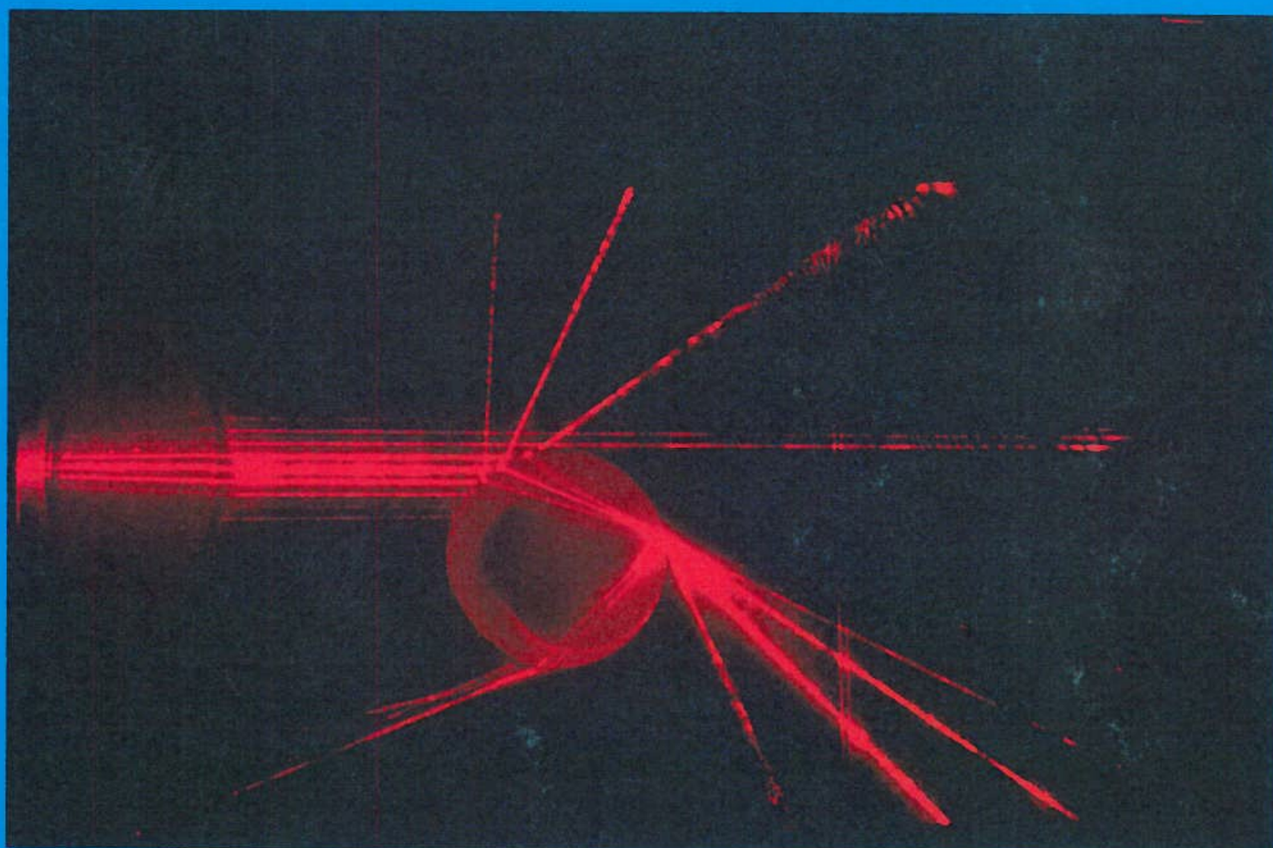
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE



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For: Teachers and Technicians in Technical Subjects and the Sciences

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NEWS AND COMMENT

Future of SSERC

It now looks as though there could well be one. The money is trickling in. Meanwhile the service is still up and running. The Centre is staffed and able to respond to enquiries and provide a full range of support services. Many of the new Unitary Authorities have already paid their annual subscription and first quarter's fees. Several others have declared their intention so to pay but matters have been delayed because of the heavy burden placed on the new Councils by all the problems of re-organisation. In the now unlikely event that any new authority does not join SSERC, we shall in due course indicate to the affected schools the withdrawal of the service.

Inaugural IoB meeting

The first of what we hope will be many annual education conferences of the Scottish Branch of the Institute of Biology was held in Stirling University on Tuesday May 14th. By any measure, this was a successful meeting. The morning session was given over largely to curricular matters and recent developments in Scottish biotechnology education. The afternoon had more to do with issues raised by the science and technology of biology in a wider context.

The curricular coverage started with an update on biological aspects of the Higher Still programme - including Management of Environmental Resources or MER as it looks like becoming known (it's too early to say whether affectionately or otherwise). Speakers on Higher Still stressed the similarity and consistency of presentation in the documents both within biological subjects as well as across and beyond the sciences. Great play was made also of the minimal changes to content and of the more holistic and less atomistic approach to assessment. The latter, quite rightly, was described as the *teach it, learn it, assess it and then forget it* approach. Also stressed was the nature of Higher Still as "only a framework" on which schools and colleges could hang their own priorities and timetables for progressing the new arrangements.

I have great respect for the people involved in the biology parts of Higher Still and I'm sure that yet again all is being done for all the best possible reasons. That parts of the new biology framework present some excellent chances to update, enrich and enhance provision for all is beyond any reasonable doubt. That the programme for the morning session was itself so crowded perhaps set the tone or at least reflected the current situation in which teachers find themselves.

The profession is yet again being presented with a whole new set of insurmountable opportunities. Without resources, and time for personal and professional development, there are bound to be limits to what teachers will be prepared to do. So full was the morning that it was entirely without any coffee or tea break - speaker following speaker in an unbroken flow. This wasn't as bad as it reads since most of them were very good. But, when the capacity of either bladder or brain (in some cases perhaps both) were exceeded, delegates understandably voted with their feet. With hindsight this was perhaps usefully allegorical. If Higher Still really is an "at your own pace and in your own way" timetable or framework, then in many schools and some colleges it will be some time a-coming. Meanwhile secondary schools may just use it as an excuse to give 5-14 Environmental Studies a body swerve and to turn a blind eye to the need to update and enhance their Standard Grade materials.

The morning ended setting the biotechnological tone for the afternoon, with short accounts from Marjorie Smith, Dollar Academy, on the *Scottish Biotechnology Education Project* followed by Kathleen Oates, of West Dunbartonshire Council, on *The Lab* - a biotechnology education facility at the University of Strathclyde, Jordanhill Campus.

The afternoon was given over to two excellent talks. The first was by Professor David Porteous of the MRC Human Genetics Unit, who spoke to the title : *Human Genetics - Understanding the Science and its Consequences*, and the second from David Rose of Barony College, who raised a number of controversial issues under the title *Biological Advances - A dilemma for land based industries*. Both speakers raised a number of ethical and moral considerations ranging from the potential difficulties inherent in counselling parents to genetic piracy and patents. Both also made their points well on the critical role which biotechnology will have and the many issues it will raise, both for biology educators and society at large, as we turn the centennial corner.

Science Review Group Report

This was launched, by Scottish CCC, at a somewhat earlier bunfight than the IoB's. Strangely, I seem to get less rather than more cynical as I age. The meeting was largely of practitioners and I have to confess to having enjoyed it more than somewhat. The gathering was aberrant, since it seemed to consist largely of science education enthusiasts. What heartened me was the possibility that enthusiasm may yet prove contagious.

The SRG report, which is a consultative document, is well worth a read, possibly even a response.

What's wrong with electronics?

When a group of Glasgow University electrical engineering students were shown round Motorola's East Kilbride semiconductor manufacturing plant recently, the factory manager mistook the student party he was guiding for a group of overseas visitors. Out of the 24 students, 21 came from South East Asia; 3 were indigenous UK nationals. I heard the story in Edinburgh University. "The mistake could just as easily have happened with a group of Edinburgh students", the academic staff said. "We get relatively few youngsters from Scottish schools applying to do electronics."

At a time of massive youth and graduate unemployment it is hard to comprehend why it should be that the Scottish electronics industry is starved of recruits. There are just not enough local youngsters being trained in electronics either at university or HNC level. The universities have the capacity, but because of the absence of indigenous applicants, have to fill their places with students from abroad. It may not help either that fee levels for overseas students are significantly higher.

Tony Joyce, Director of External Relations at Motorola, believes that the cause of the shortfall stems from schools. Yet it is not clear why. Whereas 10 years ago the amount of electronics taught was effectively zilch, the subject now has a sizeable presence. It's there in a big way in Physics, in Technological Studies and in Short Courses. Whereas Physics used to suffer from an identity crisis, its current ranking alongside other science courses as the third most popular Higher is evidence that in many schools it is being taught with pizazz. Why then do sufficient numbers of youngsters with a Higher Physics pass not proceed into our local physics-based electronics industry? Do school pupils find the electronics parts of courses to be dull, boring and difficult. Is it the wrong type of difficult in the sense of being tiresomely complex instead of intellectually challenging? Is it poorly taught? Is it that relatively few teachers have either the academic training or practical experience to teach electronics with zest? Whatever the root cause, we seem to have all the symptoms of a problem with popular interest which is difficult to understand.

Harris and Unilab

We are too close to many persons in both companies to publicly say all the things which we may think in private. It would be invidious to be completely open on this occasion. There are however many positive comments we can make about the acquisition (reported on page 29) of Unilab by Philip Harris. Firstly since one of our functions is to test equipment we have intimate knowledge of the strengths and weaknesses of different manufacturer's products. We trust that the merger will lead to a levelling up in quality of the joint companys' wares. From private discussions with senior management, and from the ways the companies are being reorganised, it would seem that this is the intention. Secondly, while the lack of competition between British manufacturers may adversely affect Scottish customers, this is unlikely to be significant because of increasing international trade. Indeed it is to be hoped that a greatly strengthened home-based company will be better able to compete internationally, which should help local customers. Thirdly, any manufacturer of science and technology equipment must have a strong and effective R and D team. There is already a good R and D presence in the joint company. It must be allowed to flourish. We wish the new company and its management team well.

Another science teacher fined

Peter Martin Beagan, a science teacher in North Wales, has been prosecuted by the HSE under section 7(b) of the Health and Safety at Work Act following an accident in a chemistry class during pupil assisted demonstrations of burning sodium in halogen gases. The case was heard at the Magistrates Court. Mr Beagan pleaded guilty and was fined £1100.

As with the last such case on which we reported [1] this prosecution, although this time successfully brought, raises more questions than it answers. Because Mr Beagan pleaded guilty no defence as such was led. His side of the story could only emerge via his own legal representative's plea in mitigation. Even so, there seems far more to this case than a straight factual account of the trial might suggest.

For example, it is by no means clear why the teacher alone was charged. Given the nature of the pupils' injuries some might question why the case had to be brought at all. Compared to other kinds of school activities, the practical subjects - although decidedly hazardous - are among the least risky. One has to wonder then, why only science teachers seem to be getting hauled off to court. In so prosecuting individual employees, however apparently justifiably in this case, HSE also may be in danger of ignoring its own advice. Taking a case against Beagan alone might be seen as a tad biased toward what is known as the "Safe Person" ploy, whereas the HSE in particular and safety professionals in general have tended to favour a balance between that approach and a "Safe Place" strategy.

There are technical and scientific reasons also which cause us not to pontificate just yet on the ramifications of this case. The reaction which caused the incident was that between sodium and bromine. Initial work both going through the literature and at the bench suggests that the science of these matters is not as straightforward as the court may have been led to believe. We intend discussing all of these issues more fully with our colleagues at CLEAPSS School Science Service, with the ASE and with relevant specialists in the Health and Safety Executive. Should we succeed in answering just some of the questions raised above we shall return to this case in a future Bulletin.

Reference

1. *Prosecution : Crown v. Bird, 1995*, Safety Notes, Bulletin 186, SSERC, Autumn 1995, p2.

Disintegrating reagent bottles

We have received a report of an incident involving a plastic reagent bottle, reported to us to be "polycarbonate", containing dilute potassium hydroxide. This disintegrated whilst being handled by a school technician. It is thought that when supplied the bottle had originally contained another substance - possibly a bicarbonate or Universal Indicator solution. It had been used subsequently to store dilute potassium hydroxide and labelled accordingly. It was while the label was being renewed that the accident happened. The technician suffered chemical splashes to the face, eyes, neck and upper torso.

The incident is still under investigation by the school, the reporting Council's own Health and Safety Unit and the original supplier of the reagent and bottle. During preliminary examination of similar bottles in the school a second container disintegrated. The Council concerned has thus issued a "Safety Flash" suggesting certain interim measures be taken until the full circumstances of these incidents and their cause(s) become clear.

