally non-technical subjects can or should be forced on teachers from above. Currently fashionable top-down approaches based on *technology entitlements* and *curricular mapping* or *technology audits* may not be a total waste of time. They prompt, stimulate and till the ground. Whilst they may so be useful, it is our believe that they lack subtlety. They are unlikely therefore to have great effect on classroom practice.

We would make the same claim over other issues such as changing teaching approaches - introducing active learning, project work etc. Some teachers may adopt changes in methodology because they have seen someone else demonstrate successful practice. They are unlikely to take kindly to anybody who merely preaches at them. Now we can ramble back to the point - which is: Why did we concentrate on supporting only the *hard*, tricky technical bits? Like all good educational answers, ours comes in three bits.

Firstly, 'cos that's what we are good at! There's rarely much harm to be done in sticking to your last. The truthfulness of this is inversely proportional to staff numbers. Maybe other projects and their personnel might like to take note! Secondly, many teachers likely to present for Technological Studies need and deserve all the help they can get. They are being asked to simultaneously build a new personal knowledge base, change teaching approaches and become familiar with a whole range of new equipment. I know they aren't unique, but, they are special. They hold the keys to so many practical problems and processes. That brings us to our third reason.

1. Sorry about "prioritized" - horrible word! Some *technology educationese*, like tetanus, is as infectious as it is deadly. Unfortunately, it lacks the same effect on the jaws!

In the absence of confidence and competence in specialist areas what would be the point of cross-curricular co-operation? Why negotiate and bargain if neither, or no, party has anything worthwhile to offer? We find it hard to see why any teacher beleaguered within their own, once familiar, territory should so boldly venture forth because someone outside and above tells them to do so. This is especially true if they are being asked to go about naked, technologically speaking!

In contrast: what if individual teachers are not only encouraged but also actively enabled to increase and broaden their own skills and knowledge base? Then word soon gets round, that's what. You need an ABC motor control and a DEF printer driver? See Mr X, or Fiona Z, goes up the cry!

In our view, co-operation most often grows from real practical needs - either separate or shared. It can be encouraged. Unlike rhubarb, cross curricular or no, it can't be forced.

Encouraging but not enabling is counterproductive. It merely raises expectations in the absence of means by which they might be met.

In our JSA Project we tried to make some groups of teachers better equipped to meet certain technical needs. By-the-by, we trust we also demonstrated, through example, some ways to manage active and integrated project approaches to teaching and learning.

Topics and problems were deliberately selected as contexts for much of this work because success within them was virtually impossible unless assistance were sought from some other subject specialists. Just try working on control techniques within a biotechnology context without an approach to or from the school's biologists (on microbiological safety if nothing else). One of our Technological Case Studies deals with instrumentation and control in fermentation vessels (bioreactors).

Something about "skinning" cats wasn't it?

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Publications

SSERC Publications

Serial publication ISSN 0267 - 7474:

"SSERC Science and Technology Bulletin" back numbers £2 (£1.50 to callers)

Health and Safety

COSHH Seminar Proceedings 1989 £4

Fume Cupboards in Schools £3

Preparing COSHH Risk Assessments etc.
£4 to members £7.50 to others.

Protection Against Ionising Radiation in Science Teaching - Explanatory Notes; to members £2
non-subscribing Scottish H.E. establishments; £10
all others £40

Transport of Chemicals £2

Equipment and applications etc.

pH Meters & Probes £3

Light Meters Parts A & B (incl. test reports - members and associates in Scotland only) £2

Technical Notes:

(Notes with hand sketches etc. but all good technical stuff!)

Motor Control: £1 per title £3 per set:
Servo Motor - Angular Position Control
Servo Motor - Speed Control
Servo Motor - ZN409 i.c.
Controller Stepper Motor - National Course Notes

A-D and D-A Conversion Notes £0.50

Curriculum support materials:

Standard Grade : Chemistry Practical Guides:
Vol.1 £4; Vols. 2 and 3 £5 each.

Physics Technical Guide Vol.1 (Units 1 and 2) £4
other volumes available in provisional form with final publication during 1991; each volume: £5

(Equipment lists for all three sciences - please enquire)

Revised Higher Grade: Physics - hints and suggestions for experiments and practical activities. £2

Resource File, Case Studies and Teachers' Guide for Technological Studies at the Higher Grade - see advert. on page 26.

Occasional papers

The School Technology Room: Design Brief Basics - A Discussion Paper £2

Standard Grade Biology New Technologies & Training £3

Information Technology Applications

New SSERC "Interfacing in....." series of booklets for each of biology, chemistry and physics. Each set consists of "Background Information"; "Techniques Sheets" and "Task Sheets", per set: £5

The materials are suitable for staff development through flexible learning since they can be used for formal INSET, supported self-study etc. SSERC can also train tutors to support the use of these materials - enquiries welcomed.

DIY Interfacing with the BBC Micro £3

Standard Grade Chemistry Equipment and Chemicals Databases on disc. Running under Beebugsoft *Masterfile II* (Beeb/Arc) or Colton *Pipedream* (Arc only) Site licences - £7 per school or £50 per EA (members only - others on application).

