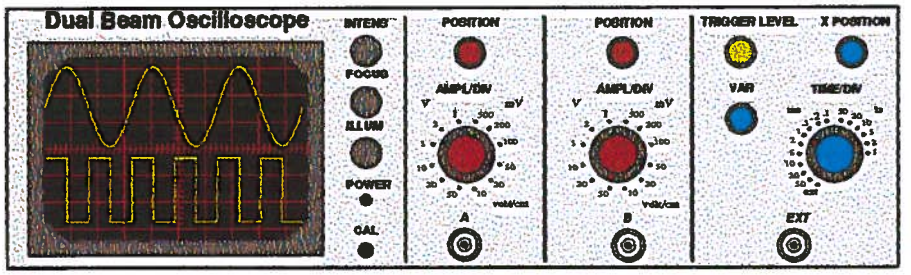
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

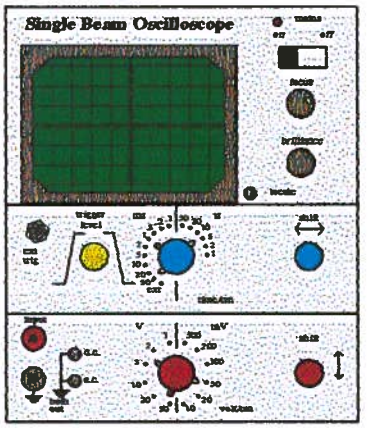
Science & Technology Bulletin

For Teachers and Technicians in Technical Subjects and the Sciences

WHICH OSCILLOSCOPE ?



TODAY



10 YEARS AGO

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Contents

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Opinion

A question of standards

Whilst in some educational circles quality assurance remains flavour of the month in others the mere mention of the phrase means reaching for that wooden stake and the cloves of garlic. The latter are in any case *de rigeur* also in the other camp since much of the push for quality assurance is Euro-driven. Because of the single market the search is still on for that latter day Holy Grail - the level playing field. It's a shame for us that in much of Scotland you don't get many of those to the Ecu.

Particularly fashionable with the gourmets of quality is BS 5750 and its international equivalent ISO 9000. Now SSERC has for some time been a member of the British Standards Institution. Given the number of Ecus that this costs us each year you may assume that we strongly support the aims of that organisation. We are also for the business of testing products according to technical standards and against the raising of technical barriers to trade. What we are not in favour of is that our clients - education authorities and teachers as customers for goods and services - should be misled as to what are reliable and relevant indicators of quality.

Relevance is the key.

BS 5750 is a good standard for which to aim and approval isn't easily obtained. The process involves any organisation in a significant expenditure of time, effort and money. Firms like Philip Harris who recently received approval for their quality control systems are thus to be quite properly and heartily congratulated. Note though that it is a quality system and its associated documentation for which approval is given and not the individual goods or services which are sold. That is why we very carefully add the word "relevant" to the "reliable".

BS 5750 is much concerned with the standard of quality assurance documentation, less so with actual products. The cynical say that it is entirely feasible for a firm which produces shoddy goods or a college which delivers tatty training merely to polish up its paperwork to 5750 standard. Sadly there is nothing then to prevent such firms or institutions from delivering well documented shoddiness and tat.

We speak from a number of recent, annoying experiences. Over the last year or so we have tested several products of registered firms where some aspects of design and construction never came within sniffing distance of meeting the relevant technical and safety standards. Our complaints no doubt were meticulously fed into immaculate quality assurance systems. We still await the emergence of acceptable products at the other end. We must also mention the printing firm with which we dealt, once, whose 5750 system did not include any complaints or disputes procedure. Now there's an assumption!

A parallel can be drawn here between this confusion over the real status of BS 5750 and that of some of the newspapers who got hold of our work on the risk of burns from the wearing of shell-suits in practical rooms. Parents were advised by these august journals to "make sure you buy a more expensive type from a well known maker and if possible one carrying a British Standards number". There is no relevant BS for flammability in such garments. Any BS referred to on a clothing label will be one dealing with issues such as resistance of the fabric to abrasion, colour fastness etc.

We are not saying that BS 5750 is worthless - far from it. It is a useful indicator that an organisation has put in place a systematic approach to quality control. Nonetheless that firm's goods or services still must be judged against separate technical standards directly relevant to that class of product. As the good book says :

"By their works shall ye know them"

Introduction

Notice : Further Education Colleges

Readers in Scottish colleges which will be incorporated on 1st April of this year should note that this will be the last bulletin issue they will receive through the distribution system of the education authority. In future FE colleges will only be able to receive our publications and access our advisory and training services by becoming subscribing members in their own right. Details of subscription rates and application forms can be obtained by writing to the Executive Director of SSERC .

Diary dates

Technology Conference

The World Council of Associations for Technology Education (WOCATE) is this year to hold its international conference in Scotland. WOCATE '93, is to be a "Festival of Technology Education for Elementary Stages (5 - 14)". It will take place at the Aberdeen campus of Northern College.

For the submission both of papers and workshop proposals the deadline is April 30th. These should be sent to the Conference Director for consideration (see Address List on the inside rear cover of this issue).

TTA Annual Meeting

The Technology Teachers' Association has once more given generous notice of the date and venue for its major meeting. The AGM will again be held in Coatbridge High School and the date this year is Saturday 6th November (note studious avoidance of jokes about there possibly being lots of fireworks [Ed.]).

Science and Technology Festival

The Edinburgh International Festival of Science and Technology will be held from 10th - 24th April with the schools' programme running from 1st March until the main festival closes. The schools' programme includes an Olympiad at Heriot Watt University on the 23rd to 24th of March. SSERC will be hosting some workshops on the Schools Chip which will be held here in the Centre and will be open to the general public on a ticket holder basis. Further details on the festival itself are available from the address given in our address list on the inside rear cover of this bulletin.

SSERC Courses

All this stuff about dates reminds us that our own diary is rapidly filling up. Already we have bookings for courses in Health and Safety as far ahead as the Spring of 1994. There is some slack in other areas such as courses on the Schools Chip and other practical workshops. Given all the other things we have to do however - such as publishing bulletins and developing new courses - once we have taken a manageable number of additional bookings we intend closing the diary for the whole of next session. So, if you want a SSERC course in the session 1993-94, don't hang about!

From your own correspondence

In order to demonstrate to our own Lords and Masters (Ladies and Mistresses?) that this place is no ivory tower, (sceptred lotus eaters' isle what you will) we keep enquiry logs. Of late we have been a little disturbed to see that for some regions the balance of our contacts has begun to swing away from the established pattern.

In the past this has shown that most of our work has been done directly for teachers, technicians and senior pupils in schools. We believe that this demand led nature of the service keeps it in tune with the needs of schools. In our latest reporting period however, for some areas the enquiries from directorate and advisory staff have outnumbered those from schools, sometimes by as much as two to one. At the same time we are getting more ideas for articles from direct teacher and technician enquiries than we have for some years - curious isn't it?

It has been decided to open up the bulletin to more direct access and also to trial a readers' letters section. Rather than begin with a literally empty gesture, we have included some readers' letters in this issue. The conditions under which we will accept and publish your letters are also outlined in an introduction to that section.

Readers' letters

Introductory

We would be pleased to receive your letters on any subject relevant to our remit. Such matters include problems with the supply or maintenance of equipment, usage including safety, and general technical difficulties with practical work.

We would also appreciate your (reasonably polite, please) comments on material appearing in this publication or on more general matters which in your opinion are germane to our broader concerns in promoting the more practical aspects of science and technology education in Scotland.

It would be helpful if letters were kept short and to the point. SSERC reserves the right to edit them if necessary - but in sympathetic manner. Names and addresses must be supplied but we will not publish these unless your permission is specifically given. Where a published letter receives an open reply we undertake to treat the subject appropriately. In other words we undertake not to patronise correspondents, not to treat enquiries or questions flippantly or facetiously and there will be no attributions of the type :

"Yours, Worried of Auchtermuchty".

In order to illustrate the type of direct enquiry we have in mind we are publishing, with permission, one or two typical examples recently received from advisers, teachers or technicians.

Health and Safety

Hazard warning labels

Dear Sirs,

In connection with the requirements of COSHH :

Are hazard warning labels or pictograms required on bottles or worksheets when solutions are very dilute eg < 0.1 M?

If a chemical has three hazard warning signs associated with it, is it necessary to put all three on the bottle eg copper sulphate solution?

Yours etc.

The Carriage, Packaging and Labelling (CPL) Regulations require suppliers to put specified labels on the bottles which they supply to you and I but they do not require us to repeat that exercise when we break chemicals down from bulk. In order however to meet general provisions of the Health and Safety at Work Act and of the COSHH Regulations, it is prudent to put some of the relevant information on reagent bottles.

Some dilute solutions are not required by the CPL Regulations to carry any warnings or the same hazard warnings as would be needed for more concentrated forms. Similarly for other solutions of identical molarity but of different substances. For example, both nitric and sulphuric acids have to be labelled "irritant", but not so hydrochloric acid unless "the molarity exceeds four".

Personally I would ignore such anomalies and would attach the risk phrase "irritant" even to 1 molar HCl or even to 0.1 M if it were in a bulk supply. This is just common sense. Handling a larger volume increases the risks of splashing and a splash of HCl, even if only 0.1 molar would certainly irritate.

On the other hand it is certainly not necessary to attempt to put all the relevant risk phrases on the label of a secondary container. In cases where reagent bottles are small there will be insufficient room!

You will see from the chemical catalogues that suppliers sometimes use two hazard pictograms but usually only where both types of hazard are sufficiently serious. That may serve as a useful model for our own practice. When you get down to the last stage however - where the chemical is collected in a beaker or flask by a pupil - then a single self adhesive label with the name of the substance and any one principal hazard will be sufficient[1].

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Sticky question

Dear Sir/Madam,

I wonder if you would comment on whether it is still permissible for teachers to provide pupils with first-aid treatment or are they just making themselves liable to litigation? For example what if a pupil were allergic to ordinary sticking plaster?

Yours etc.

We first contacted the St.Andrew's Ambulance Association for their advice and they were of the opinion that there could be a slight risk of litigation in the circumstance described. They themselves would only use pads rather than plasters. We thought it best then to seek a

[1]Note that the CPL Regulations are to be replaced by the Chemical Hazard Information and Packaging [CHIP] Regulations sometime during 1993 but that the changes should not affect the above advice.

second opinion and did so from the Employment Medical Advisory Service (EMAS) of the Health and Safety Executive.

The EMAS spokesperson took the line that teachers would be acting in *loco parentis*. Any first aid treatment which did not go beyond that which might be expected of a reasonable parent - say in treating a small cut - would be difficult to challenge at all effectively. (The EMAS spokesperson also said however that all teachers would benefit from basic first aid training and that they had noted significant criticism from parents who generally had a perception of poor provision of first aid care in schools).

It is also worth remembering that most EAs will have arranged cover for their legal liability in such situations. It would be wise to have a general policy as to who sticks on plasters or supervises, say the washing of eyes, and to what extent the employer will back up such actions by its teachers.

A sense of proportion is needed also however. Which would be the greater negligence : causing some minor additional irritation to the skin or eye or standing back and doing nothing whilst the designated person is sent for and meantime the pupil carries on bleeding or alkali continues to burn their eyes?

* - * - *

Weil's Disease

Dear SSERC,

Some of our Principal Teachers have recently raised a specific issue of health and safety in fieldwork. This is in connection with possible contamination of water by the microbe Leptospirosis (from rat urine). Do you have comments or background information to offer?

Yours etc. ....

Weil's disease (*Leptospirosis icterohaemorrhagica*) is a zoonosis or zoonotic infection - a disease transmissible between animals and man. It is a relatively rare yet serious infection which begins with symptoms rather like those of a common cold or 'flu but if not recognised and treated in time its effects, acting chiefly on the liver, can prove fatal.

It is important however to put leptospirosis or Weil's disease in a proper context. I enclose information on zoonotic infections in general and on a range of specific diseases of this type. This information comes from a recent IPMS publication which is in a handy folding card format [1]. You will see from the references on this card that further information, specific to Weil's disease is available in the HSE pocket card ;

"Leptospirosis - are you at risk?" [2]

Similar cards recommended to be carried by persons perceived to be in "higher risk" groups, for example anglers and canoeists, are available from some of the watersports organisations such as the British Canoe Union or the Flydressers' Guild. The cards contain information about the need to take seriously certain symptoms which otherwise could be mistaken for influenza.

Weil's disease has had a higher profile over the last three years or so. This is because of an increase in recorded cases although the total in any one year remains very small. The increased incidence is thought to be linked to an increase in rat populations because of a recent succession of mild winters. That in turn has slightly increased the probability of *Leptospirosis* contamination of water courses and reservoirs etc and thus the likelihood of infection in those who regularly come into contact with untreated waters - such as anglers, sailors, canoeists who habitually partake in water sports on reservoirs, gravel pits etc.

I don't have any separate statistics for Scotland but would be surprised if on rivers and lochs away from populated areas the risk was significantly greater now in rural Scotland. It is also important to remember that the reported increase for the UK as a whole was from an already small base.

References

1. "*A Working Guide to Zoonotic Infections*", IPMS, 1992.
2. "*Leptospirosis - are you at Risk?*" HSE, IND(a) 84L 2/9 70 M.

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Technical queries

Dodgy question?

Dear SSERC,

The enclosed is a photocopy from part of a specimen question paper for the new Higher Grade Human Biology course. This states that Clinistix changes from pink to blue with glucose but not with any other reducing sugars. We realise that the question works okay as a question but there is a mis-match here with our own experience of what actually happens at the bench. We get a positive result with Clinistix and maltose.

Try out the practical yourselves and tell the world about it before it becomes gospel. Our maltose could be contaminated and we could be wrong. Don't tell the world about that!

Awra best, awra time!
Yours etc

cont./.

You are both right and wrong at the same time. We reckon we should perhaps tell others about that - but you flatter us if you think the Bulletin covers the entire known world!

We checked our own stocks of maltose and like you we obtained a positive result with Clinistix but not usually within the 10 s period recommended as the reading time after immersion of the active tip. We also re-read our detailed technical literature on Clinistix and confirmed that the test is indeed claimed to be specific for glucose. This is because it is an enzyme based system and thus markedly substrate specific (see Biology Notes in Bulletin 161, October 1988 for a detailed account of the workings of Clinistix).

We then even more carefully read the small print on our bottle of maltose and discovered that it contained "not more than 1% dextrin". Us old fogies recognise "dextrin" as a synonym for d-glucose. Eureka! A search through the catalogues showed that even relatively pure grades of maltose are never completely glucose free. Even grades recommended for tissue culture or chromatography for example typically contain 0.05% w:w. So in theory the question setter was correct. In practice so are you. In the real world many samples of maltose will test positive for glucose with Clinistix.

Many thanks for alerting us to this problem.
Best wishes,
Yours etc....

* - * - *

Demonstrable gain

Dear SSERC,

Standard Grade : Electronics - Gain of an amplifier

Further to our earlier correspondence : I believe that there is a much simpler way to show gain. Using the circuit shown, the input and output voltages and current can be measured.

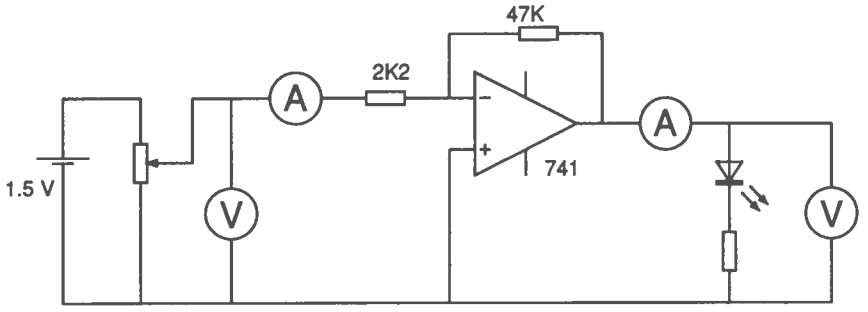


Fig. 1 - amplifier circuit

In addition the LED and series resistor can be used as the load for the amplifier.