Because there is potential for such incidents to occur in other locations, it is recommended that :

- existing stocks of plastic reagent bottles be examined ensuring that the person(s) doing this wear personal protective equipment (PPE) appropriate to the substances so stored;
- locations of bottles containing chemicals be reviewed and that steps be taken to ensure that none are exposed to excessive heat or direct sunlight;
- all containers of chemicals be checked for accurate and clear labelling;
- bottles used for storage are of materials appropriate to the chemical they contain and that they are being used according to the manufacturer's or supplier's instructions;
- until further notice such plastic storage bottles are handled only by staff wearing appropriate clothing and other PPE and that any decanting be carried out well away from pupils or other staff;
- emergency procedures on spillage and action to be taken following chemical contamination of persons should be reaffirmed with all science staff.

We have as yet insufficient information to be able to provide a full commentary on or explanation of the causes of this particular incident. Once the investigations have been completed we shall probably return to the subject in this section of a future issue.

New safety publications

Two new and major publications on safety in science education appeared recently. Both have involved members of the Association for Science Education's (ASE) Safeguards in Science Committee.

The first is a tenth edition of *Safeguards in the School Laboratory* [1], prepared by the committee and published by ASE itself. The second is entitled *Safety in Science Education* [2] and has been published by HMSO on behalf of the DfEE (Department for Education and Employment). Both ASE and our sister organisation CLEAPSS provided members of the task group which drafted the DfEE book.

Scottish teachers will find *Safeguards in the School Laboratory* of direct relevance to their own practice. This is because it combines wide coverage with fairly pithy guidance. It also refers out to and takes account of documents which cover situations peculiar to Scottish practice. At £10.95 a copy it couldn't be said to be cheap. We would though recommend the tenth edition of *Safeguards* as an essential component of any science subject department's safety library. FE colleges running SCOTVEC science courses would also find it a useful source of sound and practical advice.

Safety in Science Education is a different proposition in that it was specifically prepared for schools south of the border. Understandably, it therefore carries few references to Scottish documents or practice. Successive manifestations of English, Welsh and Northern Ireland Departments of Education have consistently taken a different line from that adopted by the Scottish Office. The former have continued centrally to publish health and safety guidance for schools whilst the Scottish department has always taken the view (probably correctly) that under the Health and Safety at Work Act this was largely a matter for employers. This is not to say that the DfEE book is totally without relevance in Scotland. At £14.95 a copy it is best seen as a useful reference on a whole science department scale rather than as a vital part of individual teachers' or separate sciences' safety libraries.

Whereas *Safeguards*' . . peculiar strength is its pithiness, *Safety in Science Education* does comment usefully on some issues at greater depth. There are a few points on which we disagree - such as its advice on lasers. Helpfully, it brings official endorsement of some activities which, because of the rumour mill, many teachers thought were banned. These were also some of the functions of ASE's *Topics in Safety*, which is widely held in Scottish schools. With so many safety publications now appearing we may end up being spoilt for choice suffering from too much rather than too little information. ASE we know is thus likely to examine the need for some rationalisation in the range and nature of its own published advice.

References

1. *Safeguards in the School Laboratory*, 10th Edition, ASE Task Group of the Safeguards in Science Committee, ASE, 1996, ISBN 0 86357 250 2). Available from ASE Booksales £10.95 inc. p.&p.
2. *Safety in Science Education*, HMSO for DfEE, 1996, ISBN 0 11 270915 X. £14-95 from HMSO Publications Centre, HMSO Bookshops, HMSO Accredited Agents and good booksellers.

SAFETY NOTES

SOEID Circular 7/95 on lasers

The purpose and ideas behind the circular [1], prepared by SSERC on behalf of SOEID, are explained. Basically the circular updates controls on the use of lasers to conform with present health and safety legislation, laser standards and practices.

At the time the original circular (No. 766) [2] controlling the use of lasers in schools was issued by the Scottish Education Department in 1970, just twelve years had elapsed since Schawlow and Townes had extended maser techniques into the infrared and optical regions. Quickly in the early 60s the subject moved from being a scientific curiosity into a widely developing field. The word *laser* was coined and applications in research, industry, medicine and education became apparent. In recognition of the risk to eyes from this novel, intense, optical radiation with which, by the late 60s, schools were already experimenting, a set of safety rules for the use of lasers was drawn up by SED and issued to schools as part of Circular 766. Until the issue of the revised circular, 7/95, these safety rules had been in force for a period of 25 years - which is quite a time!

Because Circular 766 did not set a maximum limit for the optical power of laser radiation used in schools, its safety rules were devised to control radiation which in general could be presumed to be more powerful than the body's defence mechanisms were able to protect against. Probably because of this, Circular 766 did not envisage that lasers might ever be used by pupils, except perhaps by more advanced students. It has thus come about that the laser has normally only ever been used by teachers in demonstration experiments. The requirement for the demonstrator or experimenter to wear protective goggles could also be regarded as an impediment to using lasers, even although it was not practised by everyone.

Aims

That really was how matters stood up until last year. Meanwhile in the world at large protection from laser radiation had become dependent on engineering rather than on administrative or procedural controls. These engineering controls centred on a classification scheme of laser radiation sources [3]. It had become obvious that controls in schools should also relate to the classification of laser products. By doing so, it would limit the hazards. In contrast, under Circular 766, the hazards were unbounded.

We therefore set about revising the circular with three aims in mind :

- to limit the types of laser classes so as to facilitate the safe use of lasers in school laboratories recognising that the past practice wherein lasers had been used solely by teachers in demonstrations was too fearful and over cautious;
- to set up for pupils a safe system of work with lasers;
- to widen the scope of laboratory work with lasers, or, expressed in another way, to encourage teachers to look upon the laser as the best or preferred source of optical radiation in many laboratory applications.

We believe that the cornerstone to achieving these aims has been the restriction to Class 1 or Class 2 laser radiation. For practical purposes, accessible laser radiation in experimental work will be Class 2. Because eye protection is normally provided by aversion responses such as the blink reflex, radiation from a Class 2 product is not capable of causing injury except just possibly under conditions of deliberate gross abuse. However such injury is extremely unlikely because of physical and physiological reasons and because of teacher supervision.

Why limit to Class 2?

The decision that had to be made was whether to limit the highest permitted laser class to Class 2, or Class 3A, or whatever else, or to continue in the spirit of deregulation to permit work with any laser class subject to the requirement for separate, appropriate, risk assessments.

The fundamental health and safety principle that no person should be exposed to danger has of necessity to be set aside if laser radiation is to be used in practical work in schools. The following two principles then have to be applied :

- no hazardous physical agent shall be used unless there is a justifiable reason; and
- if a person is to be exposed to risk then the risk must be kept to a level which is as low as reasonably achievable (sometimes called the ALARA principle).

With respect to meeting the first principle, the use of laser radiation can be justified if the educational demonstration is significantly improved by such use. There are many instances where a substitution to laser radiation improves the demonstration.

As regards the second principle, so far as we understand and from our own experience, radiation from a Class 2 product is suitable for a very wide range of applications in education. There is generally no practical need to work with a Class 3 product in schools. By limiting to Class 2 products, we are not aware of any reasonable optical experiment which a school might be prevented from doing.

The rationale underlying Class 2 in the classification scheme was also considered. The standard [4] states : "*Each demonstration laser product used for educational purposes in schools, etc. should comply with all of the applicable requirements for a Class 1 or Class 2 laser product and shall not permit human access to laser radiation in excess of the accessible emission limits of Class 1 or Class 2 as applicable*". This rationale illustrates the safety principle of hierarchical controls. Engineering controls are more effective than administrative controls and procedures. It is safer to work with lasers designed to be safe than to attempt to handle, by safe procedures and by systems of management, laser radiation that is highly hazardous.

Finally, of the many persons or agencies contacted during the consultation period, not one disagreed with the decision to restrict laser radiation to Class 2 accessible emission limits.

Laboratory controls?

The only safety measure specified in the standard [5] for Class 2 lasers is the advisability of terminating the beam at the end of its useful path. It was felt that more stringent working procedures were required in schools for the following reasons :

> Underlying the recommendations in the standard is the presumption that the person working with laser radiation is adult, trained and competent. If young people are to be allowed to work with laser radiation, none of these conditions would be met.
>
> Because of the relative immaturity of young persons and because of their relative unfamiliarity with laser radiation, further controls would be needed.

The controls which have been adopted are ones which are in use in work with other classes of laser radiation. Thus some pupils will find that the training is directly applicable to higher education or to employment.

The following notes relate to specific controls in the circular.

Position of beam stops

Some further advice on positioning beam stops is offered. We originally envisaged that these should be placed around the perimeter of the workbench rather like fiddles around a ship's messroom table (Fig. 1), but taller. However in the light of experience we now recommend that beam stops are drawn in to fit closely round the region where laser radiation needs to be worked with (Fig. 2). Side stops preferably should not be far enough apart to allow a head to be placed in the direct beam. However they should be far enough apart to allow optical elements to be manipulated by hand with relative ease and to allow experimenters to view laser radiation on screens. The separation between side stops should lie between 100 mm and 300 mm typically.

In a teacher demonstration of a laser display, the use of side stops may have to be dispensed with altogether to let pupils see what is being done. However the direct beam should always be terminated with an end stop.

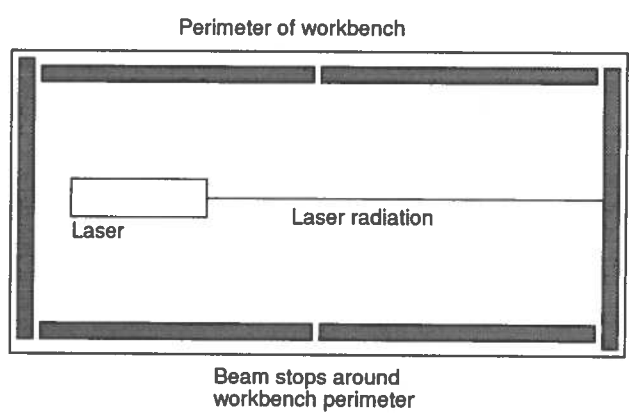


Figure 1. Beam stops around workbench perimeter. Horizontal plan.

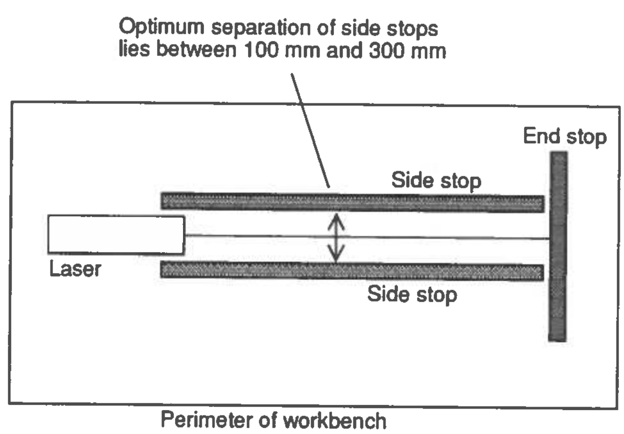


Figure 2. Beam stops around radiation. Horizontal plan.

Placing optical elements in laser radiation

There are many different ways of safely placing an optical element in laser radiation. A variant of the one described in the Code of Practice [6] [7] is described opposite (Fig. 3).

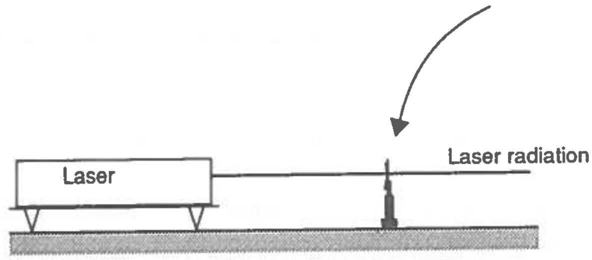
Laser screen pointers

The controls introduced by Circular 7/95 on the use of laser screen pointers in schools have been well timed because these devices have very recently become available from High Street shops and from educational suppliers. We have had a report from one school that pupils had been found bringing laser screen pointers into school. We have heard from a teacher in another school a story reported to him by senior pupils who have part-time employment in a local branch of Dixon's. Apparently there is a shop assistant in this branch who passes idle moments by staring into a laser screen pointer! If these devices are about to become ubiquitous gizzmos, a gadget that every nerd strives to possess, then clearly there may be an urgent need for schools to inform and explain to pupils the danger to eyesight from trying to stare into direct laser radiation. The message to get across, which applies to all laser radiation, is that people should not look into the primary beam or at specular reflections of the beam, unless necessary, even if the exposure limit is not exceeded.