SSERC Graphics Library - see separate advert. inside rear cover.

Other publications

The following titles are joint publications or documents where SSERC originated material is incorporated or where the Centre was otherwise involved and is thus acting as agent or publisher.

Interfacing with Datadisc (Phil Strange then of Argyll & Bute TVEI) £2

Microcomputers in the Science Laboratory (reproduced from Lothian TRIST material) £2

Simple BBC Interfacing Experiments (G.MacNaught Montrose Academy) £3

Unilab Interfacing Workshop (SSERC reset by Lothian TRIST) £4

Microelectronics Monographs:

Funded by IDS, BP and Britoil as was and originally distributed through SCCC. Subsidised cover price originally £1-50 now £1 to clear.

Memo 1 - Construction Techniques
Memo 2 - Data Logger & Battery Backed Memory
Memo 3 - now out of print
Memo 4 - Making a Start in Teaching Electronics
Memo 5 - Industrial Control: Programmable Sequence Controller.

STOP PRESS!

SSERC Graphics Library Bug Fixed!

If any of you have been annoyed by loss of vertical hold when trying to use the !BigScreen or !MaxScreen applications provided on our Graphics Library - why didn't you tell us? We hope it's just that it hasn't happened to you. It only occurs on certain monitors. The problem is now fixed - at any rate for all the combinations of equipment we've been able to try! If it has plagued you - get your £7.50 upgrade. You'll also be getting lots of new DrawFiles and DrawFile generating programs.

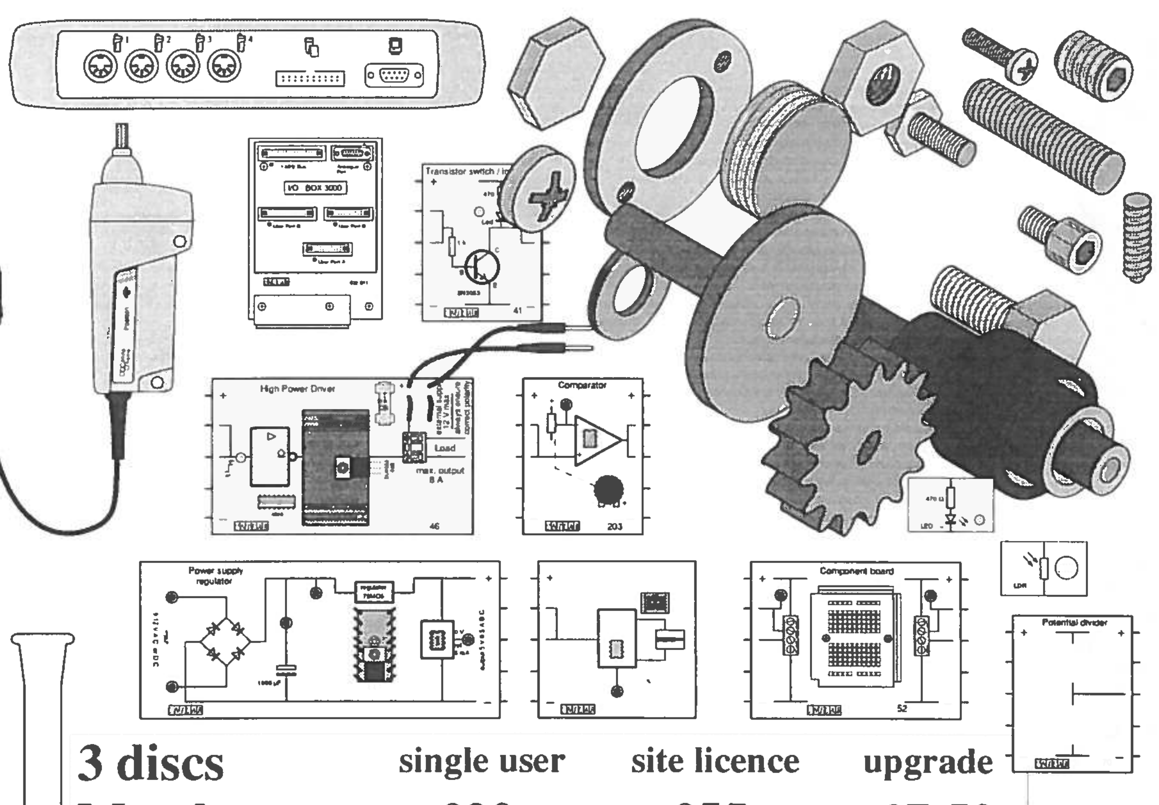
SSERC GRAPHICS LIBRARIES

For Science & Technology Education

For Arc users of Draw, DTP, Magpie, Revelation etc.

Latest:- now with Alpha boards, First Sense, new dataloggers, pneumatics (ISO 1219), better gears and more . . . .

NOW THREE DISCS!



3 discs	single user	site licence	upgrade
Members	£20	£55	£7.50
Non-Members	£30	£85	£7.50

Authority licences available by negotiation

SSERC, 24 Bernard Terrace, Edinburgh EH8 9NX
Tel. 031 668 4421 for more information
or send stamped A4 self-addressed envelope.

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