For voltage gain the input and output voltages can be measured.

For power gain the LED and resistor can be connected directly to the potentiometer to show that power to the amplifier is not enough to light the LED. When the LED is connected to the amplifier as the load, it lights showing sufficient power from the amplifier.

Once the idea of power gain is established using input voltage and current compared with output voltage and current then the idea of input/output "resistance" can be introduced.

It follows then that $P = V^2/R$ can also be derived.

Please excuse the scribble but I am writing this and trying to tidy up all those loose ends before the school breaks up tomorrow for the holidays!

I hope that this may be of use.

Yours etc.....

P.S. The meters we used were Cirkit 7040/6040 multimeters on the current range 20 mA and voltage range 20 V.

The method you present is technically correct and has the merit of being simple and neat. It is not however wholly satisfactory because it misses some subtleties.

1. Drive capability of amplifier

The maximum current which can be drawn from a 741 op-amp is 20 mA. It can be argued from a relativity viewpoint that the absolute size of this maximum current does not matter. As well as driving LEDs, you can find small lamps and motors that run off currents of less than 20 mA. However stuff relativity! I am 6 feet tall. I would not like to be six inches tall. Nor would I like to be 60 feet tall! It is too contrived to work within a 20 mA limit. In my judgement the limit should be at least ten times higher, preferably one hundred times or so.

2. Two stage amplifier

It's normal practice for amplifiers with power outputs to be constructed in separate stages. The first stage amplifies the voltage; the second, the power. Although few pupils at Standard Grade could be expected to appreciate all the reasons for this two stage system, they can at least be introduced to the concept of separate stages for voltage and power amplification.

3. Drive capacity of signal source

The reason that the LED cannot be lit if directly connected to the potentiometer is because the supply voltage is too small, not because the supply's drive capacity is too little. For instance, if your single 1.5 V cell were to be replaced by a battery of cells, the LED would light provided there was a suitable value of series resistor.

To demonstrate the need for power gain, you should really start off with an e.m.f. source whose internal resistance prevents the load being operated. For example you could show that a low voltage motor cannot be driven directly from a small solar cell. Or, instead of the motor you could use a 3.5 V, 300 mA, MES lamp, which also would not operate.

All of these subtleties were incorporated into the Suggested Activity written up in the Standard Grade Technical Guide (pages 76-77). Unfortunately I must have been getting weary when I wrote that part for I did not explicitly state them, for which I apologize.

There is a lot of meat here and interesting issues are raised. They are really not about right or wrong but more about shades of correctness. What, from a pedagogical viewpoint, is the best way of demonstrating power amplification?

Many thanks for writing again. You have undoubtedly raised some very interesting points.

Safety notes

New regulations - ACoPs published

The new legislation of which we gave advance notice in Bulletins 173 and 174 came into force on 1st January this year (or more accurately at midnight on Hogmanay - you probably never a felt a thing!). All of the new sets of regulations are now available together with either their relevant approved code of practice (ACoP) or guidance. They all follow a useful format wherein each regulation or clause is straight way followed by relevant information which explains usually in plain simple English what is required in practice.

The collection of all the combined regulation and ACoP or Guidance booklets has already and inevitably become known as "The Six Pack". They are entitled slightly differently from the Regulations themselves and all are dated 1992.

Each title, with Regulations and ACoP or Guidance combined, costs £5.00 per copy from the HMSO Publications Centre, HMSO bookshops, or from HMSO accredited agents (see Yellow Pages) or through good booksellers.

References

1. "*Management of health and safety at work*", ISBN 0-11-886330-4.
2. "*Workplace health, safety and welfare*", ISBN 0-11-886333-9.
3. "*Work equipment*", ISBN 0-11-886332-0.
4. "*Manual handling*", ISBN 0-11-886335-5
5. "*Display screen equipment work*" ISBN 0-11-886331-2
6. "*Personal protective equipment at work*" ISBN 0-11-886334-7.

Electrical safety problems
Radford Labpack accident report

A technician early this year got a nasty shock from a Type 59R Labpack he had been renovating. The accident occurred when he was trying to remove the cap securing the mains fuse. Because the fuseholder of circular cross-section was insecure, the entire fuseholder rotated, causing a side terminal at live potential to touch the frame of the isolating transformer (Fig. 1). This caused the enclosure to become hazardous live. Had the rest of the electrical system been in good order, a fuse should have blown almost instantly to render the apparatus dead. Unfortunately there were several other fault conditions:

- The protective earth conductor in the extension socket that supplied the Labpack had significant resistance. This fault would have caused the shock voltage to be higher than 120 V, and perhaps nearly as high as 240 V. It would also have prolonged the shock current by delaying the eventual blowing of a fuse.

- The supply live had been wrongly taken to a side connector rather than to the base connector on the fuseholder (Fig. 1). This isolated the 2 A instrumentation fuse. Had that fuse been in the fault circuit, it would have provided better protection than the fuse in the 13 A plug.

- The 13 A plug had been fitted with a 13 A fuse, which was far too high a value. Had this fuse rating been 3 A, the shock current period would have been shorter.

In conclusion, the accident was caused by the compound effects of four fault conditions, added to which was the dangerous procedure of removing a fuse while the

apparatus was live. Electrical systems in general are failsafe - that is to say they are designed to be completely safe in single fault condition. It is nearly always when there are multiple faults that electrical accidents occur.

There are lessons to be learned for all of us from this incident. (In health and safety management jargon this is called reactive safety monitoring). We would stress that we are not merely exercising the wisdom of hindsight. Nor do we intend attaching blame to or scoring points off any of those involved - whether they be manager or the managed. Our recommendations are listed below:

1. The importance of routine safety checks on portable apparatus and fixed installations needs to be restated. None of the faults found here are unusual. All are specifically referred to by the Health and Safety Executive [1] in their checklist for testing school apparatus.

2. The renovation of sub-standard apparatus to comply with acceptable standards of electrical safety requires careful consideration including technical expertise and competence, and proper supervision. The capabilities of employees needs to be taken into consideration. Responsibility rests entirely with the employer in organising such work and ensuring that it is carried out competently. It was noted that some fault conditions in this accident were copied from the original Radford design.

3. If there are multiple problems with sub-standard apparatus such as Radford Labpacks, it would be preferable to institute a programme of replacement with new apparatus of satisfactory design and construction. This would prevent new fault conditions being introduced when attempting renovations.

4. The installation of residual current circuit breakers (RCCBs) at least in test and repair areas desrves serious consideration. This supplements the protection provided by protective earthing and insulation and should prevent injury from this type of incident.

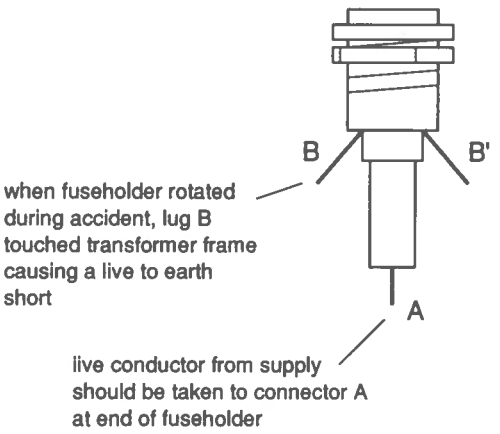


Fig. 1 Fuseholder

Some technical matters

1. The supply live must be wired to the connector on the base of a fuseholder (Fig. 1) and not to a side connector. This ensures that the outer fuseholder collar is dead when the fuse is removed. It helps to prevent a person inserting or removing a fuse from getting an electric shock when the apparatus is connected to the supply.

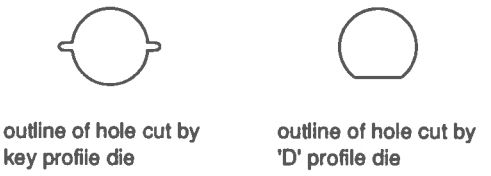


Fig. 2 Die profiles for fuseholders

2. Fuseholders and other round sectioned parts have anti-rotation mechanisms. These must be utilized. For instance some fuseholders are fitted with an anti-rotation spigot which fits into a key profile mounting hole (Fig. 2). Others have a D profile. A suitable punch and die should be used when preparing the mounting hole. These are stocked by RS Components and are, we admit, expensive! Reliance should not be placed on lock nuts solely.

Reference

1. *Electrical safety in schools (Electricity at Work Regulations 1989)*, Guidance Note GS 23, Health and Safety Executive, HMSO, 1990.

Ambiguous connectors: 3-pin Bulgins

Going from reactive to proactive safety management, your attention is drawn to a hazard which might present a high risk in your school. It concerns some low voltage equipment such as soldering irons which use the same type of connector as a relatively small group of 240 V mains apparatus. The solder stations include ones made by Antex and Weller, sold by distributors such as Rapid Electronics, RS Components and Farnell Electronics.

The 24 V output from these stations is through a 3 pin Bulgin connector which the Rapid catalogue refers to as type PX0429 and which RS Components call a 3-way miniature connector. The RS reference number for one example of the cable socket is 489-504, to be found on page 205 of their current catalogue.

The apparatus we know of which uses this same connector on a detachable lead at the 240 V supply inlet are a version of Radford Labpacks and products made by EDU-ELEQUIP, a company possibly now defunct that also used to trade under the name of Educational Electronic Equipment. Their products included power supplies, function generators, digital counters, and so on.

The hazard is a grave one. Were 240 V to be applied to the outlet of a l.v. solder station, a very dangerous system would be in place. In order that there can be no opportunity for such a mix-up, we recommend that any detachable 3-pin Bulgin connector supplying 240 V should be taken out of service and replaced with one with an IEC connector. This recommendation is meant to apply to all schools whether or not they already use solder stations because of the likelihood that at some stage in the future such a solder station might be purchased.

The list of types of apparatus at risk is not meant to be definitive. Other types may be found using this connector.

Spiralux shaper saws

Back again to reactive management. We have come across an earthing problem with Spiralux shaper saws. The fault develops in the protective earth conductor connecting the vibrator plate to the earth bond point on the enclosure base. This is a 64 stranded 0.2 mm diameter conductor that is wound into a series of spirals so as to absorb the stress generated by the vibrations. Unfortunately it is liable to sever. Fractures in 4 out of 7 relatively new Spiralux saws have been found. They can occur at either end of the earth conductor, either at the vibrator plate, or at the enclosure. The fault can only be found by opening the enclosure because there is no external access to the vibrator plate.

Some three months ago we requested that Neill Tools, the company who own Spiralux, investigate the problem. Whilst this Bulletin was being prepared we enquired as to what stage these investigations had reached. To be blunt, it seems that they had not got very far. To be fair, we have also to report that in the interim the relevant specialist personnel had changed. Nonetheless we were gobsmacked by their response which was that "the product instructions state that the top should not be removed".

In other words the advice seems to be that what you don't see shouldn't worry you! Presumably you have to wait either until someone actually gets a shock because of a break in the earth continuity or burned because the accumulated dust inside the saw body goes on fire.

We get the feeling that this might just be one that could run and run!

Laser safety and laser diodes

Several schools have enquired about laser diodes. We address the safety issues here in this part of the Bulletin and give some technical information and buying advice in the Equipment Notes section.

Firstly, what is it that we are writing about? A laser diode is a p-n junction structure made from gallium arsenide. If the diode conducts, there is stimulated emission from the junction resulting in the emission of laser radiation. These devices therefore are hazardous.

The use of lasers in schools is still legally controlled by SOED through Circular 766 [1], but as we pointed out in Bulletin 174 this is now hopelessly out of step with current safety standards, the one now applying in the UK being BS EN 60825 : 1992 [2]. This classifies and sets down requirements for laser products and equipment, and provides a user's guide. Although it doesn't have the status of government regulations, it provides a framework of advice and restrictions which in effect must be complied with. However it may be prudent for schools, because of the risks of irresponsible or bad behaviour, to impose further restrictions to those in the British Standard.

Classification

Laser products are classified according to the hazards they present. They are grouped into classes known as Class 1, 2, 3A, 3B and 4, the hazard rating going from low to high. Each product is classified according to the laser light that is emitted from the product's enclosure. For instance a typical laser printer may contain a laser that would be Class 3B were the laser out on the open workbench, but because the laser is embedded within an enclosure that prevents any laser light from being emitted, the product is classified as Class 1. A simplified description of Classes 1, 2 and 3A is given:

Class 1 lasers are those that are inherently safe.

Class 2 lasers are low power devices emitting visible radiation only (the wavelength range is 400 nm to 700 nm). The maximum output power limit is 1 mW. Class 2 lasers are not in general inherently safe. Were it possible to look continuously at them, the eye would suffer retinal damage. They are, in practice, reasonably safe. Because of the two natural aversion responses - blinking, and turning the head away - you would be very unlikely to suffer harm. However exposure to a Class 2 laser is distressing and the eye can take about a week to recover. On no account let pupils look at the emission from a Class 2 laser.

Class 3A lasers are those that have an output power of up to 5 mW if emitting visible light, or up to other limits if emitting invisible radiation. The aversion

responses to visible light still normally give protection, but direct viewing with optical aids may be hazardous. There is no aversion response to infrared.

Safety precautions to comply with BS EN 60825

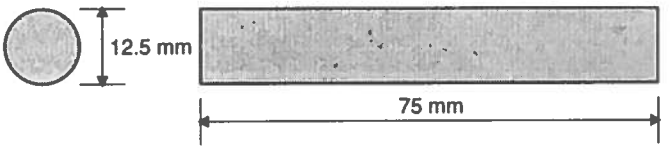
A summary of the precautions to take when working with lasers of Classes 1, 2 and 3A is shown in Table 1. As pointed out above, some further classroom restrictions may be advisable. The table shows the minimum requirements. Class 1 and 2 lasers can readily be used in full compliance with the standard in schools because of the lack of restrictions. However the standard effectively precludes the usage of Class 3A lasers because of the need for training and because of the need to assess the maximum permissible exposure (MPE). It also effectively precludes the use in schools of infrared lasers because they could not be in Class 2 since they emit radiation beyond the visible spectrum. In addition they are unlikely to be of low enough power to fall into Class 1.

Laser diodes

Laser diodes can be purchased as discrete components, but are more usually available as laser diode modules. This comprises a laser diode, a drive board and a collimator housed in a metal case.

The optical output power of laser diodes tends to lie in the range between 3 mW and 100 mW depending on type. In fact we do not at the time of preparing this article have any catalogue reference to a laser diode with an optical output power of 1 mW or less. There are therefore at present possibly no discrete laser diodes of sufficiently low enough power for use in bench work in schools.

There are however several laser modules whose output power does not exceed 1 mW. These would be, in some circumstances, suitable for school use. The radiation they emit must of course be visible - not infrared, which many of them are. Our main concern is portability (Fig. 1).



Weight: 55 g

Fig.1- Laser diode module - typical size and weight

Classification	Class 1	Class 2	Class 3A
Remote interlock	Not required	Not required	Not required
Key control	Not required	Not required	Not required
Beam attenuator	Not required	Not required	Not required
Emission indicator device	Not required	Not required	Not required
Warning signs	Not required	Not required	Not required
Beam path	Not required	Terminate beam at end of useful length	Terminate beam at end of useful length
Specular reflection	No requirements	No requirements	No requirements
Eye protection	No requirements	No requirements	Required if eng. & admin. procedures not practicable and MPE exceeded
Protective clothing	No requirements	No requirements	No requirements
Training	No requirements	No requirements	Required for all operator and maintenance personnel

Table 1 - Summary of use precautions (from BS EN 60825)

They are very easy to move about. There is then of course the attraction of using them as pointers - or as Star War guns to zap out the opposition at the far end of the classroom! It therefore seems reasonable to insist that they must be clamped in a jig. Normal laboratory clamp stands might do, but probably are too big and clumsy. Therefore a suitable laboratory jig should be bought, or made.