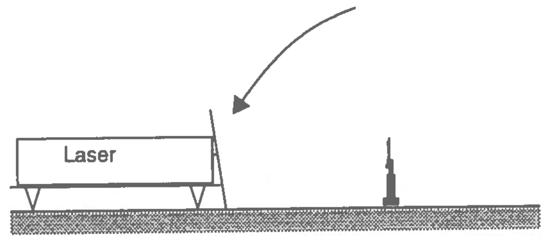
LEDs

A common problem with new technology is that it is often hard to get agreement on standardization. When we wrote the Guidance on laser products, while there was agreement amongst international bodies that LEDs should be included within the scope of the laser standard [3], there was no agreement as to how to assess the hazards of LED radiation. The Guidance was therefore deliberately fuzzy on this point. We now have to report that there is still no consensus. Although the specialist IEC Technical Committee had intended to have devised a scheme for classifying and testing LED products by March of this year, they have not done so. We understand that some LED manufacturers had lobbied to stall any such move. We cannot therefore offer advice additional to that in the Guidance at this stage. There are however two educational products which cause concern. These are described in a following article.

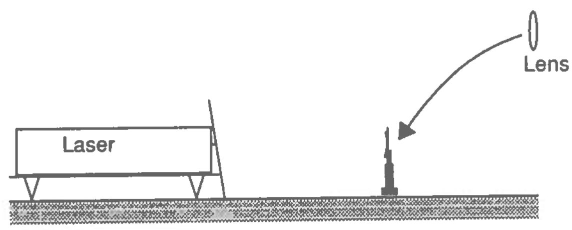
Please bear in mind the interim advice in paragraph 29 of the Guidance. If you would like advice on any specific device, please phone us giving its technical specification. We may be able to classify it unofficially.



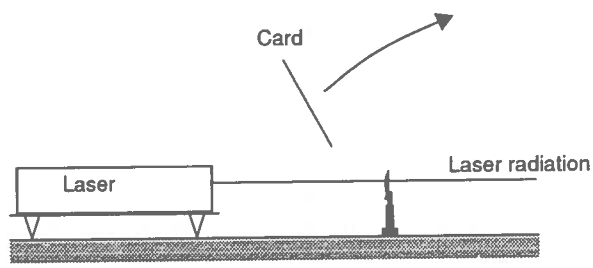
Place the empty support in the laser radiation. Carefully adjust the relative height, position and direction of the radiation and support so that, when the optical element is placed in the support, only fine adjustments are further required.



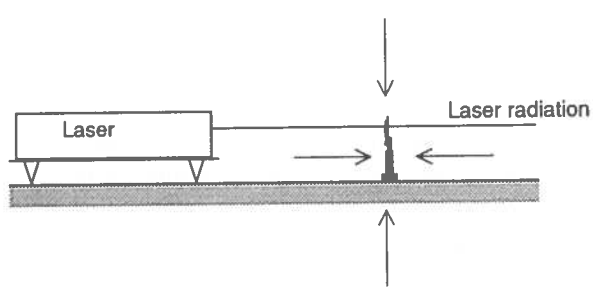
Shut off (not switch off) the laser radiation.



Place the optical element in, or on, the support.



Open the shutter.



By hand make final, fine adjustments to the optical element using a paper screen as an aid as necessary.

Figure 3. Procedure for placing an optical element in laser radiation.

Acknowledgements

As part of its preparation, drafts of Circular 7/95 were circulated to many persons or organisations for comment. This article provides me with the opportunity of thanking these persons in public. In particular I would like to express my gratitude to Ron Wheelton and Irene Clerk in the Glasgow office of NRPB and their Oxford office colleague and BSI representative, Mike Whillock, for much general and detailed guidance. I would also like to acknowledge the assistance of Chris Butlin, Education Officer of IOP, not least for redrafting the recommended code of practice for pupils or students in language they might at least understand! To Professor Brian Tozer and to Paul Tozer of Lasermet I owe great indebtedness. Their assistance in the complex and unsettled field of light emitting diode radiation has been generous. Representing SOEID, on whose behalf the Guidance was written, Ian Rowley HMI has been a firm supporter in the need for revised arrangements and has been excellent to work with. Others who assisted with comments and advice, much of which was of a substantive nature, were :

ASE Scotland :
Mr S Farmer (Secretary), PT Physics, Alford Academy
Mr A Allardyce, PT Physics, Nairn Academy

Central Region :
Mr T Harrison, Science Adviser
Mrs V Corry, PT Physics, Stirling High School
Mr J Cowan, PT Physics, Wallace High School
Mrs M Henderson, PT Physics, Balfron High School

CLEAPSS :
Mr R J Orton, Deputy Director

Heriot Watt University :
Mr J F Marshall, University Laser Safety Adviser, Physics Department

HSE :
Dr P Jeffrey, Employment Medical Advisory Service
Mr P Nellis, HM Inspector of Factories

IOP Scottish Branch :
Gerald Buller (Honorary Secretary), Physics Department, Heriot Watt University
Prof A C Walker (Chairman), Professor of Modern Optics, Heriot Watt University

University of Strathclyde (Jordanhill Campus) :
Mr J Muir, Head of Physics

Unilab :
Mr D A Duff, at that time Research Director

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1. Circular No: 7/95 *Guidance on the use of lasers in laboratory work in schools and colleges of education, and in non-advanced work in further education establishments*, SOEID, 1995.
2. Circular No: 766 *Use of lasers in schools, colleges of education and further education establishments*, SED, 1970.
3. BS EN 60825-1 : 1994 *Safety of laser products* Part 1. *Equipment classification, requirements and user's guide.*
4. Ibid. Section 12.4.
5. Ibid. Table D3, Annex D.
6. Circular No: 7/95, Part 13, Code of Practice, Annexe B.
7. Ibid. Part 11, Code of Practice, Annexe C.

SAFETY NOTES

Ultrabright LEDs in educational products

Although at the time of writing this note we are still awaiting a decision by an IEC technical committee on how to assess the hazards of LED radiation, we know of two educational products incorporating ultrabright LEDs whose radiation may possibly be harmful.

LED Board : JJM Electronics

The LED Board is one of a set of circuit boards designed by JJM Electronics for the optoelectronics section of Higher Grade Physics. It has an 8 mm high brightness red LED at 660 nm wavelength and 1600 mCd intensity. As a result of approaching SSERC for a risk assessment, we understand that the company has written to customers warning them not to operate this high intensity LED, but to replace it with a low intensity substitute which has been enclosed with their letter.

The company would seem to be acting prudently by taking a cautious approach to possible risks from LED radiation.

Speed of Light Kit : Unilab : 432.010

This kit emits radiation from an ultrabright LED which, from a provisional risk assessment, would seem to be in laser Class 3B. We have written to Unilab about our assessment and understand that they have frozen current stock before deciding what to do next.

By way of interim advice to any school that has a Speed of Light Kit, we advise that it should not be used in its present form unless the IEC decide that this LED radiation is harmless.

This is an interesting and otherwise worthy piece of physics apparatus. It would be a pity to see it banned. We therefore hope that it may prove to be possible to enclose the beam in such a way that the radiation cannot be viewed directly. By calculation the minimum distance for safe momentary viewing is over one metre. Therefore to be on the safe side the beam should be enclosed for several metres from its source. We would welcome suggestions as to how this might be done.

SAFETY NOTES

Radford Labpacks

Two years in a Bulletin [1] we warned that because some of the outlets from secondary windings of the isolating transformer do not have overcurrent protection, there is a risk that the insulation around internal conductors might melt if the outlet were to be short-circuited. This might then cause LT conductors to connect to an internal HT conductor - either at 230 V a.c. mains, or 300 V d.c. The likelihood is exacerbated by the fact that in places, internal conductors are laced together. As a result of inspecting a number of Radfords, we had come across evidence that persons might be at risk of electric shock from this type of fault condition.

It has therefore come as no great surprise to learn that a person in a school in England has had the misfortune to get a shock from this cause. This fault condition is difficult to spot. It would not be picked up by routine GS23 maintenance tests. What is required is an internal inspection for signs of overheating or deterioration backed up by a series of special tests on the insulation system. However because these checks and tests call for a high level of competence, we are reluctant to publish details of methods that we could not be confident would be properly used. The Centre therefore recommends, as we did two years ago, but now expressed more bluntly, that as soon as practicable schools should cease to use Radford Labpacks.

The Centre would be willing to provide any council or school with further information and assistance on this problem.

Reference

1. *Labpacks - the latest episode*, Bulletin 180, Spring 1994, SSERC.

Bulgin mains plugs

Bulgin Components plc have issued a warning to customers and to the press of a plastic welding defect identified in a small sample of their 13 A BS1363/A non-rewireable plugs fitted to Bulgin cordsets (or mains leads) bearing their test date stamp 3/94 (March 1994). As a result of this fault condition, the plug cover may either become detached or partially so in use. If this defect is present, the user would be at risk of an electric shock.

The 13 A non-rewireable plugs in question may be identified by the symbol drawn in Figure 1 engraved on the underside adjacent to the neutral pin. Having contacted some equipment manufacturers, Bulgin cord-sets have never been fitted to Philip Harris manufactured products, nor to Unilab products except for the Beaver Power Supply 022.111. This product along with all other apparatus purchased since March 1994 should be inspected. Any 13 A plug found with this marking should be carefully examined to ensure that the cover is securely attached. If there is any indication of cover detachment, the cordset should be taken out of use.

Figure 1. Bulgin identification mark on underside adjacent to the neutral pin.

Bulgin have set up an advisory service to handle enquiries. It is accessible on a FREEPHONE number (see address list).

We understand that the chance of a school having one of these defective plugs is very small. At the time of the press release by Bulgin a total of five plugs had been detected with the fault out of a batch of 7800 manufactured in March 1994 .

Apple MAC danger

Shortly before the regions were disaggregated, we were notified by officials of Strathclyde Regional Council of the following problem relating to the VDU supplied with an Apple Macintosh Performa computer system. As part of a package wherein schools (mainly primary) sent pupils on residential courses to the Kingswood Computer Centre, Wolverhampton, the school in return was sometimes offered an Apple Macintosh computer system.

We understand that this computer system has the following potentially dangerous faults :

1. The visual display unit was designed for the American market and operates on 120 V.
2. Transformers have been supplied to enable this display unit to operate at 230 V. However :

   (a) these transformers are under-rated causing them to overheat in operation (they are rated at 75 W and the VDU operates at 85 W);

   (b) because these transformers are auto-transformers, they fail to isolate the VDU from the mains supply;

   (c) the transformers are not encased.
3. The 120 V IEC mains input socket on the display unit is compatible with the normal 230 V IEC connector in use in this country. Thus it is possible for 230 V to be applied to the VDU (there have already been three reported incidents where this has occurred).

If any school has used the Kingswood Centre and obtained a computer system as part of the package, the system should be removed from service and the matter referred to your school's AV service manager.

SAFETY NOTES

Earth system on Lancashire Power Unit

The following notes relate to the protective earth system on the obsolete Unilab power supply 122.312 built to a specification from Lancashire County Council - hence the name. This product was phased out in the early 1980s.

So as to follow the earthing system, please refer to the sectional view (Fig. 1) (not drawn to scale).

The protective earth conductor is bonded to a pre-formed steel end plate which covers part of the isolating transformer. In later versions, the screw which fastens the earth terminal also secures a P-cord grip which gives strain relief to the mains cord. In early versions the cord was knotted.

There are four long screws at the corners of the end plate which travel through the transformer laminations and bracket into four aluminium pillars. These support the Bakelite front. So as to prevent currents being induced in conducting loops around the transformer laminations, only one of the four screws makes electrical contact with the transformer bracket, which it does through a pair of brass washers between the pillar and bracket. The other three pillars are separated from the bracket by pairs of insulating washers.

The four remaining sides are enclosed in an enamel painted (Hammerite or similar) steel shell, which is fastened by four screws to the transformer bracket.

Thus every part of the exterior excepting the Bakelite lid is bonded to earth. In addition the four corner screws that secure this lid to the pillars are also part of the earthing system. When testing for earth bond continuity, any of these exterior parts may be tested. If any part fails to show continuity, the earth system is shown to be faulty.

We have come across examples of the Lancashire Power Unit failing earth bond tests because of a combination of defects due to the age of the product - namely corrosion and loose fitment. Before anyone attempts to repair such a fault, they should examine how the different parts in the earthing system are bonded to each other before proceeding to act. If you are in any doubt please contact us or Unilab.

We might also repeat our advice given in the Radford article opposite that if practicable such aged electrical equipment should be disposed of and replaced. No person should attempt to renovate such equipment unless competent to do so.

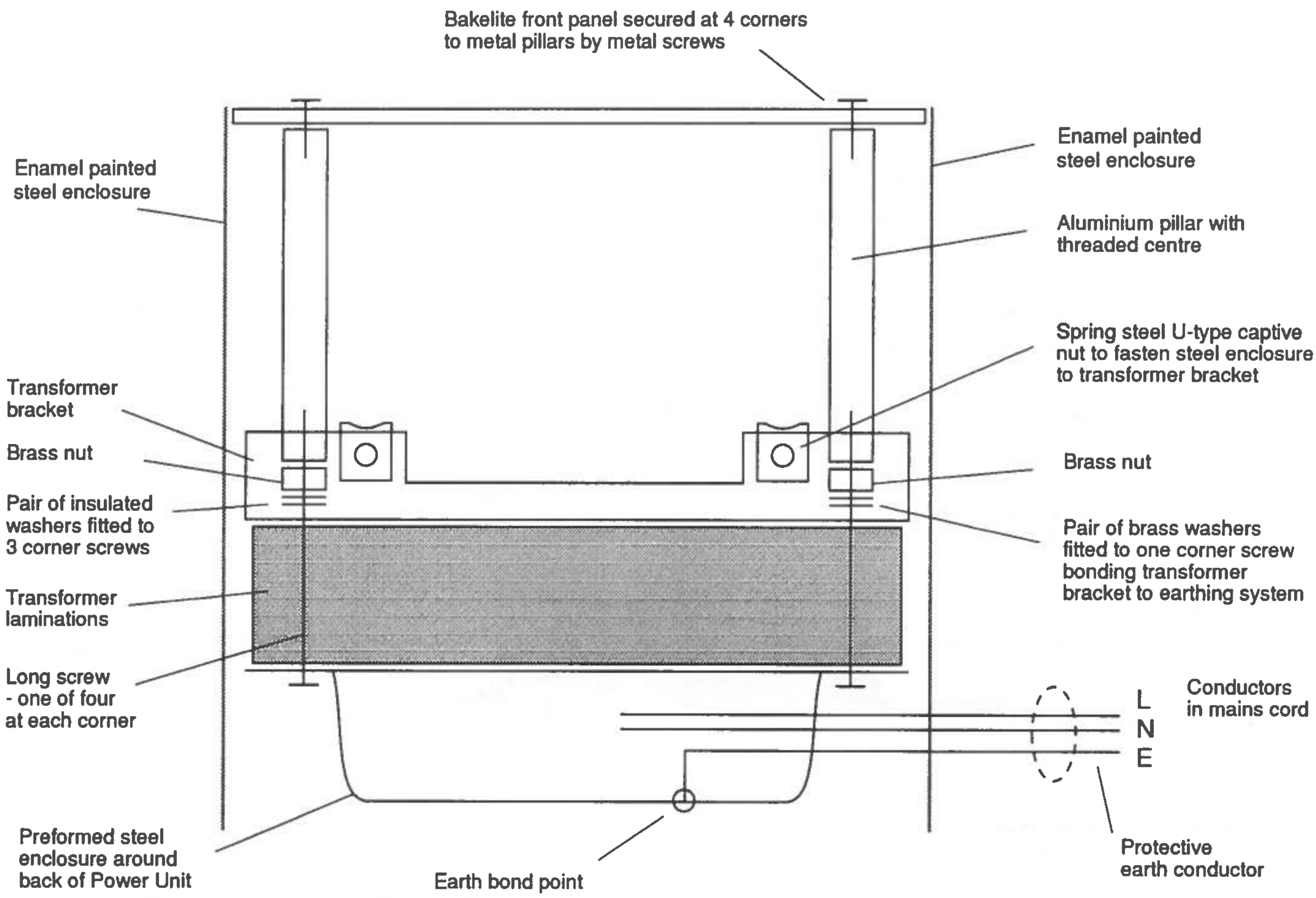


Figure 1. Earthing system on the Unilab Lancashire Power Unit 122.312 (Section - not to scale).

TECHNICAL ARTICLE

Optics with lasers

One of the purposes of Circular 7/95 was to widen the scope of laboratory work with lasers. This article describes ways of using laser radiation with ray optics and with spherical lenses. It includes models of double refraction and internal reflection within a water droplet to explain the rainbow.

Ray optics

If a laser beam is spread out into a thin vertical sheet that transects the workbench it can be used to illustrate light paths in optical devices. For instance it may be used to show refraction in glass blocks, prisms or cylindrical lenses. Because by this means you have a light beam far more intense than you get from a raybox, it is a most effective source for ray optics demonstrations.

The method consists of placing a short length of 4 mm diameter glass rod horizontally in the laser radiation. This acts as a powerful cylindrical lens. The radiation diverges into a vertical sheet transecting the workbench (Fig. 1). It may be necessary, as the figure illustrates, to work on a raised platform. This minimizes the slant of the radiation to ensure that a ray passing through an optical element travels a long distance beyond. A vertical displacement of around 12 mm between the direct laser radiation and platform work surface was found to be suitable.

Cover the work area with a large sheet of white paper so that the ray is clearly seen. The ray is usually sufficiently powerful to work with in normal roomlight and may indeed be used in ray optics experiments without any form of blackout. However it is more effective under subdued lighting and stunningly so under full blackout.

Unless the work surface and paper cover are completely plane the ray may have a pecked appearance or otherwise vary in brightness because of shadows caused by undulations in the surface.

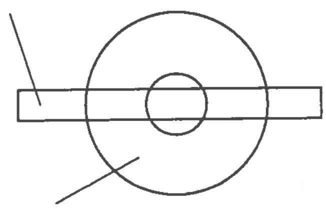


Figure 2. Using glass rod as a cylindrical lens. It is secured to the aperture of a laser or to a lens holder with a magnet.

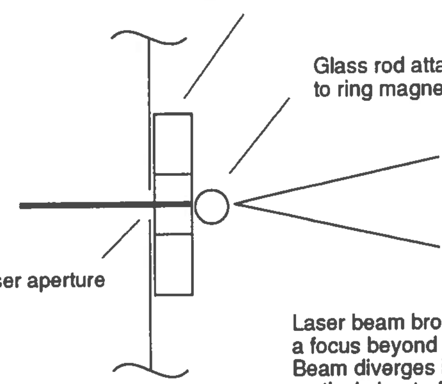


Figure 3. Using glass rod as a cylindrical lens. It may be secured to the aperture of a laser with a magnet. Section view.

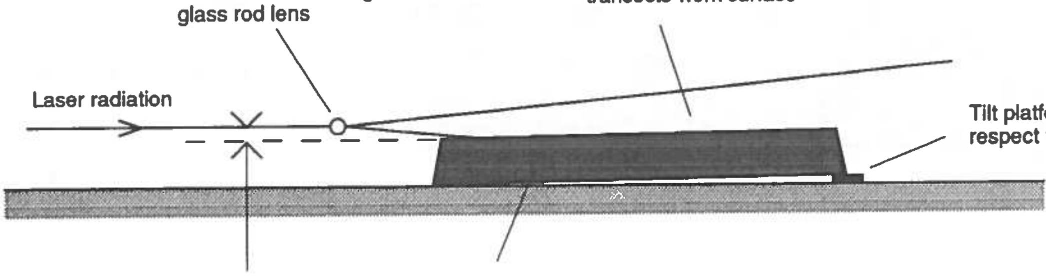


Figure 1. Producing a ray of laser radiation along the workbench. A glass rod is used as a powerful cylindrical lens. Section view. It may be necessary as indicated to work on a raised platform downstream of the rod lens. The platform should in area be about the size of a sheet of A3 paper.

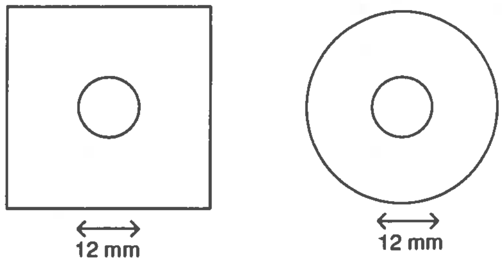


Figure 4. Examples of steel plates to which to fasten ring magnet with glass rod lens. Diameter of central hole between 10 mm and 15 mm. Overall shape and dimensions to suit lens holder.

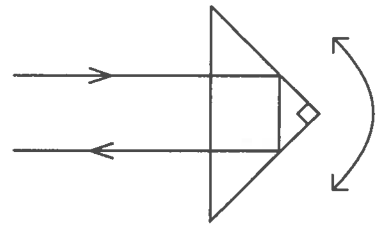


Figure 5. Using a 90° prism as a retroprism. The reflected beam remains parallel to the incident beam for small angle rotations of the prism.

The glass rod can be supported horizontally in laser radiation by means of a retort stand. However since making fine adjustments with this type of support is awkward, we recommend that you bond the glass rod with Araldite to a ring magnet (Fig. 2). This is then attached to the steel enclosure of a laser over its aperture (Fig. 3), or to a lens stand. If a lens stand is used, it may be necessary to make a steel plate to fasten the magnet to the stand (Fig. 4).

Use both hands to make final, fine adjustments to the glass rod. When doing this watch the sheet of laser light projected on a vertical screen one or two metres distant along the bench. Carefully adjust the magnet so that the sheet of light is itself vertical and of maximum brightness. If necessary tilt the sheet slightly downwards so that the lower half streaks across the worktop.

Rather than using the ordinary workbench surface, a Lazy Susan can be employed as a rotatable platform on which to place optical elements.

Suitable optical elements include prisms, rectangular glass blocks, semi-circular blocks and cylindrical lenses. For a simple demonstration, try showing the action of a retroprism. This is a device that reflects light straight back at you no matter what its alignment. NASA placed retroprisms on the surface of the Moon so as to return laser radiation to its source on the Earth. To see the action of a primitive retroprism, all you need by way of apparatus is a 90° prism. If the prism is rotated through a small angle, the alignment of the reflected beam is not disturbed - it continues to travel parallel to, but in the opposite direction from, the incident beam (Fig. 5).

A set of multiple diverging rays can be produced with some clean glass microscope slides wedged apart with matchsticks. Rays transmitted in the forward direction are too faint to be of much use (Fig. 6). Rays reflected back by specular reflections are much brighter and generally more useful (Fig. 7). The angle between successive rays is about 3.5° for 76 mm slides.

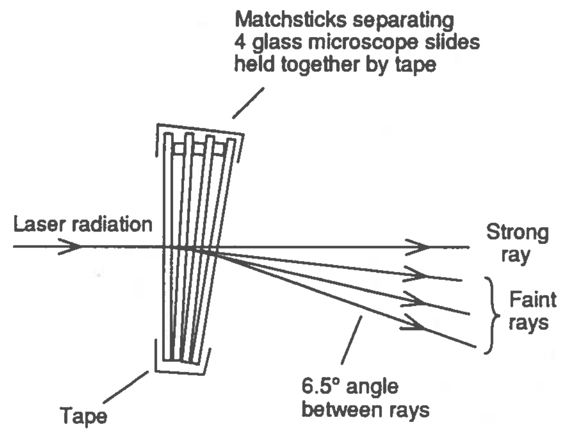


Figure 6. Method for producing multiple diverging rays - but generally too faint to be of use.
Horizontal plan.

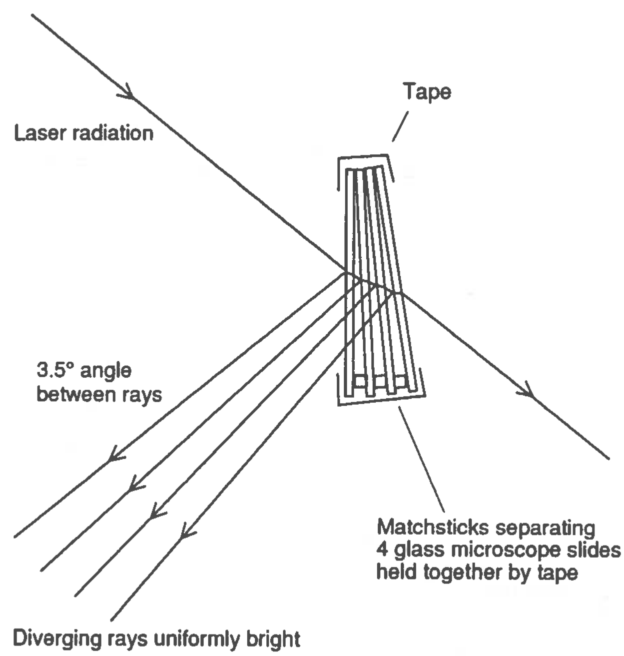


Figure 7. A better method for producing multiple diverging rays - these rays are reasonably bright and uniform.
Horizontal plan.

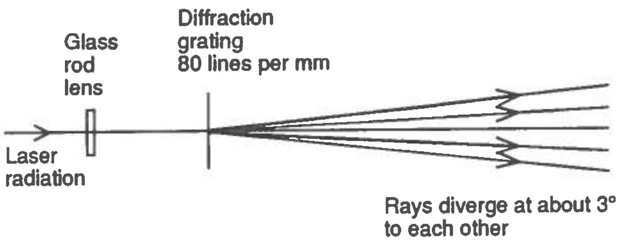


Figure 8. Method for producing multiple diverging rays with a diffraction grating. Horizontal plan.

A set of diverging rays at about 3° to one another can be generated by a diffraction grating with 80 lines per millimetre (Griffin XFY-510-P) (Fig. 8).