Recommended code of practice

This is a suggested code of practice for applying to laser diode systems in schools. It may soon need to be modified in the light of experience and because of technological change.

1. Laser diodes should not be used as discrete components, but may be used in laser diode modules.

2. The laser should be rated Class 1 or Class 2.

3. The radiation from a laser diode module must be visible.

4. The optical power output of the laser diode module should not exceed 1 mW.

5. The drive circuit of a laser diode module should never be modified so as to increase the output power of the laser diode.

6. The lens should never be removed from a laser diode module because such removal would raise the power output.

7. Under no circumstances view the laser directly unless the radiation has been greatly reduced in intensity.

8. Do not direct the laser radiation at another person.

9. The laser diode module should not be powered up unless the module has been clamped in a laboratory jig.

10. Optical beams should be prevented from leaving the workbench working area by bench stops unless there is an experimental requirement for the beam to travel beyond the confines of the workbench.

11. Optical beams should remain if possible in a horizontal plane within 20 cm of benchtop height.

12. If it is not practicable to restrict the laser radiation to a horizontal plane or to the confines of a worktop, the use of barriers to prevent persons accidentally viewing the radiation should be considered.

13. A laser hazard warning sign should be positioned at the work area.

14. When the system is being set up, the operator should use a slip of white paper as a translucent screen to track the whereabouts of the radiation to arrange bench stops and optical apparatus.

15. If using optical fibres, you should not look into the fibre and you should not direct the fibre at another person. When setting up the system, a slip of paper should be placed at the end of the fibre to detect the emergence of laser light.

16. Normal classroom lighting should be used whenever possible, but blackout conditions may be used if the experiment warrants this.

17. Relevant parts of this code of practice should be explained orally and given in writing to pupils before allowing them to work with laser diode modules.

References

1. *The Use of Lasers in Schools, Colleges of Education and Further Education Establishments*, Circular No. 766, SED (now SOED), 1970.

2. BS EN 60825 : 1992 *Radiation safety of laser products, equipment classification, requirements and user's guide*, British Standards Institution.

Acknowledgement

Extracts from EN 60825 : 1992 are reproduced with the permission of BSI. Complete copies of the standard can be obtained by post from BSI Publications, Linford Wood, Milton Keynes, MK14 6LE.

Making necessary links

An account is provided of some basic linkage mechanisms and suggestions made as to their usefulness for project work and the improvement of technological competence at upper primary and lower secondary levels.

Background

The answer from politicians to the recent marked increases in youth and adult unemployment appears always to be yet more training and 'better education'. Many only too willingly will offer opinions as to what constitutes "better education". Even the normally garrulous become silent when asked "Training for what"? It is generally training for the sunrise industries, electronics and computing that is highlighted as leading to the dawn of a new age of fuller employment.

Ironically it is these same industries which are often indirectly responsible for so many job losses throughout commerce and industry. A non apochryphal tale I can relate is that of my neighbour sent on a word-processing course at the age of sixty, being advised that in order to have any job prospects he needed to keep abreast of new technologies. He had been made redundant by the closure of the last ink manufacturer in Edinburgh!

Electronics base bias?

In technology education many of us must, and do, keep up to date with what is happening in electronics and computing. We should not lose sight however of the need to understand other basic concepts and acquire the other skills required to undertake a modern technological education.

Attempting to exchange a book token, given as a Christmas present, on some worthwhile literature, I made a visit to James Thin Ltd, booksellers, to browse through their selection on technology. It was dispiriting to find the majority of the publications were aimed at the English National Curriculum, with few specific to Standard Grade or Higher Grade Technological Studies. Of equal concern were the number of publications concerned solely with electronics.

This interest in electronics is understandable and based on what we ourselves have in the past pointed to as its advantages as an educational vehicle. It is reasonably inexpensive to resource, clean and perceived both as 'high tech' and as giving most pupils the opportunity of some success. But, of itself it is not technology. There is an added concern that electronics projects may become educationally sterile. You know the sort of thing : lights on at dusk; how hot is the bath water, can you automatically control a greenhouse ventilator? etc. etc.

Rarely can electronics alone carry out useful work.

This is by no means to denigrate the work of pupils in electronics. Much of what we have seen in recent years has been excellent and at the time of writing a member of the Centre staff had just adjudicated at one school where the standard of the electronics based projects was mind-bogglingly high. This was not just in the circuit designs but also in their wiresmanship and sheer complexity.

Beyond electronics

But where are all the linkages, levers, pulley systems or interesting gearing systems? A few of us remember being enlightened, confused and/or bored with the endless repetition of 1st, 2nd, or 3rd class levers. Why are scissors 1st class and tweezers 3rd class? Where do nail clippers fit in the classification? Who cares?

We do not intend to backtrack to that kind of teaching nor herein to trigger off renewed trench warfare, or even re-enter discussion, on the demise of mechanics and engineering science. Instead we attempt to have a not too serious look at some ideas that may strike that vital spark in pubescent technologists.

The word pubescent is chosen deliberately. Much of what follows could be attempted at S1/S2 with 12 to 14 year olds. It may be that some readers will be reminded of both grannies and eggs as they read on - no apologies. This is not mere nostalgia but a gentle nudge to encourage recall that there was technological life before electronics.

Linkages

Much of the important work on kinematics[1] and linkages was carried out by the mathematical and engineering giants of the 18th and 19th centuries : Watt, Brunel, Newcomen, Sylvester, Kempe and probably the most pragmatic, the Swede Christopher Polhem.

[1]Kinematics is a branch of mechanics that looks at the spatial qualities of a linkage, the more formal definition is "that branch of mechanics concerned with the phenomena of motion without reference to mass or force." [1].

Technological literacy

Over a number of years some SSERC staff have been fortunate to be invited to assist with so-called Egg Races. Sometimes this has been in adjudicating. On other occasions we have helped with resources, by giving a scene-setting talk, or have provided the brief. We have always come away from such events on a high, impressed with what so many young people have managed to achieve in the limited time. On the minus side we have also been surprised that in some key areas significant numbers of pupils or students seem to lack a basic technological literacy.

This loss of an engineering vocabulary and culture is sometimes most keenly observed when, for example, structures are required in Egg Races, the tallest tower for example where some groups may not realise that triangulation is the key to a stable structure.

Other parts of a technological vocabulary which may be at times conspicuous by their absence include planning and designing using rough sketches; and an implicit understanding of basic mechanisms such as linkages.

Ideas for projects

Mechanisms which now we take for granted, eg an ironing board, a deck chair, an up-and-over garage door, almost all are dependent on some form of linkage with a long history. Such simple linkages can provide useful starting points for projects at the upper end of 5 - 14.

Simple devices such as see-saws or bell crank levers can be used to make simple card toys, the see-saw can be developed to introduce a simple balance, this can then lead to a letter balance and Roberval linkage.

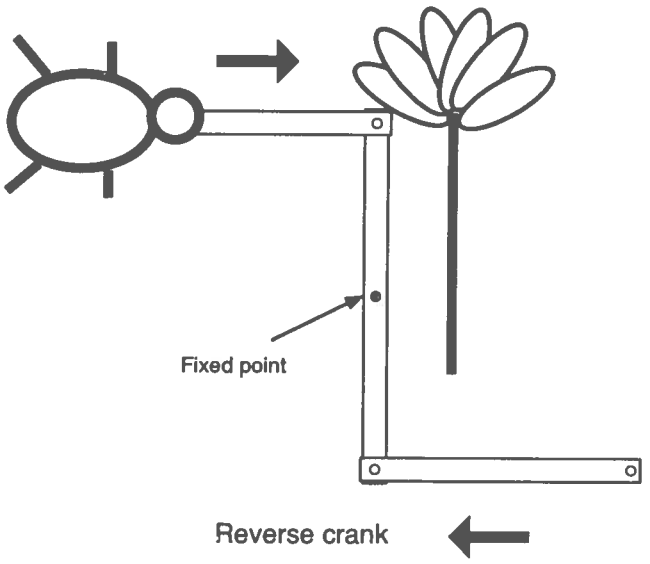


Fig.1 - reverse crank lever as the bee and flower toy

When the Adam's apple is pushed the tongue will stick out, a simple if vulgar use of the bell crank.

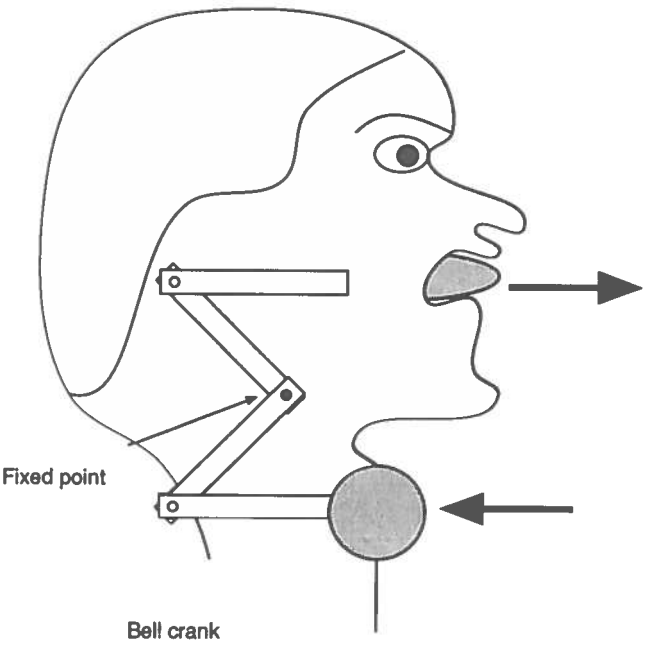


Fig. 2 - the clown's tongue

Adapting the Butchart or lever balance into a goal kicking toy, making use of the parallelogram linkage.

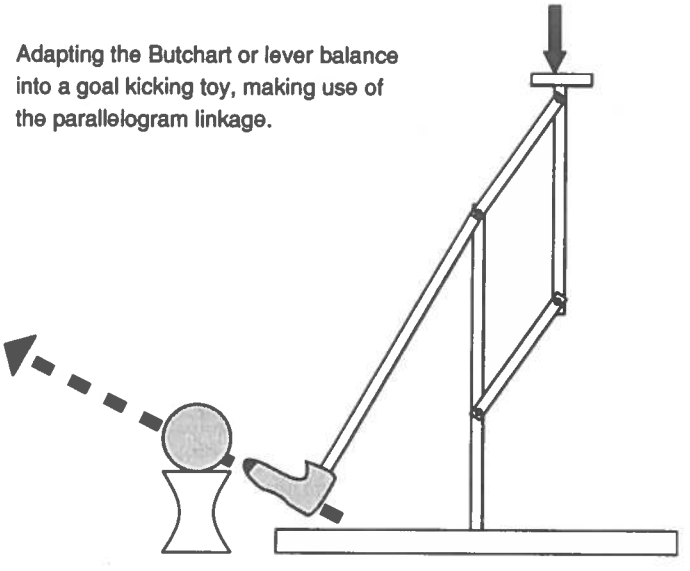
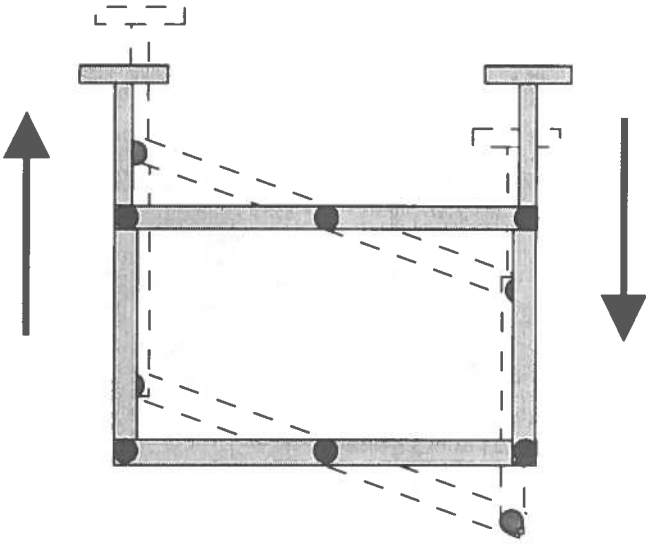
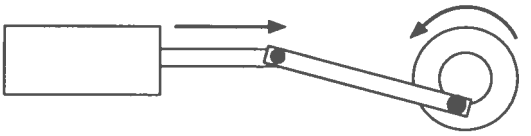


Fig. 3 - the kicking toy



Roberval balance or linkage enables both pans to remain in the horizontal plane, they remain parallel to the central pivot point. Were the arms to be extended then a total of four changes of position could be observed.

Fig. 4 - Roberval balance or linkage



Piston and flywheel, this arrangement is still in use today, examples are model steam engines and a number of steam driven traction engines. Although this is a simple and effective linkage it has a major drawback in that both the piston rod and the bearing are subject to stress and wear. This was one of the reasons Watt and his contemporaries spent a great deal of time and effort in devising methods to change linear movement to circular motion.

Fig. 5

What about Watt?

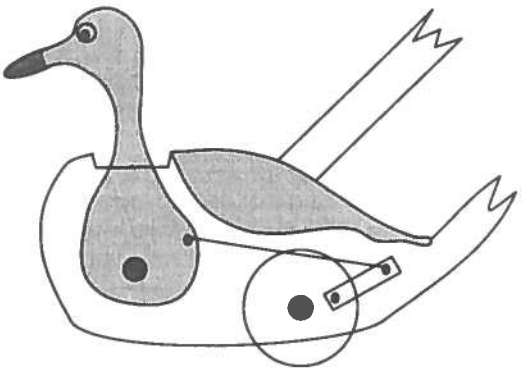
Are today's pupils, or teachers, aware of James Watt and the tale of the boiling kettle? (Now that one, I'll bet, is apocryphal). Or of the time he spent attempting to solve the problem of transferring linear motion from the piston to circular motion which would enable machines to be driven by a steam engine with minimal damage to the piston rod and bearing.

Mind you if he spent that much time day dreaming on Glasgow Green in these present times he'd like as not get taken for loitering.

A teacher in Lothian enthusing recently on the impact made by Scottish engineers, both past and present, asked the assembled second year to tell him for which of his achievements was Watt particularly famous? You guessed it, answer came there none until someone volunteeered the invention of the light bulb.

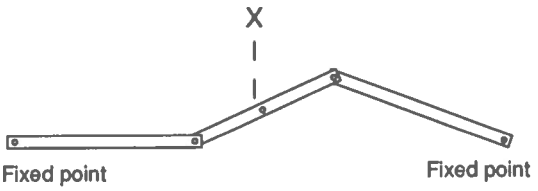
Rotary to linear motion

How might Watt's work be related to the technology curriculum? Figures 6 to 9 provide some suggestions.



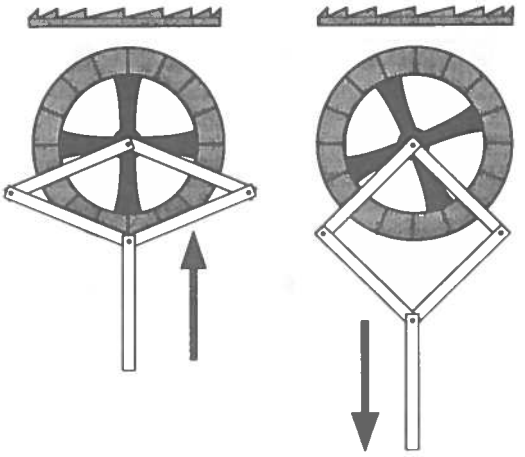
Pull-along duck making use of a similar linkage to that of the piston and flywheel.