The front cover photograph illustrates all of these techniques. The work surface is a sheet of A3 paper at an inclination of about 1° to the incoming laser radiation. Its near edge is vertically displaced by about 12 mm below the direct radiation. Glass rod, 4 mm in diameter, attached to a ring magnet, is supported by a lens holder. This generates a vertical sheet of radiation which is split into several diverging vertical sheets by a grating whose spacing is 80 lines per millimetre. This produces rays on the paper which diverge at angles of about 3° to each other. These rays are collimated by a cylindrical lens (acrylic plastic block, 98 mm radius of curvature, Griffin XFL-601-A) and directed at another acrylic block (circular, 100 mm diameter, homemade). Many rays diverge from this disk as a result of reflections, refractions, or both these effects. It is a two dimensional analogue of sunlight falling on a raindrop, discussed next.

Rainbow model with rays

The primary rainbow occurs at the position of minimum deviation for a double refraction and single internal reflection within a spherical water drop.

The effect can be modelled using a glass or perspex disk of roughly 10 cm diameter and a laser beam (Philip Harris stock perspex disks, 75 mm diameter x 25 mm thick, Q56910/2, £6.90). The laser beam should be a diverging vertical sheet of radiation produced by directing the laser radiation onto a horizontal length of glass rod.

Start off with a sheet of white paper on the workbench. Adjust the glass rod to give a vertical sheet of radiation that transects the worktop. Place the disk on the worktop in the radiation such that the radiation just touches the upper limb of the disk. Then slowly move the disk transversely to the radiation looking at the the ray on the paper that produces the primary bow and at a real image of the primary bow on a small vertical screen. At the position of minimum deviation the bow will be sharpest and brightest (Fig. 9).

Although as a general rule you should never look directly into laser radiation, in this instance because the radiation has been spread out and has undergone multiple reflections, the part that emerges as the primary bow is sufficiently weak to look at directly. To do this, remove the screen, move back two metres and look at the disk until you see the radiation. You are now looking at the bow in the same manner as looking at the sun's radiation in a rainbow.

The model helps illustrate why skylight within the primary bow is brighter than skylight outwith the bow.

Look also for the secondary bow. It will have undergone two internal reflections.

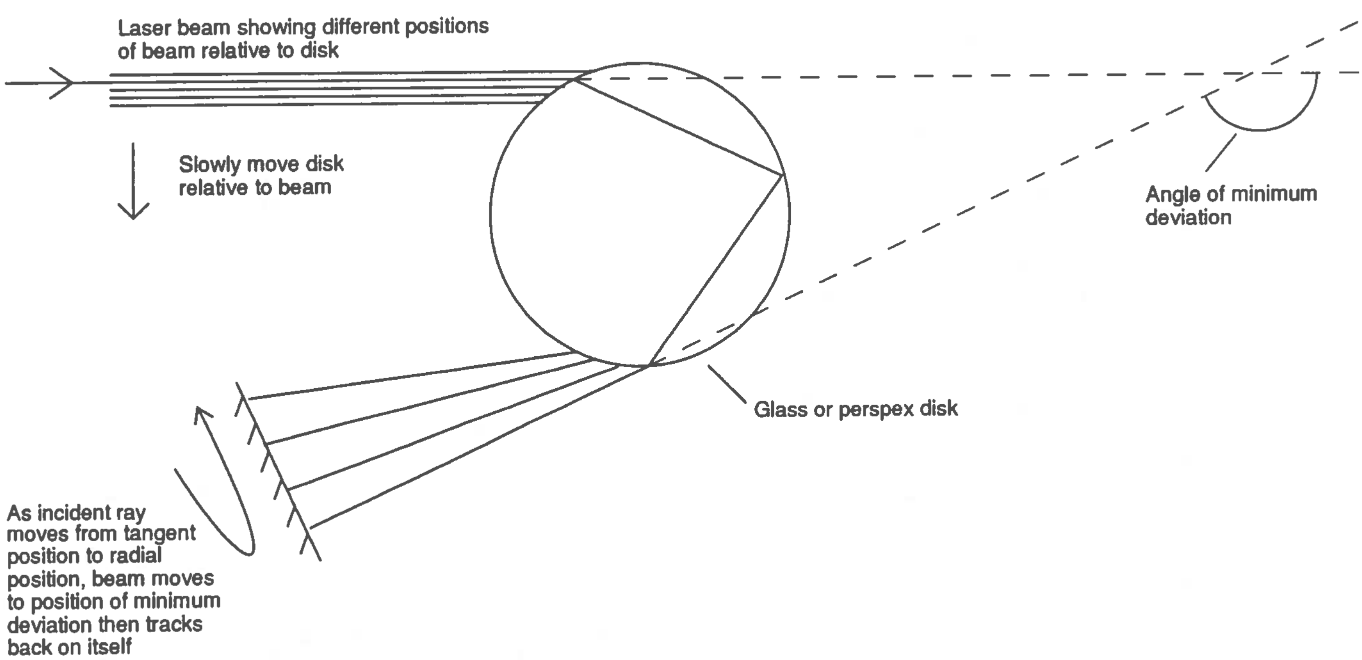


Figure 9. Ray diagram showing positions of different rays entering and leaving circular block. Ray undergoes double refraction and internal reflection. Position of ray at minimum deviation shown. Horizontal plan.

2-d spherical lens source

Because of the power of the glass rod, laser radiation is focused close to the far side of the rod from the laser. We can take this as a point source and apply it to study the action of spherical lenses.

In this application we are using a vertical sheet of laser radiation in free space rather than transecting the workbench to form a ray on the surface. By moving a small slip of paper by hand through the radiation, the experimenter can find out what is happening to the radiation. It is recommended that 6.5 mm diameter glass rod is used in preference to rod of 4 mm diameter. The larger diameter rod produces a sheet of laser radiation which has less divergence, which is useful in this application.

A spherical, convex lens placed in the diverging sheet of radiation can bring the sheet to a focus, whose position can be accurately found (Fig. 10). A sheet of paper should be moved through the radiation to explore its nature. The radiation at both source and focus is a point. Elsewhere the radiation, being in the form of a vertical sheet, produces a vertical line image on the paper slip.

The technique has two uses : it lets the experimenter find with great accuracy the position of a focus; and it gives a tacit feel for the way that radiation converges to a focus and diverges beyond that point.

(Note : This method uses a 2-dimensional sheet of laser radiation to investigate a 3-dimensional lens. A more useful variant of this uses a 3-d cone of laser radiation. This is described next.)

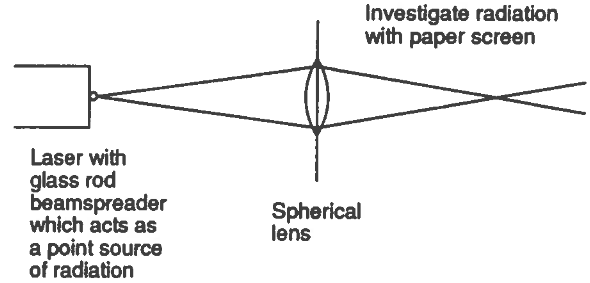


Figure 10. Method of using a glass rod lens to produce a sheet of laser radiation with which to study lens action. Vertical section.

3-d spherical lens source

Glass spheres can act as powerful converging lenses. If a laser beam is directed at a small glass sphere whose diameter lies between 2 mm and 10 mm then the radiation diverges beyond the focus. It is a simple but effective laser beamspreader.

This is a suitable laboratory source for using with spherical lenses. The focus, which is positioned very near to the sphere's surface, acts as a point source of radiation (Fig. 11). If a spherical lens is placed in this radiation, the radiation can be brought to another focus (Fig. 12). The position of this focus can be precisely determined giving you accurate values for the source-lens distance u and lens-image distance v. If a paper screen is moved from place to place within the radiation the effect of radiation converging to a focus and diverging beyond the focus may be demonstrated. It is thus a useful method for teaching and studying the effects of lenses on radiation. And because it uses spherical lenses rather than the cylindrical ones normally used in elementary education, it can be a more effective pedagogical method than the traditional route.

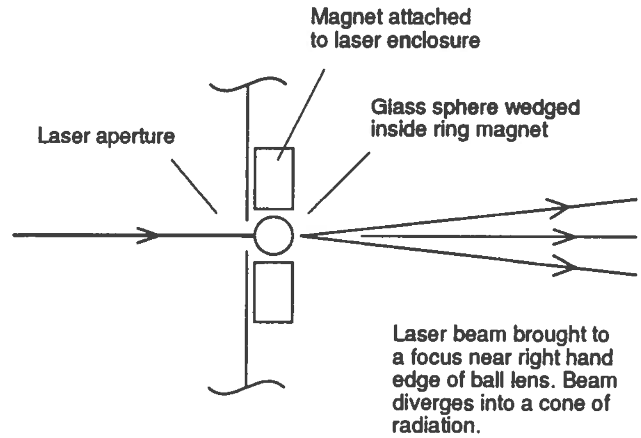


Figure 11. Method of using a glass sphere or ball lens to produce a cone of laser radiation. In this illustration, the ball lens is supported within a ring magnet fastened directly over the aperture of a laser. Vertical section and horizontal plan.

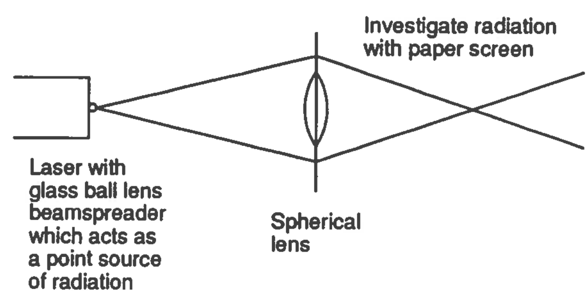


Figure 12. Use of beamspreader to investigate action of spherical lenses. Optimum ball lens diameter is 6 mm for this application. Vertical section and horizontal plan.

Ideally, when the radiation is viewed on a screen, it produces a uniformly plane circular image. Often this is not the case. There may be a messy, variegated, interference pattern. This is caused by dirt and dust on the optics within the laser and on the glass sphere, and imperfections on these parts. However in this context, in finding focal positions, the messiness of the beam does not matter. However if a clean ball lens is used (see below) it may be possible to get a beam of uniform density.

Ball lenses

As to a source of glass spheres, your Chemistry Department should be the place of first call. Chemists add little glass beads to beakers of liquids to prevent the boiling stuff from spurting. By searching through a box of beads you should be able to find one that is reasonably spherical and clear. The optimum diameter for this application is about 6 mm.

If you want a source of pukka glass spheres, then have a look in Edmond's catalogue under ball lenses. Products rated *Technical Specification* are of the highest quality. However there are lower priced lenses in sapphire or ruby. Sapphire has good optical transmission qualities. Ruby is easier to see. The UK agent for Edmond Scientific is Ealing Scientific, whose address is given on the inside rear cover.

It is also possible to make a ball lens by working soda glass rod with a hot flame. The method is explained in the following article.

Ball lenses should be handled gently with blunt plastic tweezers rather than with fingers to avoid contaminating surfaces with oil secreted from the skin. They should also be kept in clean tissue, placed only on a clean surface and not allowed to come into contact with sticky materials.

There are several methods for supporting a ball lens in laser radiation, the optimum method depending on size of ball. (Means of supporting home-made ball lenses are described in the next article rather than here.)

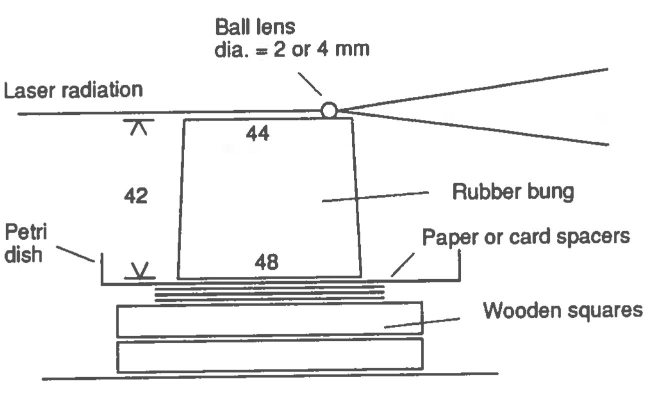


Figure 13. Ball lens mount (Section). Useful for diameters between 2 mm and 4 mm.

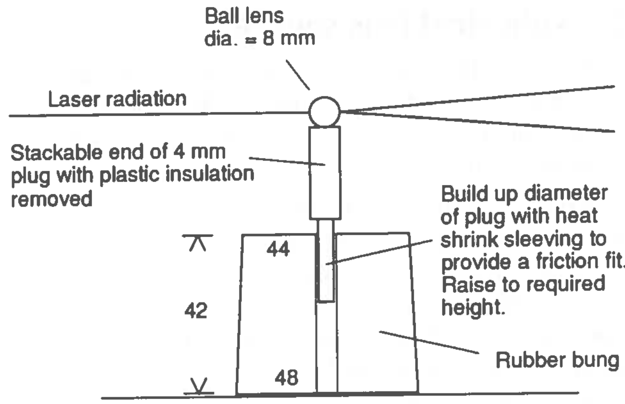


Figure 14. Ball lens mount (Section). Useful for diameters between 5 mm and 10 mm.