Fig. 6 - a toy making use of a rotary to linear linkage



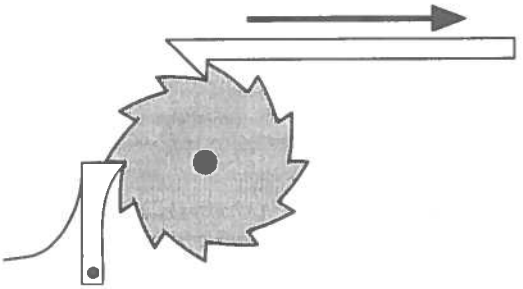
Watt linkage, in this design Watt attempts to control the lateral movement of the piston rod and thus reduce wear on the bearing. Watt considered this one of his finest achievements. It is interesting to try this linkage with a pencil placed at point X, what type of path is described by the pencil point?

Fig. 7



An elegant method of transforming linear movement to circular motion developed by Pohlem. It would be difficult to transmit much power with this system.

Fig. 9 - Polhem's linear to circular motion device



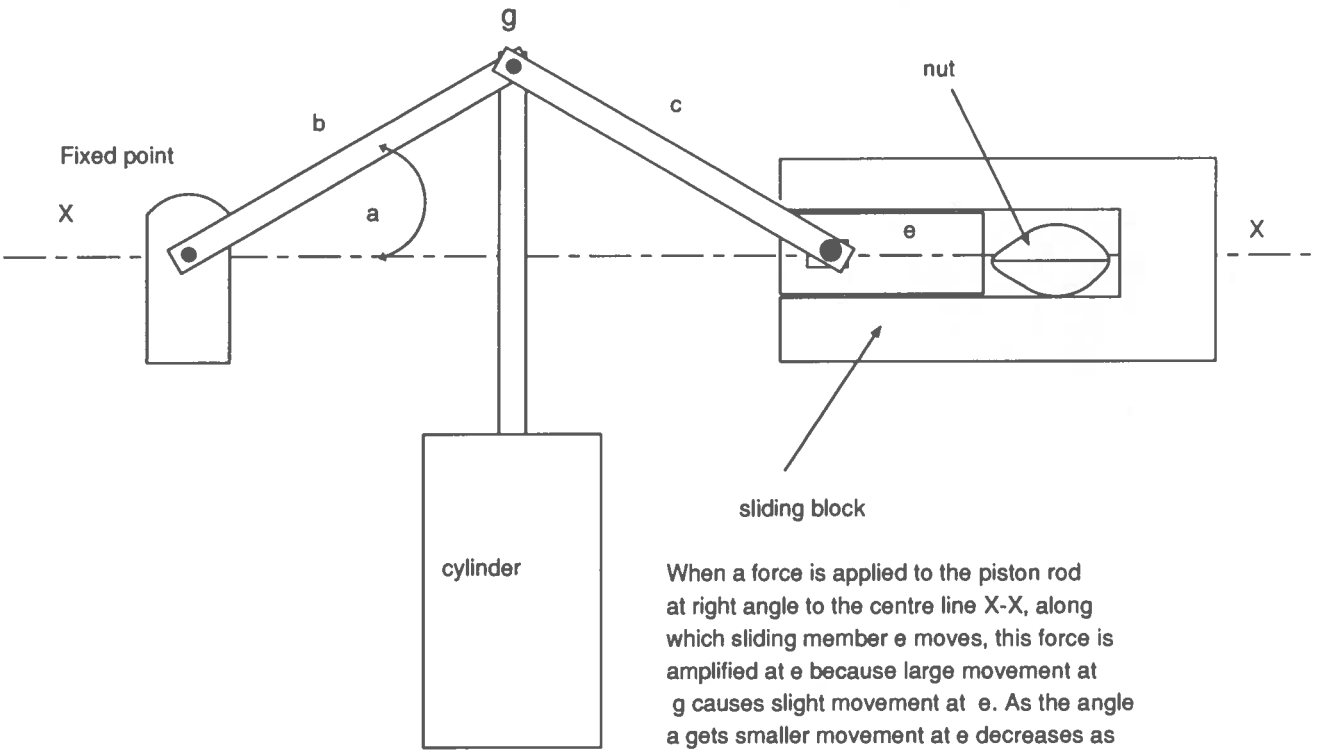
This ratchet arrangement was originally designed by Pohlem as a winch, here it could be used as a form of indexing tool activated by a pneumatic cylinder.

Fig. 8 - linear to rotary linkage with ratchet as an indexer

Standard Grade Projects?

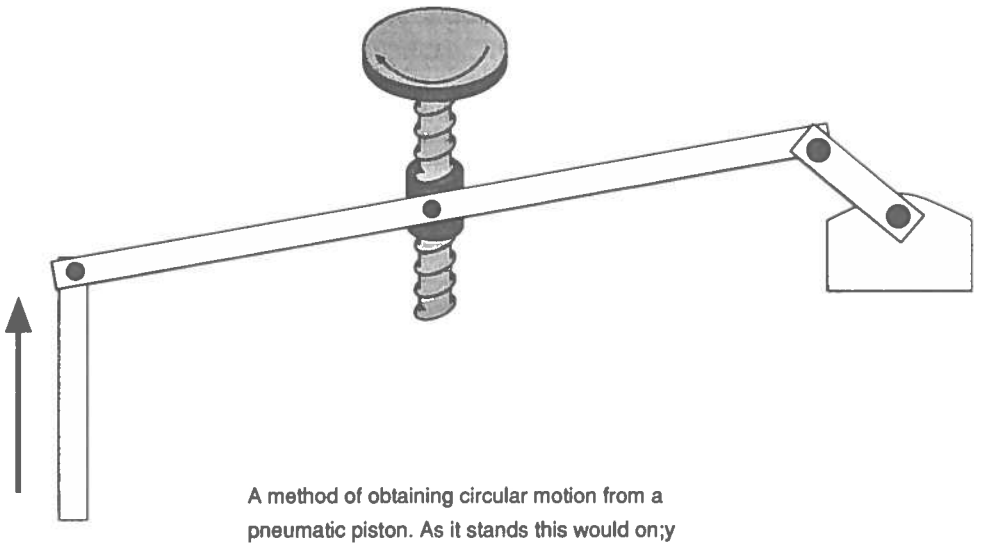
There are further examples of similar applications for use with somewhat older pupils. For example would the devices shown in Figures 10 and 11 opposite prove acceptable to the Exam Board, in satisfying two of the elements of Standard Grade in regard to integrating pneumatics with mechanisms?

This deceptively simple linkage, a toggle linkage, amplifies the power available from a hydraulic or pneumatic cylinder. It was widely used in stone crushing and in some forms of metal forming.



When a force is applied to the piston rod at right angle to the centre line X-X, along which sliding member e moves, this force is amplified at e because large movement at g causes slight movement at e. As the angle a gets smaller movement at e decreases as the force increases until the links b and c are in line

Fig. 10 - a toggle linkage which effectively amplifies the force applied by a single hydraulic or pneumatic cylinder

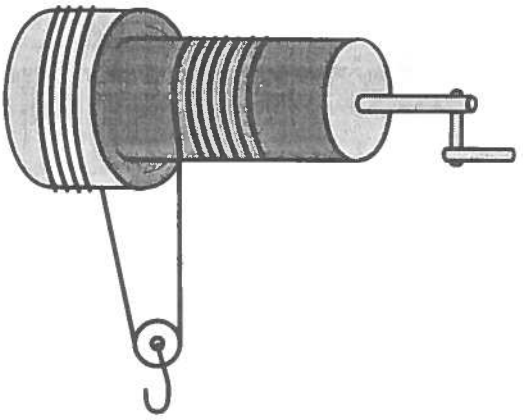


A method of obtaining circular motion from a pneumatic piston. As it stands this would on;y give reciprocating motion of the leadscrew, some form of 'freewheel' mechanism would be needed if rotation in only one direction was desirable.

Fig. 11 - rotary motion from a pneumatic system

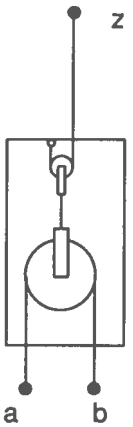
Just for fun!

Our last two suggestions (Figs. 12 and 13) are intended to be just that - fun. But, could we make an OR gate in similar fashion to that shown for the mechanical AND gate in figure 13?



Chinese windlass, this system can be designed to give very high or low transmission factors. It is also the basis of the conjuror's magic box, pulling from one end of a closed box appears to enable one to pull more string from the box than enters it. Design details are left to the maker.

Fig.12



Simple AND gate using two pulleys.

Fig.13

Conclusion

We have tried to offer a few ideas on teaching about linkages. The aims include having a bit of fun as well as others which are deliberately educational. The two are however not necessarily mutually incompatible! The fun lies in trying out new ideas, in making toys, and in building useful working linkages as well as mechanical frameworks.

The contemporary tendency to imply denigration by dubbing a model *Heath Robinson* is to miss the point entirely. Early in this century Heath Robinson poked gentle fun at what he saw as the trivialisation of many technological advances. He was in fact a first class draughtsman and, apart from the knots in his ropes, most of his pulley and gear systems would actually work.

The educational value in building some of the devices shown should be fairly obvious in the context of teaching about mechanisms and structures. But how about applying a similar approach to graphical communications or mathematics?

We believe that enhancing understanding of the possible applications of levers, of the interaction of shapes and an improved awareness of spatial movements, is important for all our pupils. It may well be crucial for those with ambitions to become effective engineers and technologists.

Any more?

As with all articles of this type we can only offer but a few ideas. There are many, many more. If you have any favourite systems you think may be of interest to others please send us the details. If it works when we build it we will try to publish it in these pages, with your name if not in lights at least in emboldened type.

References

1. *A Dictionary of Science*, Penguin Books, 1976, ISBN 0 14 051 001X (source of definition of kinematics).

Other useful sources :

2. *Mathematics meets Technology*, Bolt, B. Cambridge University Press, 1992, ISBN 0 521 37692 0

3. *Machines - an illustrated history*, Strandh, S., Mitchell Beazley, 1968, ISBN 0 86134 0 124 (Out of print).

Equipment Notes

Oscilloscopes

This article describes the general features which are available on oscilloscopes and gives advice on their relevance for schools. We also describe and compare the performances of five single trace and twelve dual trace oscilloscopes, and give buying advice thereon. The need for the *pupil oscilloscope*, or instruments with minimalist controls is recognised.

Introduction

The oscilloscope is perhaps the most complex scientific instrument to be found in quantity in schools. Costing typically between £200 and £300 apiece, the purchase of even just one oscilloscope is a sizeable part of a department's budget. Since they are more suited for individual pupil work rather than for teacher demonstration, they are therefore normally required in multiples of five or more per class. The purchase of sufficient number of 'scopes is therefore of some import.

There are now few single trace oscilloscopes on the market. Our report looks at five of these, including three that have been specially designed for schools, the so called *pupil oscilloscope*. On dual trace instruments, we have in general tested the instrument with the lowest specification out of a manufacturer's range. We have chosen to look at some of the big names - Hameg, Hitachi and Philips - at instruments from some of the principal distributors - Farnell, Rapid and RS - at some imports from Asia distributed by smaller companies - Crotech, Kenwood and Sampo - and at a new model from Beckman, assembled here in Scotland. Sadly, it does not come out too well in some tests!

That does of course leave many models untested. Unlooked at, for the present, are the Griffin Novoscope and models from Blackstar, GW, ITT, Leader, Topward, and so on. We are sorry that some models, from lack of time, have had to be omitted, but intend to test instruments from some of these companies in the future.

The models tested are listed in Table 1. Most were tested in the last 12 months, but a few were examined some years back. Specifically, we looked at two Goldstar OS-7020 scopes in 1988, having obtained samples from Alpha Electronics and Rapid Electronics. Neither Alpha nor Rapid continue now to sell this model, although, confusingly, Rapid have transferred the Goldstar catalogue number onto its replacement, also called the 7020. In case the Goldstar is still available from other stockists, it is included in the test report summary.

Description of features and tests

We give here a description of the features and, where necessary, an explanation of technical terms to be met with in manufacturers' specifications. The relevance to school use is indicated.

Bandwidth

Bandwidth is the operating frequency range of the Y amplifier. It normally extends from d.c., or zero frequency, to the bandwidth value. This is usually 20 MHz on bottom-of-the-range machines, signifying a power loss of -3 dB in signal strength at 20 MHz. The *rise-time* is the response time of the Y amplifier to an infinitely steep step input. It can be worked out in nanoseconds from the bandthwidth f in megahertz using the relationship:

$$\text{rise-time} = 350/f$$

Thus a 20 MHz oscilloscope has a rise time of 17.5 ns. Since most of the dual trace machines in our survey have 20 MHz bandwidths, there is little purpose in their having a sweep sensitivity any higher than 20 ns/division. Excepting the model from Rapid, this is the fastest sweep rate provided on the machines with the highest specifications. The 10 ns/division sweep rate on the Rapid scope is just a nonsense (Table 2).

The bandwidth of each oscilloscope was measured by us. Compliance with specification is shown in Table 5. Most models were found to comply.

An example of a fast timing requirement is the experiment to measure the velocity of light wherein pulsed light is transmitted through 10 m of optical fibre. Since the transmission time is 50 ns, a dual trace instrument with a 20 ns/division calibrated sensitivity and 20 MHz bandwidth is able to provide a measurement of the time delay with an accuracy of about ±20%.

Oscilloscope model	Supplier	Stock number	Price (£)	Screen shape	Screen size (mm)	Graticule	Extra Facilities
Single trace							
Crotech 3036	RMR Measurements	3036	265.00 [1]	rectangular	130	10 x 8	
Hameg 103-2	S J Electronics	HM 103-2	255.00 [1]	rectangular	95	10 x 8	
Harris Super 5	Harris	P63860/8	265.65	rectangular	130	10 x 8	
Irwin EA1270	Irwin	EA 1270	238.30	circular	75	10 x 10	
Unilab Student Oscilloscope	Unilab	032.603	194.20	circular	70	10 x 10	
Dual trace							
Beckman 9012	Tait Components	9012	285.00	rectangular	130	10 x 8	
Crotech 3324	RMR Measurements	3324	325.00 [1]	rectangular	130	10 x 8	power supply
Farnell DTV20	Farnell Instruments	19 DTV 20	320.00	rectangular	130	10 x 8	
Goldstar OS-7020	unknown	-	-	rectangular	130	10 x 8	
Hameg 203-7	S J Electronics	HM 203-7	362.00 [1]	rectangular	130	10 x 8	
Harris MuPEC	Harris	P63921/2	491.93	rectangular	130	10 x 8	pwr.sply./fn.gen.
Hitachi V-212	Tait Components	V-212	360.00 [1]	rectangular	130	10 x 8	
ISO - TECH ISR 620	RS Components	204 - 476	295.00 [1]	rectangular	130	10 x 8	
Kenwood CS 4025	S J Electronics	CS - 4025	295.00 [1]	rectangular	130	10 x 8	
Philips PM 3208	Cuthbertson & Laird	PM 3208	375.00 [1]	rectangular	130	10 x 8	
Rapid 7020	Rapid Electronics	85 - 2000	270.00	rectangular	130	10 x 8	
Sampo SSI 2120	RMR Measurements	SSI - 2120	275.00 [1]	rectangular	130	10 x 8	

NOTE :

1. BNC test lead(s) supplied inclusive with quoted price.

Table 1 : Oscilloscope suppliers, prices and screen detail

Sensitivity

All of the instruments with 1-2-5 switch sequences (Table 2) can be used for quantitative measurements, in theory to the accuracy specified, which is usually ±3% or ±5%. This group comprises all of the dual trace models, together with the Crotech 3036 and Hameg 103-2 single trace models. The former has the edge over the latter because of its larger screen size (Table 1). Of the remaining three, comprising the pupil oscilloscopes, the Irwin model can indicate order of magnitude voltages and times, and the Unilab and Harris Super 5 models can measure to precisions of at best ±5% on Y and on time.

Testing for accuracy

The accuracy of the Y amplifiers and sweep rates were assessed by measuring the error on each setting at 80% of screen width. For most instruments, the errors were random rather than systematic. If the errors were random, the standard deviation σ of the percentage errors in each setting was calculated. From this a value of 3σ was obtained, which was compared with the specified accuracy or tolerance. If both values were similar, the specification was judged to be about right.

Our test method therefore looks for the common industrial practice of specifying a random error which is three times the standard deviation of actual random errors. Our test findings are summarized in Table 5. It shows that most Y amplifiers, but only half the sweeps, perform within specification.

Display modes

There are several ways of controlling the displays on dual trace oscilloscopes (Table 3). Most allow you to look at one channel at a time, with the other channel being switched off. All provide for both alternate and chopped dual displays. In *alternate* mode, each trace is swept through in its entirety, without interruption, from one end of the screen to the other. After one trace is swept through, then so is the other. The process alternates between one whole trace and the other whole trace. If the input frequencies are low, then there can be a disturbing flicker between channels 1 and 2. The *alternate* mode display should not therefore be used at low frequencies. In *chopped* mode, the sweep flips at high frequency between tracing out a little bit of channel 1 and a little bit of channel 2. If the input signal frequencies are low, the

Oscilloscope model	Bandwidth (Hz)	Calibrated Y settings (V/division)	No. of Y settings	Switch sequence	Y accuracy (%)	Calibrated sweep speed (s/division)	No. of sweep settings	Switch sequence	Sweep accuracy (%)	Max. calibr. sweep rate (s/div.)
Single trace										
Crotech 3036	20 M	2 mV to 10 V	12	1,2,5	3	0.5 µs to 200 ms	18	1,2,5	5	100 ns
Hameg 103-2	10 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 100 ms	18	1,2,5	5	200 ns
Harris Super 5	5 M	50 mV to 200 mV	9 [1]	1,2,5	5	1 µs to 100 ms	5 [1]	1,10,100	10	1 µs
Irwin EA1270	50 k	50 mV to 5 V	0	continuous	NS	100 µs to 10 ms	3	1,10,100	NS	100 µs
Unilab Student O'scope	100 k	50 mV to 10 V	8	1,2,5	NS	100 µs to 100 ms	4	1,10,100	NS	10 µs
Dual trace										
Beckman 9012	20 M	5 mV to 5 V	10	1,2,5	3	0.5 µs to 200 ms	18	1,2,5	3	50 ns
Crotech 3324	25 M	5 mV to 20 V	12	1,2,5	3	0.5 µs to 200 ms	18	1,2,5	5	100 ns
Farnell DTV20	20 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 500 ms	20	1,2,5	3	20 ns
Goldstar OS-7020	20 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 200 ms	19	1,2,5	3	100 ns
Hameg 203-7	20 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 100 ms	18	1,2,5	3	20 ns
Harris MuPEC	25 M	2 mV to 10 V	12	1,2,5	3	0.5 µs to 200 ms	18	1,2,5	5	100 ns
Hitachi V-212	20 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 200 ms	19	1,2,5	3	20 ns
ISO - TECH ISR 620	20 M	5 mV to 5 V	10	1,2,5	3	0.2 µs to 500 ms	20	1,2,5	3	20 ns
Kenwood CS 4025	20 M	1 mV to 5 V	12	1,2,5	3	0.5 µs to 500 ms	19	1,2,5	3	50 ns
Philips PM 3208	20 M	5 mV to 5 V	10	1,2,5	3 [2]	0.2 µs to 500 ms	20	1,2,5	3	20 ns
Rapid 7020	20 M	5 mV to 5 V	10	1,2,5	3	0.1 µs to 200 ms	20	1,2,5	3	10 ns
Sampo SSI 2120	20 M	5 mV to 5 V	10	1,2,5	3	0.5 ms to 200 ms	18	1,2,5	3	50 ns

NOTES :

1. The Harris Super 5 uses pushbutton switches rather than rotary switches to select amplifier and sweep sensitivities.
2. The accuracy of the Y sensitivity is stated to be ±5% in the Technical Specification for the PM3208 scope. This is completely honest and fair of Philips because they are quoting the worst case accuracy of the combined effects of the stepped amplifier and x5 magnifier. However no other manufacturer is as honest as Philips in this respect. By common practice, the best case accuracy is quoted in specifications. To keep things on a level playing field, we therefore quote the best case accuracy for the Philips amplifier, viz. 3%.

Table 2 : Oscilloscope specifications

chopping is of too high a frequency to be noticed. However, at high input frequencies, chopping will be evident and break up the traces. Therefore, *chopping* should not be used at high frequencies.

Other commonplace display modes are *add*, which displays the algebraic sum of channels 1 and 2, and *invert*, which usually operates on only one channel. In combination, one signal subtracted from the other is displayed.

Triggering

Most models provide several trigger modes (Table 4). All provide *automatic* triggering (formerly sometimes known as *bright line* triggering), which causes the time base to free run, giving a base line trace on the screen in the absence of a Y signal. If a signal is then applied, the trace locks onto the signal and displays it. This would be the preferable trigger mode for looking at signals of simple shape, or for operation by inexperienced students. The sole form of triggering provided on pupil oscilloscopes is *automatic*.

Normal triggering in the absence of a signal leaves the screen blank. The oscilloscope only sweeps if a trigger pulse is provided. For this, it needs a Y input signal. *Normal* triggering is preferable for displaying complex, or peculiar, waveforms, such as a square wave with mark to space ratio of 1 to 100. Were *automatic* triggering used with this type of signal, the trace might form a series of overlapping images, it being impossible to trigger properly. *Level* and *slope* controls affect both *automatic* and *normal* tiggering modes.

The *trigger level* control allows for manual adjustment of the trigger voltage. This is used together with the *trigger slope* control. On positive (+) slopes, a rising edge or slope, or an increasing voltage, causes the trigger to operate. On negative (-) slopes, a falling edge or slope, or a decreasing voltage, causes the trigger to operate. These controls are particularly useful in triggering complex waveforms. They are not provided on pupil oscilloscopes.

The *external trigger* facility causes the trace to be triggered on a signal applied to the external trigger terminal rather than from a Y input. One place where this is used is when displaying signals from data loggers such as VELA, or the Thurlby-Thandar Digital Storage Oscilloscope Unit. Signals from data loggers are often of transient events and, as such, can be highly irregular, and therefore generally impossible to trigger through the Y amplifier. Another place is displaying a complex digital waveform from a binary counter. Such a signal is triggered by applying a low frequency signal from the counter to the external trigger input. A third example is the display of amplitude or frequency modulation, where the low frequency signal is applied to the external trigger terminal.

Alternate mode (sometimes called *vertical* mode) triggering is distinct from, and should not be confused with, *alternate* mode display. On *alternate mode triggering*, two traces are separately triggered at the level and slope selected. It is especially useful in simultaneously displaying two asynchronous waveforms, i.e. two signals at different and unrelated frequencies. Without this feature, only one of a pair of asynchronous waveforms can be triggered, the other being impossible to keep steady. However there is a penalty. The phase difference between the signals can be falsified by the triggering process so that what appears on the screen may not correspond to the phase difference that physically exists. Thus *alternate mode triggering* should not be used when measuring the phase difference between signals, or when measuring the time difference between corresponding parts of two digital waveforms.

Note that *alternate triggering* is not required when displaying two synchronous, i.e. frequency related, waveforms, when triggering on one waveform will reliably stabilize the trace of the other. Usually of course, in dual mode, the two signals are synchronous. Therefore *alternate triggering* is really not that often needed.

Line triggering gives you a sure fire way of locking onto a 50 Hz signal. This is useful when examining signals derived from mains supplies, such as in analysing the operation of power supplies, or indeed any elementary

Oscilloscope features	A	B	C	D	E	F	G	H	J	K	L	M	O	X	Z
Single trace															
Crotech 3036						F	G		J	K				X	
Hameg 103-2				D	E		G	H	J	K				X	
Harris Super 5				D			G			K				X	
Irwin EA1270					E		G							X	
Unilab Student Oscilloscope							G							X	
Dual trace															
Beckman 9012	A	B	C	D	E	F	G	H	J	K			O	X	
Crotech 3324	A	B	C	D		F	G	H	J	K				X	Z
Farnell DTV20	A	B	C	D	E	F	G	H	J	K	L			X	Z
Goldstar OS-7020	A	B	C	D	E	F	G		J	K	L			X	
Hameg 203-7	A	B	C	D	E	F	G	H	J	K				X	Z
Harris MuPEC	A	B	C			F	G	H	J	K				X	Z
Hitachi V-212	A	B	C	D	E	F	G		J	K			O	X	Z
ISO - TECH ISR 620	A	B	C	D	E	F	G		J	K	L		O	X	Z
Kenwood CS 4025	A	B	C		E	F	G		J	K			O	X	Z
Philips PM 3208	A	B	C	D	E	F	G		J	K	L		O	X	Z
Rapid 7020	A	B	C	D	E	F	G	H	J	K	L	M		X	
Sampo SSI 2120	A	B	C		E	F	G		J	K			O	X	Z

Key to features :

- A Alternate and chopped operation
- B Algebraic addition of traces
- C Inversion of one or both traces
- D Y amplifier switched magnifier or attenuator
- E Y amplifier variable gain or attenuator control
- F Sweep rate switched magnifier
- G Sweep rate variable magnifier or attenuator control
- H Component testing facility
- J Calibrator output provided
- K Trace rotation adjustable
- L Illuminated graticule
- M Trace locate function
- O Amplifier output
- X X - Y facility
- Z Z modulation facility

Table 3 : Oscilloscope features

Oscilloscope triggering	A	B	C	D	E	G	H	J	K	L	S	T
Single trace												
Crotech 3036	A	B	C	D	E							
Hameg 103-2	A	B	C	D	E							T
Harris Super 5	A	B			E							
Irwin EA1270	A											
Unilab Student Oscilloscope	A											
Dual trace												
Beckman 9012	A	B	C	D	E	G		J	K	L		T
Crotech 3324	A	B	C	D	E		H	J		L		T
Farnell DTV20	A	B	C	D	E		H	J		L		T
Goldstar OS-7020	A	B	C	D	E		H	J	K	L		T
Hameg 203-7	A	B	C	D	E	G	H	J	K	L		T
Harris MuPEC	A	B	C	D	E			J		L		T
Hitachi V-212	A	B	C	D	E	G				L		T
ISO - TECH ISR 620	A	B	C	D	E	G	H	J		L	S	T
Kenwood CS 4025	A	B	C	D	E	G				L		T
Philips PM 3208	A	B	C	D	E		H	J		L	S	T
Rapid 7020	A	B	C	D	E	G	H			L		T
Sampo SSI 2120	A	B	C	D	E	G				L		T

Key to trigger features :

- A Automatic triggering
- B Normal triggering
- C Manual level control
- D Selection of trigger slope polarity (+ / -)
- E External triggering
- G Alternate (ALT) or vertical mode triggering
- H Sweep hold-off facility
- J LF triggering, or HF rejection
- K HF triggering
- L Supply line triggering (50 Hz)
- S Single shot triggering
- T TV sync pulse separator facility

Table 4 : Oscilloscope trigger features

instruction in a.c. electricity, which is normally done at 50 Hz. It is also useful for examining mains noise superposed on another signal.

The *hold off* facility delays the onset of sweeping, the delay period being under variable control. It is sometimes useful in triggering complex waveforms, but for school purposes is more of an added complexity, and therefore a nuisance, than a benefit.

Single shot or *single sweep* triggering generates one sweep only and is a means of glimpsing a transient event. Since this would be far better seen with a fast data logger, or computer and interface, the facility is of little benefit and again may be a nuisance.

Trigger modes related to TV sync. pulse separation would be superfluous because they are not normally required in schools. They may be a nuisance feature, but all of our dual trace samples have TV signal triggering.

Layout of controls

This is not an easy matter to decide upon because it is hard to be objective in comparing one oscilloscope layout with another. At least we think so! What seems to work well are logical groupings of controls, with clearly demarked boundaries between one set and another set. These boundaries seem to be easiest to work with when they extend right across the front panel, either vertically or horizontally. However a mosaic of little groups is not so easy to work with. Nor are boundaries with dog-legs, or inserts. Another feature we dislike is an array of unrelated controls all equally spaced out in line. Although superficially this looks neat, you have trouble distinguishing which does what.

The marking of controls has got to be absolutely clear. Rotary switches are generally easier to comprehend than are pushbutton switches. It is unclear sometimes whether the active state is in or out. On top of this, some pushbuttons are used for switching functions on and off, whereas others switch between different functions. This dual purpose of on/off and alternate mode function can cause confusion.

Since educational equipment should generally be as simple as possible to operate, a front panel layout that is easy to use may be of greater importance than an instrument with every gizzmo going. The presence of blanks on Tables 3 and 4 may be a recommendation !

The Pupil Oscilloscope

There is still a requirement for instruments with minimalist features. The paucity of facilities is a selling point because minimalist controls are as simple as can be to operate. The three models reviewed here (Harris, Irwin

and Unilab) are each so different in mode of operation as to offer an interesting choice - unlike the dual trace models, which are all basically alike.

Relative to a *pupil oscilloscope*, the additional features on the other single trace models, which we will call the *industrial single-trace* models (Crotech 3036 and Hameg 103-2), are

- 1, 2, 5, 10 switch positions on the Y amplifier and sweep rather than 1, 10, 100 settings;
- extra variable or switched gain controls on the amplifier and sweep;
- extra trigger features;
- calibrator output and (Hameg 103 only) component tester.

The question we now address is - how much more complex than pupil oscilloscopes are industrial single trace models?

If the oscilloscope is being used for measurement, it is beneficial having 1, 2, 5, 10 subdivisions rather than only 1, 10, 100 divisions because readings of greater precision and accuracy are obtainable. The variable and fixed magnitude gain controls can be confusing to beginners - but as every model of pupil oscilloscope has itself at least one variable gain control, there is little benefit from this factor. That really leaves the additional trigger facilities, which certainly make the industrial models more complicated to use. In mitigation, most traces are exceedingly easy to trigger. In competent usage, a greater range of signals can be successfully triggered.

If we look at the other side of the comparison, the wider bandwidth of the industrial models allows them to be used with higher frequencies. It should be noted in this respect that the upper working frequency of the Irwin and Unilab models is about 10 kHz.

In conclusion, whilst the minimalist features of the pupil oscilloscopes offer the simplest of possible arrangements, the additional features to be found on industrial single trace models are not significantly complex, yet may offer very desirable enhancements in performance.

Single or dual trace?

Since there is little financial benefit in buying single trace models, effectively the sole reason is the benefit derived from simplicity. The relative complexities are clearly shown in Tables 3 and 4. There are therefore sound educational reasons for buying single trace models.

Considering the curricular needs, the oscilloscope used to be studied in its own right in the days of O Grade Physics. This is now no longer a curricular requirement. The oscilloscope is needed as a functional instrument - for inspection, for measurement, or for testing. Its curricular usage has widened from Physics to include now Technological Studies and Electronics. With respect to Physics, an analysis of possible usage in Standard Grade Physics using the SSERC Technical Guides indicates that a single trace model will suffice in most instances. A dual trace model is seldom needed in that course. Excepting Standard Grade Physics, it is probably only in courses with a heavy electronics content that dual trace models are particularly useful. These include H Grade and CSYS Physics, H Grade Technological Studies and certain Electronics Short Courses. Elsewhere, there may continue to be places in S1/S2 Science and Standard Grade Science where an oscilloscope, almost certainly a single trace model, is needed.

In conclusion, we advise mixed purchasing - single for simplicity, dual for necessity. Our suggested buying ratio is 3:1 in Physics, and 1:1 in Technological Studies. These ratios should be modified for particular needs. For instance if a department is heavily into electronics, or CSYS, with above average intake numbers, then a greater weighting of dual trace models may be advisable.

Best buys?