For diameters of about 5 mm or 6 mm the ball lens may be secured by friction fit within the hole of a ring magnet (Fig. 11). SSERC currently has a stock of these with 6 mm diameter holes (stock item 814, price 15p). It may be necessary to make a paper sleeve to secure the bead or ball lens in the hole. This can be made out of a strip of paper, 5 mm broad, rolled up and inserted in the hole where it uncurls to form the sleeve. The length of the paper strip has to be found by trial and error.

For diameters of 4 mm or less, we suggest that the ball lens sits unsecured on top of a large rubber bung which is sufficiently big to be suitably massive and stable (Fig. 13).

If the lens diameter lies between 5 mm and 10 mm it may be supported on the stackable end of a 4 mm plug whose plastic insulation has been removed. The plug is friction held within the hole of a large rubber bung (Fig. 14). This arrangement allows the ball lens height to be easily adjusted.

Rainbow model with spherical lenses

In this analogue (Fig. 15), a 100 ml round flask of water simulates a raindrop and a broad, collimated beam of laser radiation simulates sunlight. To produce this broad beam, radiation from the laser is directed at a ball lens, which causes the radiation to diverge. This is then captured by a large bi-convex lens, of the type sometimes known as a condenser lens, and collimated. The condenser lens in use here has a focal length of 200 mm and diameter of 75 mm. The optimum diameter of a ball lens to fill this condenser lens at 200 mm is 2 mm.

Although none of the actual sizes specified above is critical, the relative dimensions are. Because the diameter of the 100 ml flask is about 65 mm, the diameter of collimated radiation must be greater than 65 mm, which is set by the diameter of the condenser lens. The separation of the ball and condenser lenses is set by the latter's focal length. The ball lens should be sufficiently powerful to fill the entire area of the condenser lens with radiation.

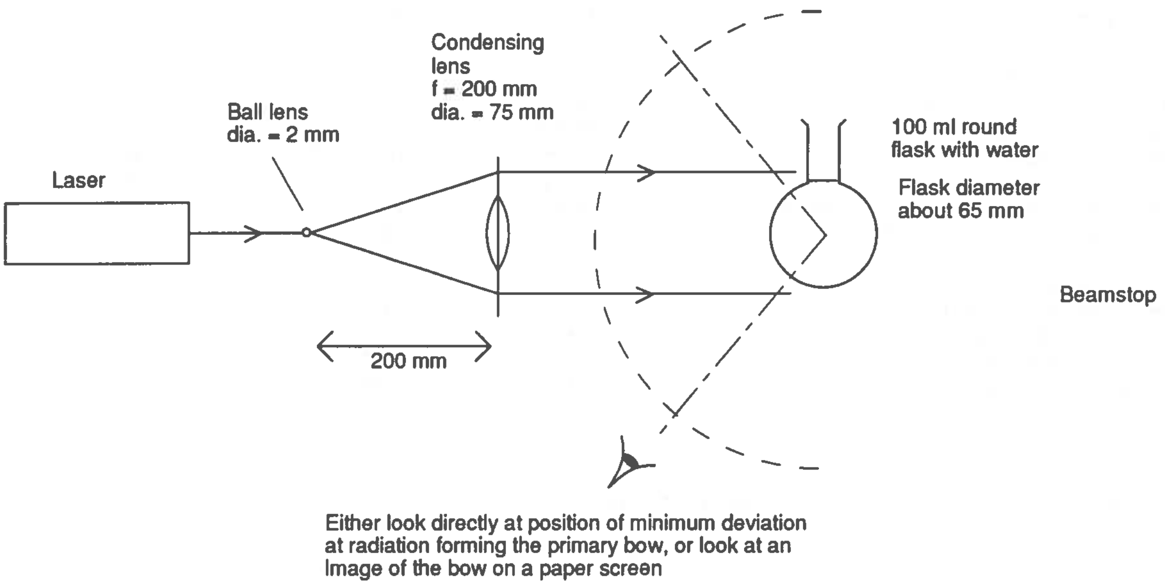


Figure 15. Apparatus for generating rainbow effect with 3-d optics and laser radiation.

The success of the demonstration also depends on the quality of the condenser lens because its full width is being used. We have currently a stock of good quality lenses in Surplus and have used one of them here.

Before setting up a 2 mm diameter ball lens on a rubber bung support (Fig. 13), switch on the laser and adjust to get the beam horizontal. Place the bung on some small wooden squares and use sufficient card or paper spacers such that the radiation just grazes the top surface of the bung. Remove some paper spacers and place the ball lens on the bung near to the path of the radiation. Position suitable screening over and around the bung. Slide the wooden squares over the bench top such that the radiation is centrally directed at the ball lens. You may have to add or remove paper spacers to finely adjust the ball lens height.

The primary bow is sufficiently bright to be seen on a screen under blackout at up to a distance of one metre from the flask. Perhaps the optimum separation for viewing by screen is 20 cm. Radiation forming the bow may also be viewed by directly looking into the flask. The angle of minimum deviation is about 130°. This is smaller than a real bow produces, but raindrops aren't enveloped in glass! The angle usually quoted, 42°, is the complement of the angle of minimum deviation.

The position where the rays emerging from the flask are brightest is at the angle of minimum deviation. Having found this position you will notice that as you move your head to positions within the bow there are at least two distinct bright rays emerging. This can be related to the bright skylight seen inside a rainbow. Moving your head in the other direction beyond the position of minimum deviation reveals an abrupt cut-off in radiation emerging from the flask. And so it should be. Outside a rainbow the sky is dark.

White light demonstration

For apparatus, you require a slide projector, the condensing lens and the round flask with water. Illuminate the condensing lens with radiation and by adjustments to the position of this lens and also the focusing lens on the projector, produce a collimated beam of white light. Place the flask centrally in this radiation and look for the bow as before.

The effect is spoiled by the fact that very much stray light spills out of the projector. Much of this stray light can be mopped up by matt black screening and a black drape. However the projector's need for ventilation ensures that a fair amount of stray light inevitably escapes. Thus the image of the bow on a paper screen is not prominent and the colours muted.

Direct viewing of the radiation coming from the flask is more interesting. As you move through the position of minimum deviation, the radiation's colour can be seen to change from orange red to greeny yellow.

Safety

The Recommended Code of Practice in Circular 7/95 should be followed when carrying out any of these laser experiments.

Because in every experiment a powerful lens has been used to cause the radiation to diverge, the risk of harm from an accidental ocular exposure is extremely slight. Thus downstream from either a rod or ball lens in each of the above applications if any radiation, whether direct, reflected, or refracted, were to enter the eye the intensity has been sufficiently reduced to be harmless. It would however be bad practice not to take full precautions. Thus the Code in 7/95 should be followed.

Material or part	Supplier	Order code	Price (£)
Glass rod, 4 mm dia., 50 x 0.5 m, soda glass	Griffin	RND-290-041C	10.10
Glass rod, 6 mm dia., 50 x 0.5 m, soda glass	Griffin	RND-290-061T	12.05
Ring magnet, 24 mm dia., 6 mm dia. hole	SSERC	814	0.20
Diffraction grating, 80 lines/mm	Griffin	XFY-510-P	7.45
Ditto	Hogg	L1100/80	6.20
Biconvex block, acrylic plastic, 98 mm radius of curvature	Griffin	XFL-601-A	10.05
Circular plastic block, 75 mm dia., 25 mm thick	Harris	Q56910/2	6.90
Ball lens, 6.0 mm dia., Tech. Spec., n=1.517	Edmund	C32746	18.90
Ball lens, 6.0 mm dia., Sapphire, n=1.77	Edmund	C43829	10.68
Ball lens, 6.0 mm dia., Ruby, n=1.77	Edmund	C43830	11.06
Ball lens, 2.0 mm dia., Tech Spec., n=1.517	Edmund	C32744	16.92
Ball lens, 2.0 mm dia., Sapphire, n=1.77	Edmund	C43642	8.03
Ball lens, 2.0 mm dia., Ruby, n=1.77	Edmund	C43643	8.41
Condenser lens, biconvex, f=200 mm, 75 mm dia., crown glass	SSERC	805	12.50

Table 1. Materials and parts required for *Optics with lasers* article. The UK agent of Edmund Scientific is Ealing Scientific. Prices have been converted from dollars into sterling.

In both of the model rainbow experiments, radiation from the model raindrop may be looked at directly. In these instances, because the radiation has been greatly spread out and has undergone multiple reflections, the part that emerges as the primary bow is sufficiently weak to view directly.

Materials and parts

Sources of materials and parts described in the text are tabulated above (Table 1).

The experiments with ball lenses were researched using Technical Specification products with a refractive index of 1.517. Sapphire or ruby lenses can be substituted, taking advantage of their lower price. However because these materials have a higher refractive index (n = 1.77), lenses made of them will be more powerful.

Acknowledgements

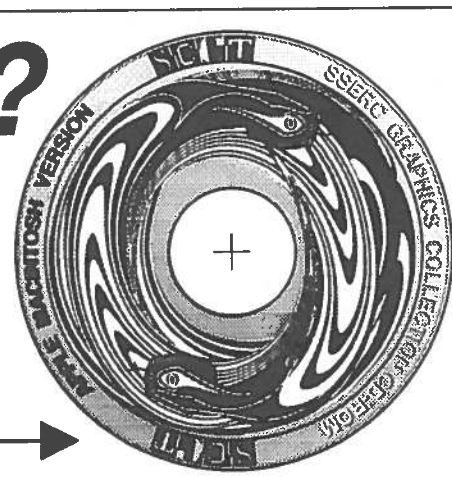
The basic idea of using laser radiation in ray optics, including the Lazy Susan idea, was originally described by T Kallard in *Exploring Laser Light* (Optosonic Press, 1977), reprinted by the American Association of Physics Teachers (1985). Kallard also describes a beam multiplier assembly with glass slide wedges, the idea being first published by W H Porter in *The Physics Teacher* (1974).

The idea of using a diverging sheet of laser radiation as a spherical lens source was described by M G Cornwall and G J Williams in their book *Lase* (1991).

The use of ball lenses with laser radiation, and experiments based on that, together with the two rainbow models, were developed by SSERC.

Training

The Centre has prepared in-service training so as to help broaden the scope of practical work with lasers and show how the work can be done safely. If interested, please contact the Director.



TECHNICAL ARTICLE

Ball lens making

You can make your own ball lenses with soda glass rod. However no matter how good the result may look, it must be tested empirically to find whether it is satisfactory.

One of the pleasures of working at SSERC is meeting teachers from lands overseas who come to share ideas with us. We currently have visitors from Nepal. One, Subarna Pradhan, helps to direct that country's national centre wherein scientific apparatus is manufactured for schools. Seizing the opportunity of Subarna's expertise in glassworking, I asked him to show me how to make a ball lens. Having watched his skill with admiration I was somewhat taken aback when, the following morning, quite out of the blue, Dennis Belford, former Assistant Director of SSERC, walked in off the street bearing a set of notes on, of all things, how to make a bead lens. Further worms crawled out of the woodwork. My colleague Mr Buchanan revealed that in his Griffin & George days he had frequently made bead lenses for fitment into a simple microscope. To cap that, Sir himself, the Centre's Director, Mr Richardson, let slip that he too once had this skill, but had not thought to tell me before this, for which he apologized.

With all this expertise at my elbow, I am but the village idiot relaying to you the tale of how it's done. Worse, it may be like teaching Granny to suck eggs! But I will try my best!

The basic material is soda glass in the form of glass rod, either 5 mm or 6 mm diameter. Although we used a Bunsen flame, this is not really hot enough. The flame of a Butane torch is preferable. The workbench should be protected with a heat resisting mat. Debris should be brushed off the mat into a glass bucket every few minutes rather than letting it accumulate. The glassworker should wear safety spectacles, unless ordinary spectacles are worn. Because the head will be in close proximity to the flame, any long or straggling hair should be tied back.

The procedure, with variants, is as follows :

1. Heat the glass rod about mid-length until it softens. Then pull gently to form a narrow rod about 1.5 mm in diameter (between 1.0 mm and 2.0 mm) (Fig. 1). When cool nick the narrow rod with a file at *X* and break.

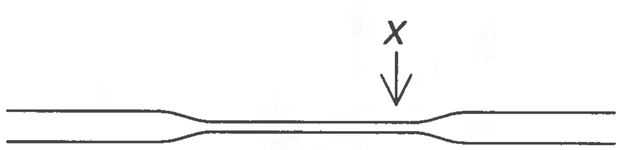


Figure 1. When glass softens, pull gently to form uniform narrow rod.

As a variant, heat one end of the rod until it softens. Introduce the cold end of a second glass rod into the flame and let it touch the softened glass tip. A few seconds later once the tips have stuck together gently pull the rods apart, thus drawing out the softened glass into a narrow rod again of about 1.5 mm diameter (Fig. 2).