Single trace

Amongst the single trace models, the *Crotech 3036*, having no significant adverse points, and fully living up to its specification, is the best buy. It is, as we have indicated above, reasonably simple to operate. Its 130 cm (5") screen gives it the edge over the Hameg 103-2. Its list price of £265 is subject to an educational discount.

The *Hameg 103-2* is also a fine instrument which fully lives up to its specification. Because of its small screen (95 cm or $3^3/_4$"), the overall enclosure size is small, which would be advantageous in laboratories with narrow workbenches. However the size of the ventilation apertures is a cause of concern. The price without discount is £255.

Amongst the pupil oscilloscopes, the *Unilab* model stands out best. Not only does it out perform the other models in most respects, it is, at £194.20, far cheaper.

Dual trace

It is pleasing to record that five models out of the twelve inspected have ended up with *A* assessments. These are the *Hameg 203-7*, *Hitachi V-212*, *ISO-TECH ISR 620*, *Kenwood CS 4025* and *Philips PM 3208*. The *Rapid 7020* just misses an *A* rating by a hair's breadth. All six are pretty sound buys. However the one which stands out with the best performance for its price is the *ISO-TECH ISR 620*, sold by RS Components, at £295.

Oscilloscope model	Electrical safety	Standard of construction	Y amplifier performance	Bandwidth performance	Sweep performance	X-Y mode performance	Layout of controls	Assessment
Single trace								
Crotech 3036	A	A	A	A	A	B[1]	A	A
Hameg 103-2	B[1]	A	A	A	A	B	B	A
Harris Super 5	A	A	C[1]	A	C[1]	B	B / C [2]	C [3]
Irwin EA1270	A	A	C[1]	C [2]	C [3]	B	B	C [4]
Unilab Student Oscilloscope	A	A	A[1]	C [2]	B [3]	B	A	B [4]
Dual trace								
Beckman 9012	B[12]	B[23]	A	B	C	A	B	B
Crotech 3324	C[12]	B	A	A[3]	C [4]	B [5]	B	C
Farnell DTV20	C[1]	A	B	A	A	A	B	C
Goldstar OS-7020	C[12]	-	C [3]	-	C [3]	C	B	C
Hameg 203-7	A[1]	A	A	A	A	A	C [2]	A
Harris MuPEC	A	A	C	A	C / A[1]	A	B	B
Hitachi V-212	A	A	A[1]	A[1]	A[1]	B	A	A
ISO - TECH ISR 620	A	A	A[1]	A[1]	A[1]	A	A	A
Kenwood CS 4025	A[1]	A	A[2]	A[2]	A[2]	A	B	A
Philips PM 3208	A[1]	A	A	A	A[2]	A	A[3]	A
Rapid 7020	A	A	A	A	B[1]	A	B	B[1]
Sampo SSI 2120	A[123]	B [4]	A	B	B	A	B	B

Table 5 : Oscilloscope performance

KEY TO PERFORMANCE RATINGS :

In general,

A Good B Fair C Poor

Specifically,

Electrical safety :

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

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

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

Y amplifier performance :
Bandwidth performance :
Sweep performance :

A Performs to specification.

B Performs slightly poorer than specification.

C Performs considerably worse than specification.

Assessment :

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

B Satisfactory for use in above.

C Unsatisfactory.

NOTES :

Crotech 3036

1. X - Y operation : Rather unusually the sensitivity of the horizontal amplifier is 400 mV/div., whereas the vertical amplifier is 500 mV/div. Because of this quirk, a 1 : 1 x - y signal ratio gives a corner to corner trace on the 10 x 8 screen.

Hameg 103 - 2

1. The enclosure has a series of ventilation apertures consisting of circular holes whose diameters are just under 4.0 mm and slots whose widths are just under 4.0 mm, but whose lengths are 26 mm. This complies with IEC 1010. However concern is expressed that pupils could insert through these slots knifeblades, coins, steel rules, or other conductors, into the enclosure and touch parts at hazardous live. The risk of accidental harm is negligible. The risk comes from foolishness or malfeasance.

Harris Super 5

1. Unusually, neither the Y amplifier nor sweep has preset controls for facilitating recalibration. The Y amplifier was found to have a systematic error of 9%, about which

nothing can be done. The sweep rate has a random error which is larger than specified, whether using the ±5% value in the handbook, or even the ±10% value in the catalogue.

2. The Super 5 uses pushbutton switches rather than rotary switches to select amplifier and sweep sensitivities. This is a deliberate attempt by Harris to simplify the controls. If you accept this, then the feature gets a B rating. If you don't accept it, then it gets a C rating. Unfortunately, whereas the Y amplifier multiplier control attenuates the trace, the sweep magnifier expands the trace. This contrariness is confusing.

3. This is the only oscilloscope tested whose trace could not be satisfactorily focused.

Irwin EA1270

1. The Y amplifier accuracy is not specified. We found that it reads 10% high at the 0.05 V potentiometer setting, is spot on at the 0.5 V position, and is 37% high on the 5 V position.

2. The bandwidth is about 17 kHz, whereas it is specified to be 50 kHz.

3. The sweep rate accuracy is not specified. We found that the fastest setting is 20% high. The other settings are 8% high.

4. Other poorish features were the triggering, which struggles to hold a trace for a signal with a high mark to space ratio, and the focusing, which does not produce a sharp image at high intensity.

Unilab Student Oscilloscope

1. The Y amplifier accuracy is not specified. We reckon on the sample we tested that it is about ±6%, which is as good as could be expected for a screen of this size.

2. The bandwidth was only 35 kHz, much lower than the 100 kHz specified.

3. It proved impossible to recalibrate the timebase such that all four calibrated settings were spot on. The best we could achieve were errors on the three fastest ranges of less than 3%, but an error on the slow range of 10%. This is reasonably fair.

4. Signals above 10 kHz are almost impossible to trigger. The trace is very sharp for a screen of this size. However the trace is skew at the top and bottom of the screen, but horizontal through the centre.

Beckman 9012

1. When we carried out our tests, the supply was fused on the neutral rather than on the live conductor. We understand that Beckman have now corrected this fault.

2. The metal panel on the front of the enclosure has some large unused cutouts (up to 73 mm long). These are protected only by the label membrane covering the front panel. The integrity of this part of the enclosure is suspect.

3. The robustness of switches with levers and with long mechanical linkages is suspect. In response, Beckman say that they have had no switch faults on any instrument referred to them so far.

Crotech 3324

1. There is a 115 V a.c. socket outlet on the rear panel, whose terminals sit at 240 V a.c. and 120 V a.c. with respect to earth. Although these terminals are recessed by 8 mm, they can be touched by a 4 mm plug. This outlet is therefore hazardous.

2. The supply voltage selector on the rear of the enclosure can be changed from 240 V to 115 V by hand, even while the apparatus is powered up.

3. An input with a fast edge causes ringing.

4. The calibrated sweep rate is badly off spec at slow sweep speeds.

5. After the sweep is switched off, the spot drifts for 10 s before settling.

Farnell DTV 20

1. The earth terminal on the front of the enclosure is a non-captive type of 4 mm socket. Farnell have so far failed to assure us that there is no risk, or that the socket is being replaced by a safe type.

Goldstar 7020

1. The earth terminal on the front of the enclosure is a non-captive type of 4 mm socket.
2. The carrying handle is not earthed.

3. The calibrated settings were found to be wildly out of spec.

Hameg 203-7

1. The enclosure has a series of ventilation holes of diameter slightly less than 4.0 mm. This complies with IEC 1010.

2. The layout of the controls is, in our opinion, a dog's breakfast. Whilst a skilled technician would find the controls easy to work with, they are bound to be confusing to beginners. We especially dislike the pushbuttons whose markings fail to indicate whether a function is on or not.

Harris MuPEC

1. Two instruments have been tested. The time base of one of them was out of spec.

Hitachi V-212

1. These features perform better than specified.

ISO-TECH ISR 620

1. These features perform better than specified.

Kenwood CS 4025

1. The earth terminal on the front panel is a non-captive type of 4 mm socket. Because a 10 cm probe inserted through this socket is unable to touch any part that is hazardous live, the risk is judged to be negligible.

2. These features perform better than specified.

Philips PM 3208

1. The earth terminal on the front panel is a non-captive type of 4 mm socket. Philips have investigated the risk and assert that no live components could be accessed by pushing wire through the earth socket to a depth of 9 inches. The risk is therefore judged to be negligible.

2. The sweep calibrated settings perform better than specified.

3. The controls were judged to be lain out more clearly and simply than on any other model of dual trace scope that we have so far tested.

Rapid 7020

1. The sweep rate has a systematic error of 2% slow, which presumably can be removed by recalibration. There is also a random error, whose magnitude is well below the ±3% value in the specification. Systematic errors in new instruments are unusual. It points to incorrect adjustment in manufacture. We swithered about giving the machine an *A* assessment.

Sampo SSI 2120

1. A metallic label covers two 16 mm diameter and two 8 mm diameter holes on the back panel of the enclosure. This label could be punctured by vandalism or accident. However, in the event of puncturing, there would be no ready access within the enclosure to hazardous live conductors.

2. There are seven 8 mm diameter holes for accessing preset controls in the base of the enclosure. A metal test pin inserted through each opening was unable to access any hazardous live conductors. This feature therefore presents negligible risk.

3. The temperature rise of the instrument was markedly higher than on other models tested, but remained well within compliance of IEC 1010 requirements.

4. The openings for preset controls were out of register with the presets themselves.

Equipment Notes

Laser diode modules

This note provides a buyers' guide to laser diode modules (LDMs) and discusses whether they are of interest to schools. The reader is directed to the safety notes section of this issue where matters of laser safety, classification and operating procedures are written about.

As discussed in Safey Notes, laser diodes should not be used in schools as discrete components, but only in the form of a laser diode module. This product comprises a laser diode, drive circuit and lens, all fitted within a cylindrical brass enclosure. The overall dimensions range from about 30 mm to 75 mm in length by between 10 mm and 25 mm in diameter. Even in module form, it really can be quite small. A low voltage external power supply is needed. Typically this could be a 4.5 V or 9 V battery, or a 5 V regulated voltage supply.

Only the least expensive types of LDMs have been listed (Table 1). They are all in Class 2. The colour of radiation emitted by all is a dull cherry red, the wavelength being about 670 nm. Shorter wavelength emitters are available, but cost very much more, perhaps over £300 a unit. If compared with the optical output from a HeNe laser of similar power, emitting at 633 nm, a laser diode's output appears to be far less bright. This is because the eye is less sensitive at 670 nm.

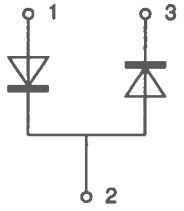
Can an LDM be used as a substitute for a HeNe laser? In some respects it performs less well. In others, it is superior. Although a collimated beam from an LDM does not give the startlingly intense spot on a diffuse white screen that you get from a HeNe laser, the beam from a 1 mW LDM is quite bright enough to use with lenses in subdued daylight, say at 400 lux. If looking at diffraction or interference patterns with an LDM, blackout or partial blackout conditions would be required - unlike similar

Supplier	Manufacturer	Stock no.	Output power (mW)	Wavelength (nm)	Operating mode	Price (£)
Farnell	Melles Griot	212-866	<1	675	CW	195
Lambda	Imatronic	LDM145/670/1.0	1.0	670	CW	99
		LDM145M/670/1.0	1.0	670	analogue or digital	140
Laser Lines	Uniphase	3505-008	0.7	670	CW	150
		0504-008	0.7	670	analogue	165
RS	-	194-010	1.0	660-690	CW	119
	-	564-504	1.0	660-690	analogue or digital	155

Table 1 - Laser diode modules

work with a HeNe laser. In a comparison of interference patterns from multiple slits, 19 fringes were seen from the LDM system against 42 from the HeNe system in blackout. Although the LDM's fringes were dimmer and fewer in number, the central group of fringes were easier to distinguish than those from the HeNe, which were too startlingly bright.

The drive circuit contained within the module enclosure typically contains one or several potentiometers to set the forward diode current. This controls the optical output power. These settings must not be tampered with. Almost certainly the laser diode is being under-run to comply with the Class 2 power limit of 1 mW. The diode itself may well be capable of producing 5 mW or more. Laser diodes operate in forward conduction mode. Why then do they always contain a second diode in reverse bias (Fig.1)? This is part of the feedback mechanism to control the optical power. The second diode is a photodiode that senses the laser power for referring to the drive circuit.



1. Photodiode anode
2. Common terminal
3. Laserdiode cathode

Fig.1 - Example of a laser diode structure

Light emerges from the LDM through a spherical lens which is mounted on a fine screw thread. You can therefore adjust the lens to get either a diverging, collimated, or converging beam. The position of the focus on the module we looked at could be brought to as near as 55 mm from the lens. This setting would make a suitable source for an optical bench light. For instance if the LDM is mounted at one end of an optical bench (Fig.2) and adjusted to produce a focused beam near to the module, the focus can be used as a point source of light. Its position can be found by a paper screen. If a spherical lens is placed in the diverging cone of light beyond the focus, the standard relationships between u, v and f can be explored.

A sheet of white paper placed in the beam makes a suitable viewing screen. Because light from the image on the paper is scattered in all directions, viewing can be from any direction except directly into the main beam. When viewed under blackout conditions, a faint aureole of light surrounds the main beam. Typical sizes at 1.6 m from the LDM are shown (Fig.3). The aureole would not be noticed in daylight.

The fitment of a collimating lens would seem to make the laser diode module a more useful laboratory tool than the standard form of educational HeNe laser. Because the collimating lens attenuates the laser power by about 20%, it should never be removed from an LDM that is emitting laser light as this could push the output beyond 1 mW.

Referring to the *Operating mode* column in Table 1, the cryptic comment *CW* stands for *continuous wave*. The output from this type of LDM cannot be pulsed or

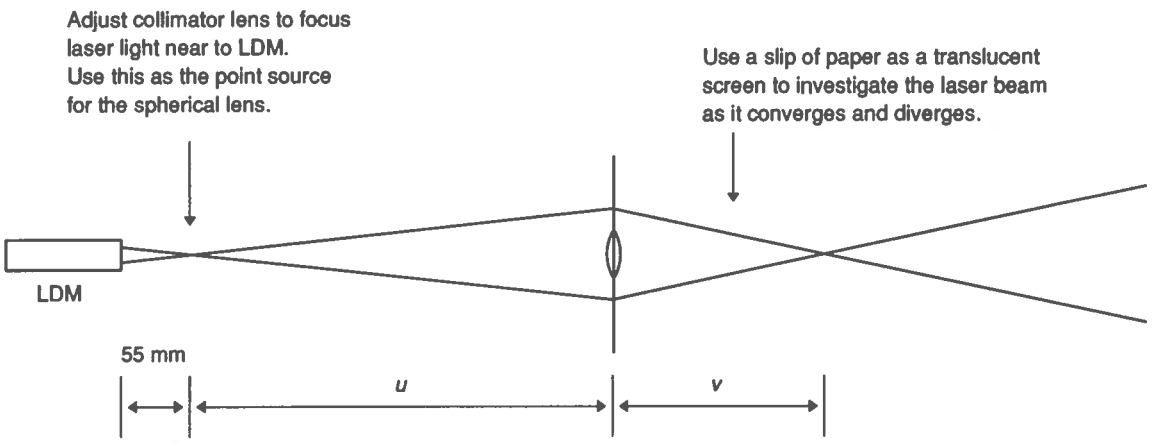


Fig.2 - Using an LDM with an optical bench

modulated by electronic means. The other types of LDM have drive circuitry for either analogue modulation, or digital pulsing, or both of these features. The preferred operating frequencies of the modulating signal may be above 100 kHz, which is rather high for school instruments to handle.

Because of the risk of destroying an LDM by applying power of the wrong polarity, it is recommended that the LDM is hardwired to a school-built power supply (12 V a.c. in, d.c. out), or to protection diodes.