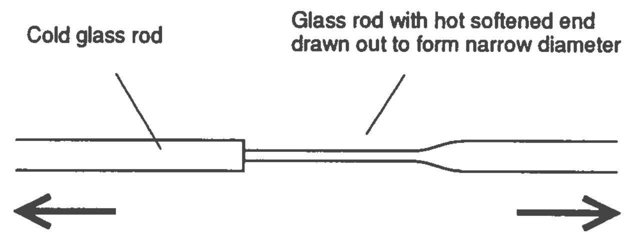


Figure 2. Variant : When glass softens, insert end of cold rod into flame to touch and adhere to hot tip. Pull gently to form uniform narrow rod.

The trick with both methods is to draw out the glass straight so that the narrow section is collinear with the remaining rod.

2. Support the rod vertically with the narrow part upward. Heat the top of the rod as shown (Fig. 3) until the glass melts and forms a small sphere. Continue to apply heat letting the sphere grow in size to a diameter of between 5 mm and 6 mm.

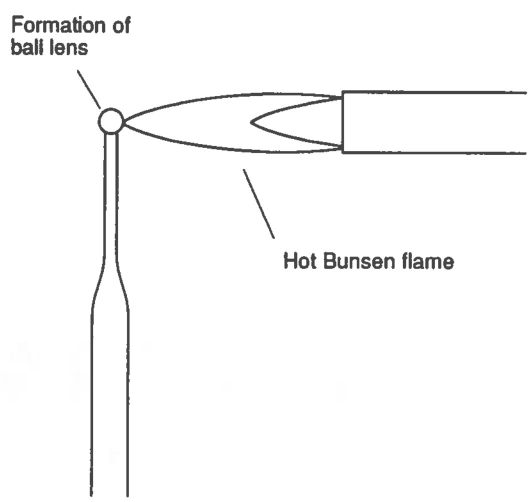


Figure 3. Support rod vertically. Heat tip in hot flame to form glass bead.

Should the rod not be perfectly vertical, the sphere is liable to topple downwards. If this happens, cease heating, unclamp the rod and hold it by hand either in an oblique or vertical position with the narrow end downwards. Begin to apply heat again until the sphere returns to its original position.

As a variant, the rod can be continuously hand held in an oblique position while its tip is being heated (Fig. 4). Twist the rod to and fro between the fingers and keep manipulating it until a bead of the requisite size forms.

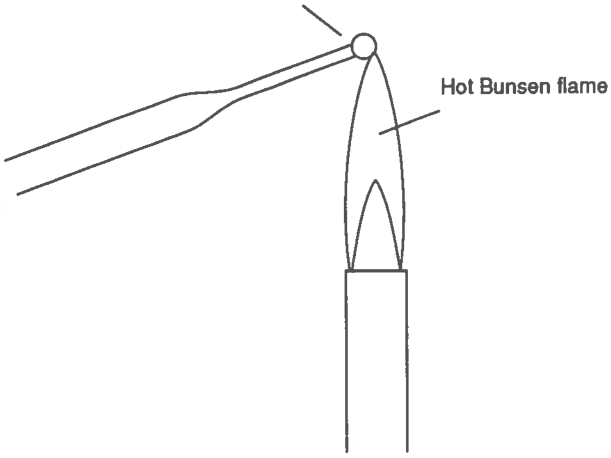


Figure 4. Variant : Support rod in hand, turning to and fro. Heat tip in hot flame to form glass bead.

3. Now that the ball lens has been formed, it should be kept very clean. It should not be touched by hand.

4. The ball lens will at this stage be in a brittle state. To prevent the glass from shattering, it should now be annealed. This is done by placing the ball lens in a yellow Bunsen flame for a period of 5 minutes, turning the rod continuously.

5. Several other ball lenses should then be made. They should then all be tested with a laser and selected or rejected on an empirical basis. Although the rod supporting a ball lens can itself be held in a clamp stand, for ease of adjustment the preferred method of support is by inserting the rod into a hole in a large rubber bung (Fig. 5).

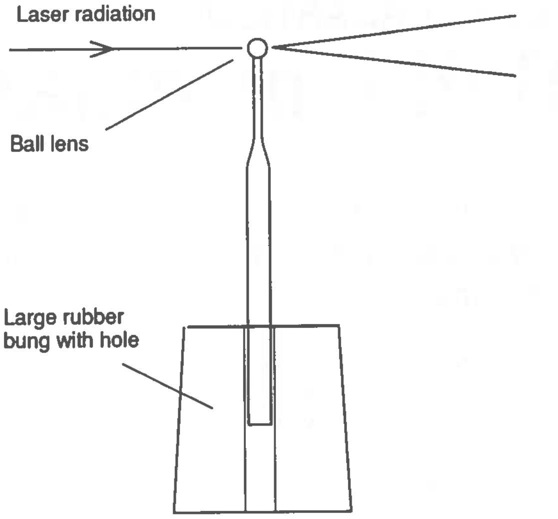


Figure 5. Support ball lens in laser radiation using large rubber bung.

6. The empirical test consists of placing the ball lens directly in laser radiation and viewing the radiation which diverges from the lens on a paper screen. If the image on the screen is a uniformly plain disk, then the test is positive. You have a good one! There are two types of poor result. One is a speckled image; the other a series of interference fringes. These fringes sometimes extend right across the image. In other instances, they are circular, of small diameter. If the image is poor, rotate the ball lens in the radiation to see whether some other position produces a fair image. If no fair image can be found, then the ball lens is relatively worthless and should be discarded.

You are of course unlikely to get an ideal image. What you end up accepting typically will be an image that is reasonably uniform across most of its overall dimensions, but with a number of flaws.

Acknowledgement

I am grateful to Subarna Pradhan, Depute Director of the Janak Education Materials Centre, Kathmandu, for patiently instructing me in making ball lenses. I am also indebted to Dennis Belford for allowing me to use his notes on this subject.

Examples of family logic

Each logic family has its own set of operating rules. In this article we look at differences between three widely used families, LS, HC and 4000B series metal gate, in the context of the sequential controller within Case Study 3, being part of support material for Higher Grade Technological Studies.

There are some simple dos and don'ts when building logic circuits. Whenever possible don't mix logic families. Do study family specifications, understand the rules and apply them methodically. While some rules may be shared by several families, don't presume this to be so.

Problems often arise if the maximum permitted currents which can be sourced from, or sunk into, an output are disregarded (Fig. 1) (Table 1). The *low-level output current* I_{OL} is the current that sinks into an output in its low-level state. The *high-level output current* I_{OH} is the current sourced from an output in its high-level state.

For those readers unfamiliar with Case Study 3 [1], the sequential controller models a series of operations in the wash cycle of a dishwasher. A clock pulse triggers a counter to count up in 4-bit binary. This is encoded by ROM to generate a 5-bit sequence of nine events to operate five actuators (valve, heater, 2 pumps and an indicator) (Fig. 2).

Logic family or device	I_{OL} (mA)	I_{OH} (mA)
LS	8	0.4
HC	25	25
74C14/40106B	0.88	0.88
4017B	0.88	0.36
4001B / 4071B	0.88	0.88
4049UB	5	1.6
NE555N	200	200
ICM7555IPA	100	100
ULN2003	500	o/c

Table 1. Maximum values of current which can be sunk into outputs or sourced from outputs.

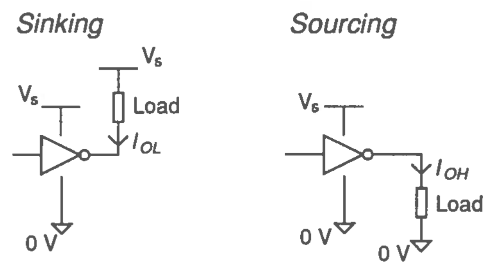


Figure 1. Sinking and sourcing.

Address code	Decoded signal	Output data	Active transducers
0 0 0 0	0	0 0 0 0 0	
0 0 0 1	1	1 0 0 0 0	Valve
0 0 1 0	2	1 1 0 0 0	Valve, Heater
0 0 1 1	3	0 1 0 0 0	Heater
0 1 0 0	4	0 0 1 0 0	Pump 1
0 1 0 1	5	0 0 1 0 0	Pump 1
0 1 1 0	6	0 0 1 1 0	Pump 1, Pump 2
0 1 1 1	7	0 0 0 1 0	Pump 2
1 0 0 0	8	0 0 0 0 1	Stop indicator

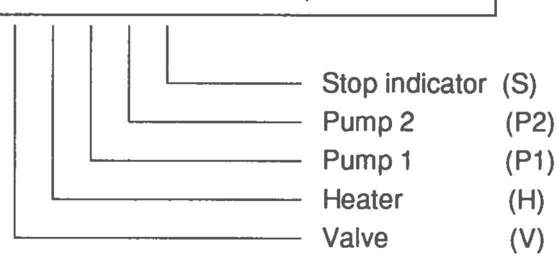


Figure 2. Sequence of operations in dish washing programme.

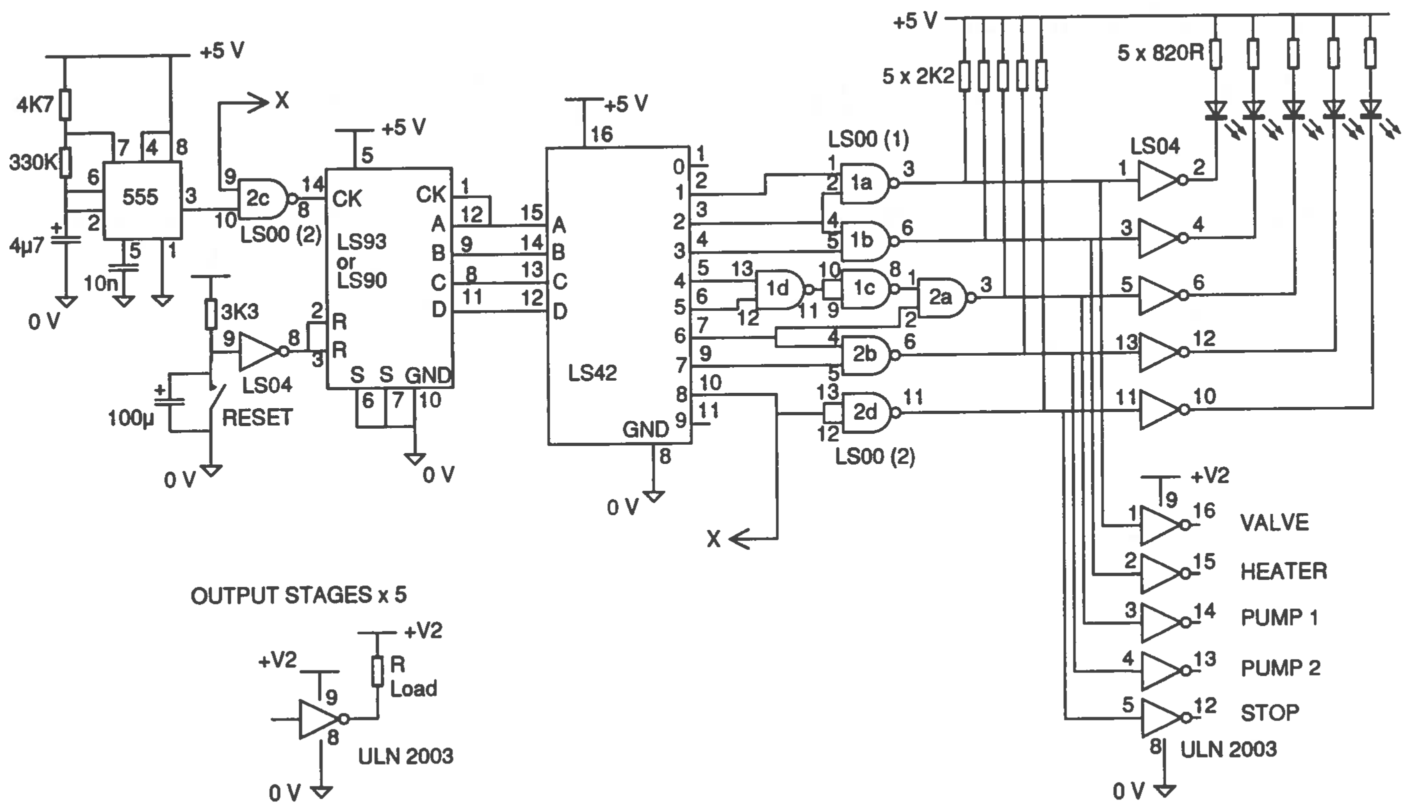


Figure 3. Circuit diagram with 74LS TTL devices.

The sub-section blocks of the system are listed below.

Oscillator.

Counter and decoder.

Combinational logic.

Control line indicator.

Driver.

The Case Study sets out the specification and outlines ways of designing a system to meet it. However from numerous enquiries it is clear that many readers might appreciate further help. Therefore four complete solutions are given, one in each of LS and 4000B series metal gate, and two in HC.