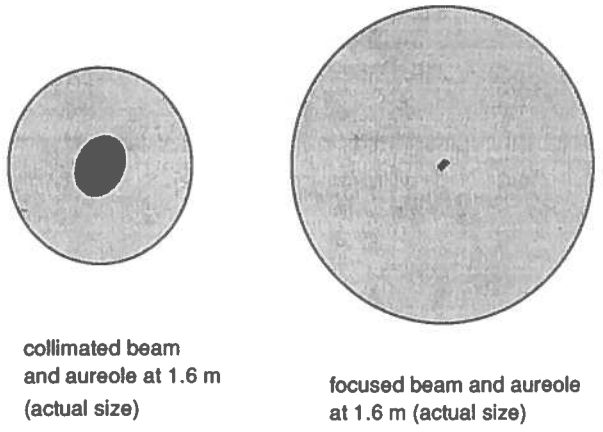


Fig.3 - Aureole and main beam

Problems with discretes

We advised against using discrete laser diodes in Safety Notes. Apart from the difficulty of limiting the optical output to 1 mW, there is a risk of static damage and there is at present no apparent financial benefit favouring discretes against LDMs. For instance Hero Electronics sell the 3 mW Philips laser diode CQL 80 at £42.80, a Philips drive board at £39.50, a collimator at £35.50 and lens key at £3.50. This totals £121.30. The laser diode in isolation is extremely susceptible to electrostatic damage. The person handling it must wear earthing straps, use an earthed iron and work on an earthed mat. Only when connected to its drive board is the system fully protected. Then it may be handled without taking static protection.

Laser pointers or laser pens

Laser pointers or laser pens are really just laser diode modules with batteries. They can be used as screen markers with overhead projector transparencies. In physical size, they might typically be about 135 mm long by 15 mm in diameter. They are easily pocketable. Because of the risk of theft, it would seem prudent for schools to refrain from buying them - even those in Class 2. Those with an optical output power of 5 mW, making them fall into Class 3A, should not be purchased.

Trade News and Announcements

Balance burn out

A number of EAs and individual independent schools have appointed outside contractors to carry out electrical safety testing to HSE Guidance Note GS23. Sometimes these firms are, to put it mildly, inexperienced in handling specialised educational equipment. One consequence of this can be that although some pieces of your kit might be working when the tester arrives - they're certainly not by the time he or she leaves! This is known in some circles as the pest control or timber infestation operative syndrome.

One category of equipment which has tended to suffer such damage has been the older type of electronic balance working on the torsion principle. The relatively heavy currents applied during the earth test may damage the torsion strips on such balances. Specialist repairers of such balances are now somewhat scarce. One firm which still does this this kind of work is SMK Balances of Newcastle-upon-Tyne. A typical charge for replacing one burnt out strip would be about £60 whilst replacing all four will cost you ca. £100.

You may well be entitled to reimbursement from the tester but you will have to convince them that it was their intitial ignorance and negligence which broke your balance. From experiences reported to us it would seem that may not be easy. At least one firm swore blind that it was technically impossible for the earth test to damage the balance and that someone in the school "must have dropped it" after the testers had left. Good luck!

CD-ROMs for science courses

When CD-ROM readers first became more or less affordable on a one per school basis most of the discs were general encyclopaedias or archived newspapers. Resources for science courses are now starting to come on to the market.

Living body

This CD-ROM from Philip Harris is an atlas of the systems of the human body. It contains a wide range of visual material including colour micrographs of tissues, photographs of organs, X-rays, animation sequences, text boxes and diagrams. An A to Z index allows searches on key words.

At present the hardware requirement is for an IBM PC (or compatible) microcomputer and CD drive although it can be read using an Acorn Archimedes running PC Emulator version 1.81. A single user version is £199 and the full network version £295.

SSERC Graphics CD

Talk of CD-ROM reminds us also to announce the fairly imminent availability of our own in-house effort. We hope to publish our own CD in early Summer which will contain, among many other things, all of our Graphics Library, Draw Guides, apparatus set ups, circuit diagrams and molecules designed using the Chemical Modeller etc. All told the SSERC CD will contain over 7,000 files. These will be made up of science and technology graphics in various formats plus datafiles from experimental procedures, and other sources.

This collection, running to some 300 Mb will be for Archimedes in the first instance, have a RISCOS front end and run in the desktop environment. It will have a thesaurus and be capable of being searched with keywords. The likely price will be around the £200 mark and distribution will be on a site licence only basis.

Apple Mac software

We have received details of some interesting software and associated resources from Israel. These are in the *Explorer* series which to date supports biology and physics courses at upper secondary levels. The approach is experiment based with built in spreadsheets and graphical display utilities.

Topics covered in biology include; genetics, population ecology, cardiovascular physiology and photosynthesis. In physics the topics to date are: gravity, harmonic motion, one body and two bodies, waves, diffraction, ripple tanks, a.c./d.c., electrodynamics and electrostatics.

Hardware requirements are Apple Mac family machines with 1 Mb minimum memory and hard disc or two 800 K floppies.

The UK distributor for the Explorer series is Anglia University - see Address List inside rear cover.

Video encyclopaedia of physics

This is a collection of 25 interactive videodiscs (12" laserdiscs) which deals with some 600 physics demonstrations suitable for use with secondary school and college students. The video material on the laser discs is augmented by slow motion sequences and animation.

Obviously this huge amount of material does't come cheap. The entire collection costs 2,995 US$ plus a shipping charge of 69.95 $ US. This means that the inclusive price in sterling is about £2,000.

A sample preview videotape is available on request from the suppliers in the USA who are known as 'The Education Group'.

We understand that SCET holds an evaluation set of these materials. At the time of writing they did not yet have any Education Group software (probably IBM PC) to allow true random access to the demonstrations on any particular disc.

Strange moves

Mention of SCET reminds us to announce the appointment of Philip Strange of TVEI and IT support fame as an officer of SCET. As from 1st March this year he became Adviser in IT in SCET's Research and Development Division.

Phil wrote "Interfacing with Datadisc" which was published and distributed by SSERC as well as being widely used in training courses in Scotland. We have since enjoyed working with him from time to time on an informal basis. This was in a number of other projects and particularly when we were a Joint Support Activity for TVEI.

We are confident that his appointment will significantly increase the support directly available from SCET for individual teachers trying to implement information technology applications in classrooms, laboratories and technology departments.

Higher physics

Adrian Watt of VELA guide fame has produced a set of resources for a practical approach to the revised Higher physics course.

His course materials have been grouped into three main topics : *Mechanics and Matter*; *Electricity and Electronics* and *Radiation and Matter*. A set of pupil materials is provided for each of these and there is one set of Teacher's Notes. The teacher's materials are set out as a single side per experiment each giving notes on the aims of the activity, previous knowledge required, list of apparatus and where appropriate a sample set of typical experimental results with notes on errors.

These materials are published by and available from Edinburgh Peripherals. Individual private purchasers and school purchasers are granted certain waivers on copyright and allowed to make multiple copies for use with classes. Further information is available from the publisher.

Chemistry project prize

The Fine Chemicals and Medicinals Group of the Industrial Division of The Royal Society of Chemistry are again holding their competition for the best schools project report. The prize is worth £2,000 to the winning school.

The project report should describe a project carried out in the school sessions 1991-92 or 1992-93. Preference is given to projects carried in collaboration with the local chemical industry. The subject should fall broadly within the areas of interest of the Fine Chemicals and Medicinals Group, that is medicinal, agricultural, veterinary, flavour or fragrance chemistry, or fine chemicals.

The aim of the competition is to promote interest in practical applications of chemistry through instructive projects and preferably in association with local chemical industry. The next submission date for entries is on or before 1st September 1993.

Projects will be judged on their novelty, applicability, quality etc. and on the quality of reporting. Summaries not exceeding 10 pages in length should be submitted to the Honorary Secretary (see Address List) before 1st September 1993. Note that the Group also can make grants of up to £500 per school for the purchase of equipment or chemicals. Again applications should be made to the Honorary Secretary at the same address.

Chemistry Club Festivals

The Chemistry Club, supported by Salters' Institute, RSC and hundreds of commercial firms, is again inviting schools to register for its Festivals of Chemistry.

In June of this year schools will receive advance details of a series of Regional Chemistry Festivals to be held in university chemistry departments for teams of 11 to 14 year olds. These festivals will be held on dates between March and July 1994 and school teams will be asked to demonstrate chemistry experiments around a theme and to compete in *chemical egg races*.

There will also be other events such as chemistry trails, lecture demonstrations, and opportunities to meet young chemists and chemical engineers. Industrial sponsorship will be offered to all schools entering teams and there will be substantial cash prizes to be won.

To register your interest and receive more information about these festivals of chemistry write to or send a fax to The Chemistry Club (see inside rear cover).

Surplus Equipment Offers

Items are arranged by similarity of application, or for other reasons, and not by stock number sequence. Often the item number serves only for stock identification by us in making up orders.

The prices quoted do not include VAT. However VAT is added to every customer's order. Local authority establishments will be able to reclaim this from the Inland Revenue.

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

Changes in stock

Since most of our stock is bought on the surplus market it is subject to an uncertainty of supply. Some items regrettably become unobtainable. Items recently dropped include several models of motor.

Amongst new stock items there is a neodymium magnet, an astonishingly powerful permanent magnet made from an alloy of neodymium, iron and boron. Anything that you might try with an ordinary magnet is enhanced many times more! We also have a low pressure sodium lamp, a Shandon chromatography kit and a stainless steel encoder disk for 4-bit Gray code (Fig.1).

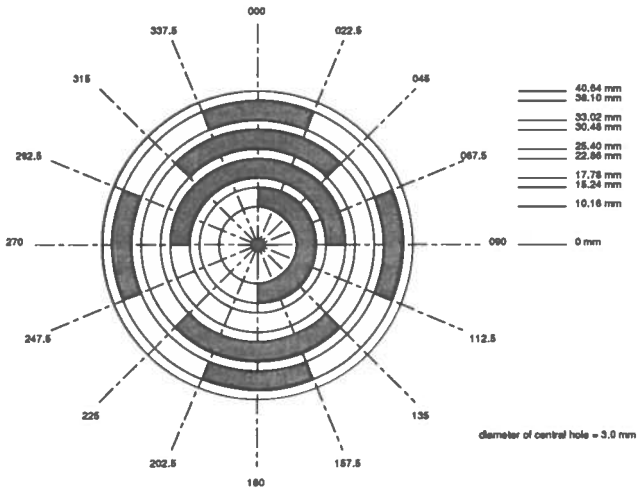


Fig.1 - 4-bit Gray code disk

Motors

591 Stepper motor, 4 phase, 12-14 V d.c., 400 mA, 27.5 Ω, step angle 7.5°, powerful motor with 15 mm x 6 mm dia. output shaft. Dimensions 40 mm x 70 mm dia. on 70 mm square mounting plate with fixing holes at 56 mm centres. Circuit diagram supplied. £4.50

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

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

766 Precision motor, 0.12 V to 12 V d.c., no load current and speed 7.5 mA and 7800 r.p.m., stall torque 14.9 mN m, 9 segments, dimensions 34.1 mm x 23 mm dia., output shaft 8 mm x 3.5 mm dia. steel spline, back EMF constant 1.55 V/1000 r.p.m. Suggested application: tachogenerator £10

767 Precision motor, 0.33 V to 24 V, no load current and speed 3.5 mA and 6400 r.p.m., stall torque 11 mN m, 9 segments, dimensions 34.1 mm x 23 mm dia., output shaft 14 toothed steel pinion, back EMF constant 3.6 V/1000 r.p.m. Suggested application: tachogenerator £10

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

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

621 Miniature motor, 1.5 V to 3 V d.c., open construction, ideal for demonstration, dimensions 19 x 9 x 18 mm, double ended output shaft 5 mm x 1.5 mm dia. 20p

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

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

773 Tachometer (ex equipment) £2.25

625 Worm and gear for use with miniature motors, nylon worm and plastic gear wheel. 35p

378 Encoder disk, 15 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 75p

642 Encoder disk, 30 slots, stainless steel, 30 mm dia. with 4 mm fixing hole. £1.30

772 Encoder disk, 4-bit Gray code (Fig.1), stainless steel, 81.28 mm dia., 3 mm fixing hole, slots sized to register with components mounted on 0.1" stripboard. Applications: shaft position sensing, wind direction indicator.
For related electronic circuitry see Bulletin 146 £3.00

Miscellaneous items

629 Dual tone buzzer with flashing light, mounted on small p.c.b. The unit has a PP3 battery clip and two flying leads for switch applications. 55p

710 Sonic switch and motor assembly. First sound starts the motor, a second reverses the direction of rotation, a third sound stops the motor. Driven by 4 AA cells (not supplied). 45p

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

746 4 mm push-in fitting, with adaptor for pressure gauge (stock item 715). £1.60

313 Thermostat, open construction, adjustable, temperature range +10° to +65°C. Rated at 10 A, 250 V, but low voltage switching also possible. 60p

165 Bimetallic strip, length 10 cm; high expansivity metal: Ni/Cr/Fe - 22/3/75 low expansivity metal: Ni/Fe - 36/64 (invar) 15p
166 Ditto, but 30 cm length. 40p

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

419 Humidity switch, operates by contraction or expansion of membrane. Suitable for greenhouse or similar control project. Rated 3.75 A, 240 V. 75p

753 Submersible pump, 6 V to 12 V d.c., 8 litres/min., 0.6 bar, dry operation protected. £4.55

371 Ferrite rod aerial, two coils MW and LW, dimesions 140 mm x 10 mm dia. 85p

758 Loudspeaker, 8 U, 5 W, 66 mm dia. 50p

771 Neodymium magnet, 14 mm dia. x 4 mm thick. £1.30

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

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

740 Microswitch, miniature, SPDT, button operated. 25p

353 Reed switch, SPST, 80 mm long overall, fits RS reed operating coil Type 1. 30p

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

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

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

742 Key switch, 8 pole changeover. 40p

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

688 Croc clip, miniature, insulated, red. 5p
759 Ditto, black. 5p

741 LES lamp, 6 V. 15p

770 LES lamp, 12 V. 15p

690 MES lamp, 6 V, 150 mA. 9p

691 MES battenholder. 20p

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

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

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

724 Dual in line (DIL) sockets, 8 way 5p
760 14 way 7p

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

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

714 Sign "Radioactive substance" to BS spec., 145 x 105 mm, semi-rigid plastic material. Suitable for labelling a radioactive materials store. With pictogram and legend. £2.30

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

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

757 Twin bladed propellor, plastic, 130 mm dia., fits 2 mm shaft. 10p

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

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

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

752 Shandon chromatography solvent trough. £1.00

754 Stereo microscope, Vickers long arm type with knuckle joint, mechanically coupled eyepiece tube, x10 eyepiece, x1 and x2 objectives on tumble change, built-in illuminator with either top or basal illumination, weight 12 kg, very stable even with arm swung away from base. Suitable for biology, primary, electronics, geology, etc. Equivalent present day model would cost in excess of £250. Delivery can be arranged for multiple purchases, otherwise has to be uplifted. £100.00

Components - resistors

328 Potentiometer, wire wound, 15 Ω, lin., 36 mm dia. 30p

737 Ditto, 22 Ω, lin., 36 mm dia. 30p

329 Ditto, 33 Ω, lin., 36 mm dia. 30p

330 Ditto, 50 Ω, lin., 40 mm dia. 30p

331 Ditto, 100 Ω, lin., 36 mm dia. 30p

421 DIL resistor networks, following values available: 62R. 100R, 1K0, 1K2, 6K8, 10K, 20K, 150K, 125R/139R and 1M0/6K0. Price per 10. 30p

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

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

Components - capacitors

695 Capacitors, tantalum, 4.7 µF 35 V, 15 µF 10 V, 47 µF 6.3 V. 1p

696 Capacitors, polycarbonate, 10 nF, 47 nF, 680 nF, 1 µF, 2.2 µF. 2p

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

698 Capacitors, electrolytic, 1 µF 25 V, 2.2 µF 63 V, 10 µF 35 V, 33 µF 10 V. 1p

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

Components - semiconductors

322 Germanium diodes 8p

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

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

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

726 MC74HC02N quad 2-input NOR gates. 5p

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

699 MC14015BCP dual 4-stage shift register. 5p

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

Sensors

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

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

641 Precision R-T curve matched thermistor, resistance of 3000 Ω at 25°C, tolerance ±0.2°C, R-T characteristics supplied. Means of accurate usage described in Bulletin 162. £2.90

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

751 Hacksaw blade with pair of strain gauges, terminal pads and leads attached. Suitable for impulse measurement as described in Bulletin 171. Delivery time 3 months. £12.50

501 Kynar film, screened, 28 µm thick, surface area 18 x 100 mm, coaxial lead and 4 mm connectors. Applications: Impulse (Bulletins 155 and 174), long wave infrared (Bulletin 155, SG Physics Technical Guide, Vol.2, pp 33-4) £20.00

502 Ditto, with BNC connector. £20.00

503 Kynar film, unscreened, 28 µm thick, surface area 12 x 30 mm, no connecting leads. 55p

504 Copper foil with conductive adhesive backing, makes pads for unscreened Kynar film to which connecting leads may be soldered. Priced per inch. 10p

506 Resistor, 1 gigohm, ¼ W. £1.25

Opto-electronic devices

507 Optical fibre, plastic, single strand, 1 mm dia. Applications described in Bulletin 140 and SG Physics Technical Guide Vol.1. Priced per metre. 40p

508 LEDs, 3 mm, red. Price per 10. 50p

761 Ditto, yellow. Per 10. 50p

762 Ditto, green. Per 10. 50p

Other components

We also hold in stock a quantity of other electronic components. If you require items not listed above please let us know and we will do our best to meet your needs, or to direct you to other sources of supply.

Items not for posting

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

Glassware

657 Screw cap storage jar, plastic cap, 4 oz., wide neck. 10p

663 Flat bottom round flask, 250 ml. 50p

664 Flat bottom round flask, 500 ml. 50p

665 Flat bottom round flask, 800 ml. 50p

747 Quickfit vented receiver, 10 ml. 20p

775 Glass volumetric bulb pipette, 25 cm^3 50p

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

Chemicals

NB: chemicals are named here as described on supplier's labels.

667 250 ml N.H carbamide (Urea). 25p

668 500 ml dodecan-1-ol. 50p

670 500 g Keiselguhr acid, washed. 25p

672 500 g Magnesite native lump. 25p

673 250 g manganese metal flake, 99.9%. 50p

674 250 g manganese(II) sulphate AR. 25p

676 500 g quartz, native lump. 25p

677 100 g sodium n-butyrate. 25p

678 500 g strontium chloride AR. 25p

681 Zinc acetate AR. 25p

682 2.25 litre ammonia solution. 50p

685 500 ml n-decanoic Acid (Lauric acid). 25p

769 500 ml 1-1-1 trichloroethene. 50p

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

SSERC, 24 Bernard Terrace, Edinburgh, EH8 9NX; Tel. 031 668 4421, Fax. 031 667 9344.

Beckman Industrial Ltd., Astec Building, High Street, Wollaston, Stourbridge, West Midlands, DY8 4PG; Tel. 0384 442394; Fax. 0384 440252.

British Standards Institution, BSI Publications, Linford Wood, Milton Keynes, MK14 6LE; Tel. 0908 221166, Fax. 0908 322484.

The Chemistry Club, Homerton College, Cambridge, CB2 2PH; Tel. 0223 414860, Fax. 0223 413543.

Cuthbertson & Laird Instruments Limited, Parkburn Court, Glasgow Road, Burnbank, Hamilton, ML3 0QQ; Tel. 0698 829711.

Edinburgh Peripherals, 14 Hallcroft Crescent, Edinburgh, EH28 8SB.

Edinburgh Science Festival Limited, Freepost, P.O. Box 92, Edinburgh, EH3 0EN; Tel. 031 557 4296.

The Education Group, 1235 Sunset Plaza Drive, Los Angeles, CA 90069, USA.

Explorer Series Software, c/o Sue Clacher, Anglia University; Tel. 0727 869791.

Farnell Electronic Components Ltd., Canal Road, Leeds, LE11 0RG; Tel. 0532 636311, Fax. 0532 633411.

Farnell Instruments Limited, Sandbeck Way, Wetherby, West Yorkshire, LS22 4DN; Tel. 0937 581961, Fax. 0937 586907.

Festival of Technology Education for Elementary Stages (5 - 14), c/o Carole Thomson, Northern College of Education, Aberdeen Campus, Hilton Place, Aberdeen, AB9 1FA; Tel. 0224 283642, Fax. 0224 487046.

Fine Chemicals & Medicinals Group, Dr Norman Rogers, Hon.Sec., Smith Kline Beecham Pharmaceuticals, Great Burgh, Yew Tree Bottom Road, Epsom, Surrey, KT18 5XQ.

Griffin and George Limited, Bishop Meadow Road, Loughborough, Leicestershire, LE11 0RG; Tel. 041 248 5680, or 0509 233344, Fax. 0509 231893.

Philip Harris Education:

2 North Avenue, Clydebank Business Park, Clydebank, Glasgow, G81 2DR; Tel. 041 952 9538;

Lynn Lane, Shenstone, Lichfield, Staffordshire, WS14 0EE; Tel. 0543 480077, Fax. 0543 480068.

Health and Safety Executive, Public Enquiry Service, Information Centre, Broad Lane, Sheffield, S3 7HQ; Tel. 0742 892345, Fax. 0742 892333.

Hero Electronics Limited, Dunstable Street, Ampthill, Bedfordshire, MK45 2JS; Tel. 0525 405015, Fax. 0525 402383.

IPMS (Institution of Professionals, Managers and Specialists), 75 - 79 York Road, London, SE1 7AQ; Tel. 071 928 9951, Fax. 071 928 5996.

Irwin-Desman Limited, 294 Purley Way, Croydon, CR9 4QL; Tel. 081 686 6441, Fax. 081 681 8429.

Lambda Photometrics Limited, Lambda House, Batford Mill, Harpenden, Hertfordshire, AL5 5BZ; Tel. 0582 764334, Fax. 0582 712084.

Laser Lines Limited, Beaumont Close, Banbury, Oxfordshire, OX16 7TQ; Tel. 0295 267755, Fax. 0295 269651.

Neill Tools, Handsworth Road, Sheffield, S13 9BR; Tel. 0742 449911, Fax. 0742 431360.

Rapid Electronics Limited, Heckworth Close, Severalls Industrial Estate, Colchester, Essex, CO4 4TB; Tel. 0206 751166, Fax. 0206 751188.

RMR Measurements, 2 MacTaggart Road, Seafar, Cumbernauld, G67 1JL; Tel. 02367 28170.

Professor J.M. Robertson, Lothian Professor of Microelectronics, Department of Electrical Engineering, The University of Edinburgh, The King's Buildings, Mayfield Road, Edinburgh, EH9 3JL; Tel. 031 650 5574, Fax. 031 650 6554.

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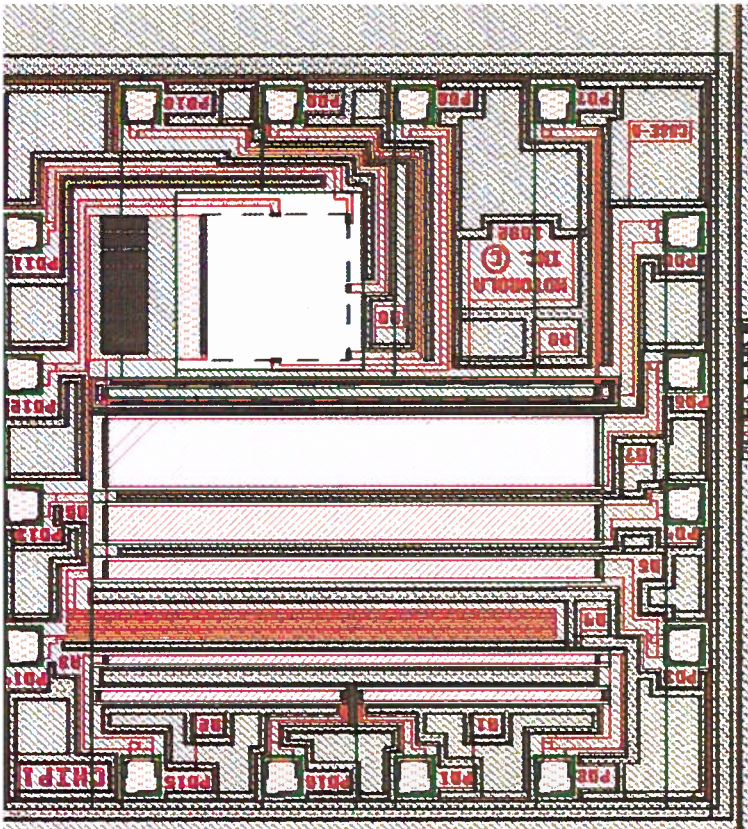
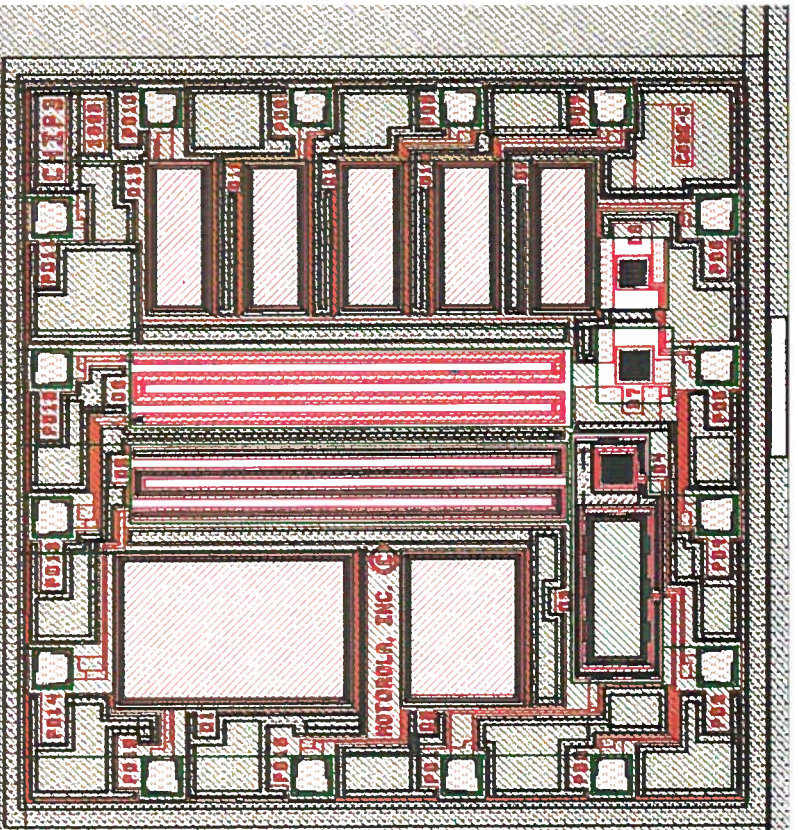
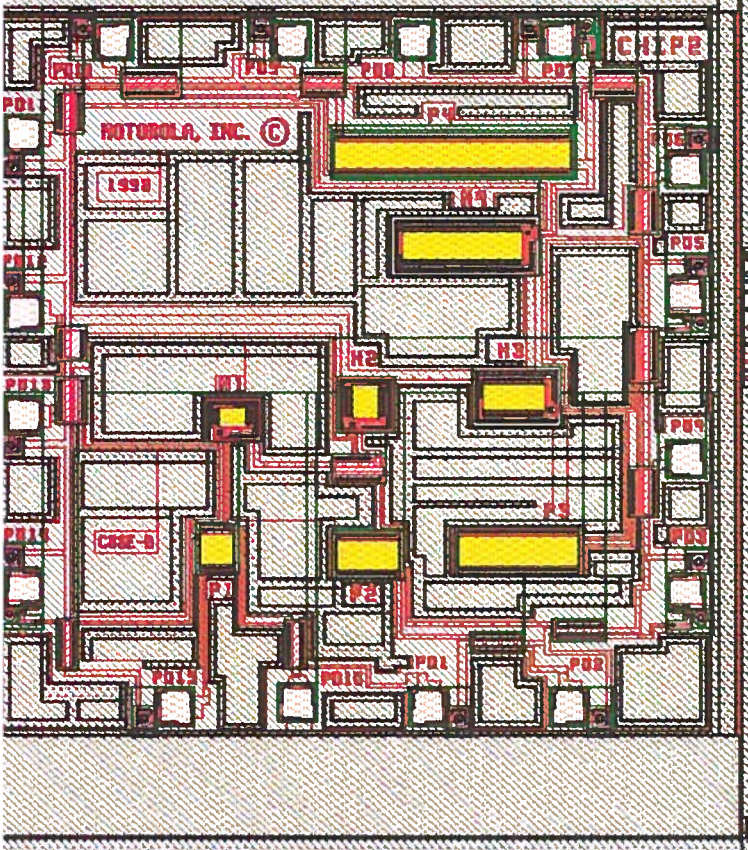


Chip 1 Resistors

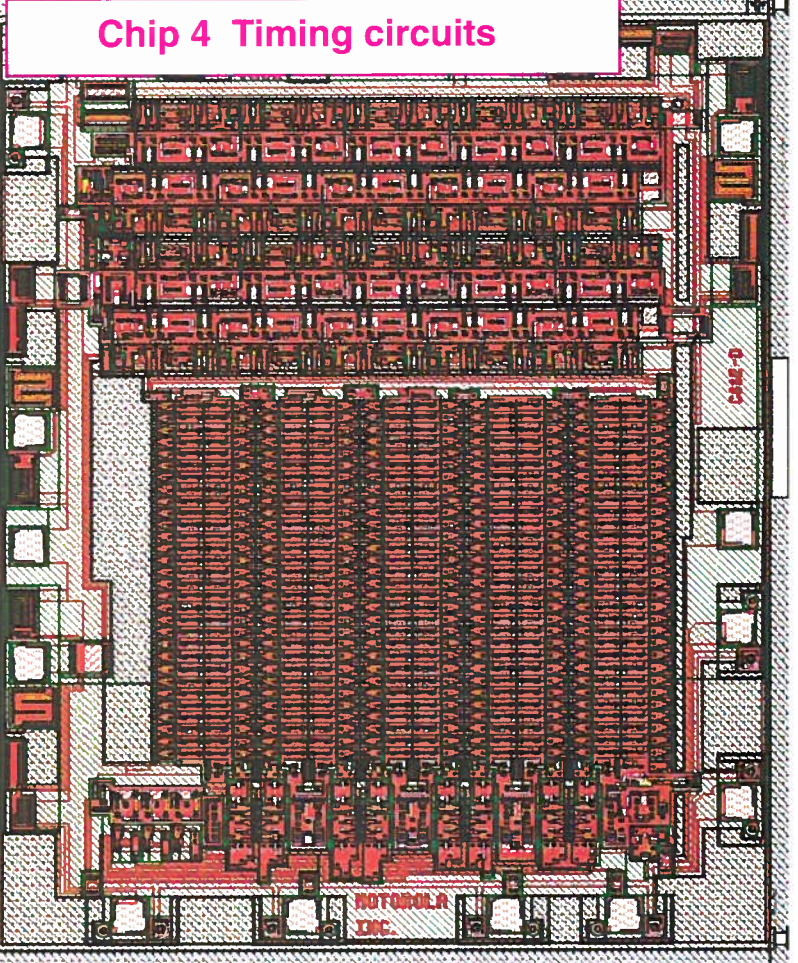


Chip 3 Opto-electronics

Chip 2 Transistors



Chip 4 Timing circuits



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