Although the operating supply voltage varies from family to family (Table 2), each of the families discussed here can run off a regulated d.c. power supply of 5 volts. That is what is used in every case. A separate power supply (V2) should be used with the actuators.

Supply voltage	Min (V)	Max (V)
LS	4.75	5.25
HC	2	6
4000B	3	15
NE555N	4.5	15
ICM7555IPA	2	18
ULN2003	-	50

Table 2. Supply voltage range for various logic families and devices.

LSTTL circuit

The 74LS family has outputs that are capable of sinking loads which draw up to 8 mA, but only sourcing loads to 400 µA. So as to avoid problems with noise, unused inputs should not be left floating. Depending on circumstances they may be tied high through a suitable resistor (3.3 kΩ), or connected directly to ground, or commoned with another input which is in use.

The oscillator for this system can be a standard NE555N timer. The values of added resistors and capacitors (Fig. 3) give a slow oscillation period of several seconds.

The counter in this circuit is a 74LS90, but there are lots of other devices in the 74LS family which would do instead. The reset facility within the 74LS90 is active high. This means that the reset inputs have to be held low to let the chip count. A spare inverter does this function. When a clock pulse is applied to the clock input of the 74LS90 the four BCD outputs count up. The outputs are applied directly to the respective inputs of a decoder chip, the 74LS42, which converts the BCD into decimal outputs. The 74LS42 outputs are active low, i.e. the outputs go low for one clock period, in sequence, one at a time. In a reset condition the BCD data from the LS90 is 0000 resulting in output 0 (pin 1) of LS42 being kept low while the other nine outputs remain high. When the reset button is released the counter increments until output 8 on LS42 is reached, which goes low. This disables the NAND gate (2c), preventing clock pulses reaching the counter, thus locking output 8 in an active state. This

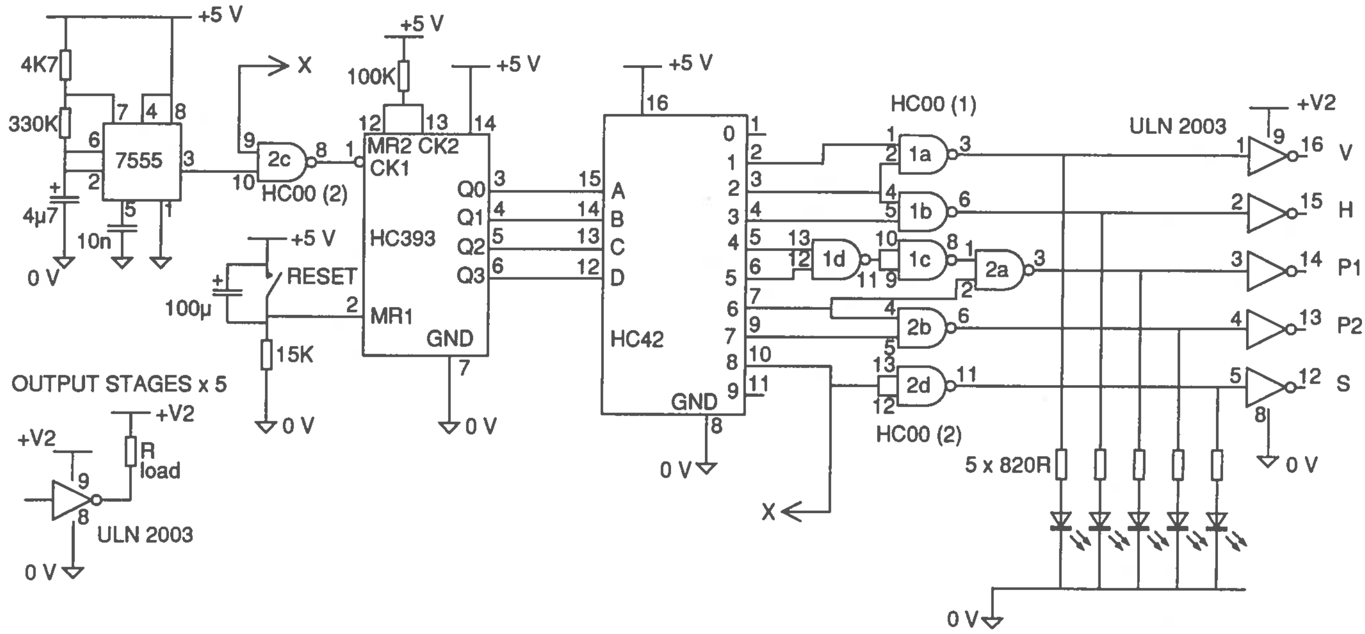


Figure 5. HC circuit using separate counter and decoder devices.

condition simulates a washing machine indicator informing the operator that the wash cycle is over. Output 8 remains active until the reset button is actuated. When the reset button is released counting will restart at 0 again.

The combinational logic area of this system requires 2-input NAND gates, packaged in the 74LS00. Because outputs of the 74LS family are capable of sourcing no more than 400 µA into a load, a LED cannot be sourced from such an output. It requires a few milliamps to produce a reasonable intensity of light from a LED. As sinking them would produce a logically incorrect indication, an additional inverter has to be added to each output line. If the output state of one of these inverters is low, the LED to which it is connected will be on. In the circuit illustrated (Fig. 3) a standard 3 mm red LED with an 820 Ω series resistor sinks 3.6 mA into the output stage of the LS04 gate to which it is connected.

The driver device is a ULN2003, which contains an array of Darlington transistors. These are good at switching large currents. As it has internal 2.7 kΩ base resistors on each of its inputs, driving them with the 74LS family would be conventionally unsound, although you often get away with it. As mentioned earlier, the manufacturer's specification for the 74LS00 gives a maximum high-level output current of 400 µA. In a circuit bench tested in this mode, it was found that the ULN2003 drew 900 µA from an LSTTL high-level output of 3.6 V. This is tolerable. Although it breaks the rules and has been found to work reliably, it cannot be depended upon in all circumstances.

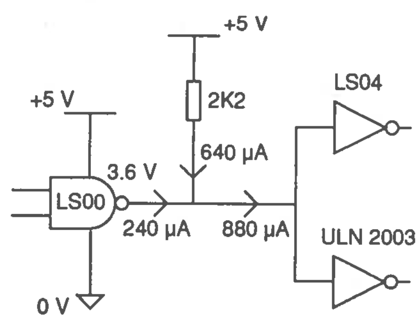


Figure 4. Effect of pull-up resistor on NAND gate output when output is in a high-level state. Most of the current required to drive the following stages is drawn from the supply through the 2.2 kΩ pull-up resistor.

Matters can be improved by connecting a 2.2 kΩ pull-up resistor between the supply rail and LS output (Fig's. 3 and 4). When the LS output state is high, most of the current drawn by the input stages of ULN 2003 and LS04 is routed through this resistor. The actual high-level output current I_{OH} is about 240 µA, which is well within the limiting value of 400 µA.

HC circuits

The circuit can be translated from LS into HC with only minor changes (Fig. 5). Although the standard NE555N timer will often operate HC devices, its CMOS version, ICM7555, should be used so as to comply with rules of usage. An oscillator based on the 74HC14 Schmitt trigger may also be used.

There is no straight replacement in HC for either the LS90 or LS93. We have therefore gone for a 74HC393, which is a dual 4-bit binary counter. Only one counter in the package is used. The rest of the counting and decoding details exactly match the LS case.

Because HC devices are able to source up to 25 mA per output, it is possible to directly drive LEDs which are connected through their respective ballast resistors to ground. Such LEDs give the correct indication of the logic state of the line to which they are connected without any effect on the signal and without the need for any additional driver inverters. It was found that each red LED with a series resistor of 820 Ω drew 3.6 mA.

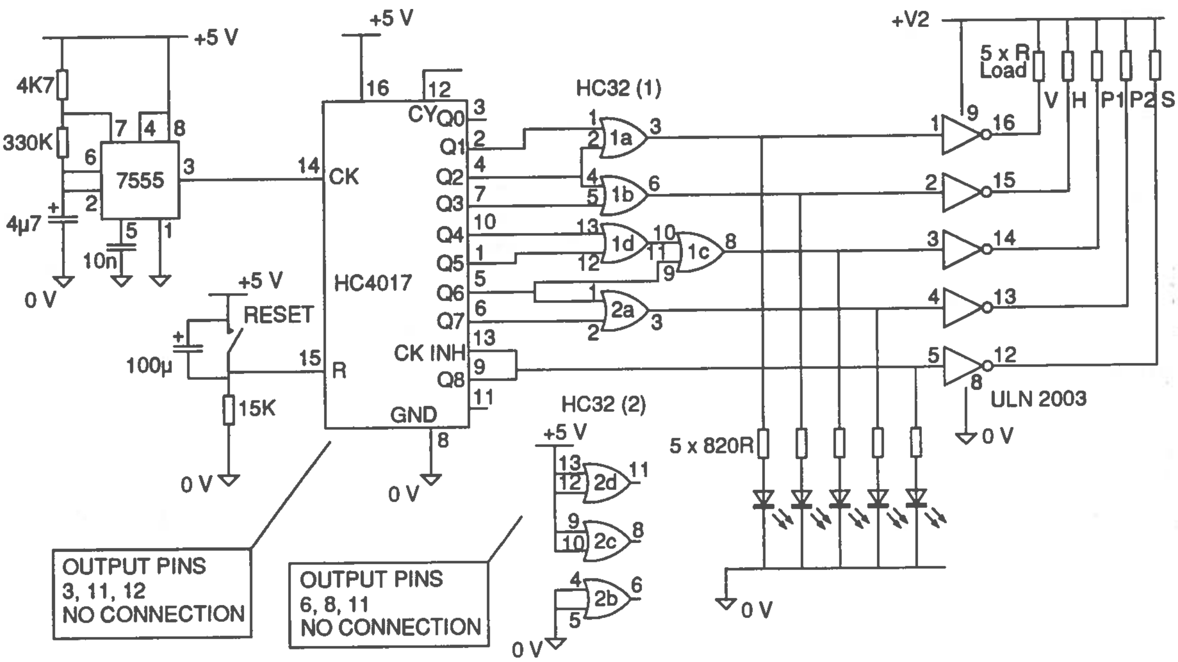


Figure 6. HC circuit using integral counter and decoder device.

The ULN2003 Darlington driver has internal 2.7 kΩ base resistors on each of its inputs and is therefore easily driven by the 74HC family. Thus if a control line is high, the HC output stage sources about 1.2 mA into a Darlington driver and 3.6 mA into a LED. This totals about 5 mA - a mere snitch compared with the maximum current allowed by the family rules.

By replacing the counter and decoder with a single device which has both of these functions, the chip count can be reduced.

The 74HC4017 decade counter/divider (Fig. 6) has ten decoded outputs. These outputs are normally low. When a clock pulse is applied to the clock input (pin 14) each of the outputs goes high for one clock period, in sequence, one at a time. In a reset condition the output Q0 (pin 3) is high while the other nine outputs remain low. The reset is activated by making pin 15 (*RESET*) high. When the reset button is released, the counter will increment until Q8 is reached. Output Q8 (pin 9) has been linked to the clock enable[1] input (pin 13) to hold Q8 high. While pin 13 remains high, the device will not increment any further counts unless the overriding reset push-button contact is activated to begin the sequential counting from Q0 again.

All unused inputs to HC devices must be tied. Since there are three unused OR gates in an HC32 package, the inputs to these gates have been connected to either the supply or ground depending on whichever topographically is more convenient (Fig. 6).

Metal gate CMOS 4000B series circuit

The 4000B family outputs have limited sinking and sourcing capabilities which can vary from device to device. LEDs should not be driven directly from any of the 4000B series family except the 4049UB hex inverting buffer. All unused inputs must be tied.

The sub-section blocks of the 4000B system have features in common with the second HC system previously described. However the ways in which Darlington transistors and LEDs are driven are different.

The five control lines are monitored with LEDs by allowing the LEDs to sink into a hex inverting buffer, namely the 4049UB. This has an output sinking capability of up to 5mA, which is sufficient for this purpose.

Were the ULN2003 to be driven by standard members of the 4000B series family such as an OR gate in 4071B, the direct equivalent of the HC design in Figure 6, a current of over 1.2 mA would be drawn from each high-level state 4000B output (measured to be 4.5 V). However as mentioned earlier, most of the 4000B series can only guarantee a typical high output current of 880 μA. While bench tests show that Darlington drivers in the ULN2003 can be operated by 4000B devices, such operation is illegal.

We have therefore interposed hex buffers between the gate outputs and Darlington drivers (Fig. 7). Since the buffer can source 1.6 mA and sink 5 mA, the system can be seen to comply with the rules. Because this introduces another inversion, the OR gates in the preceding HC design have been replaced with NOR gates in the 4000B series design. Seven such NOR gates are needed. They are packaged in a 4001B.

1 Referred to by some manufacturers as the *CLOCK INHIBIT* input.

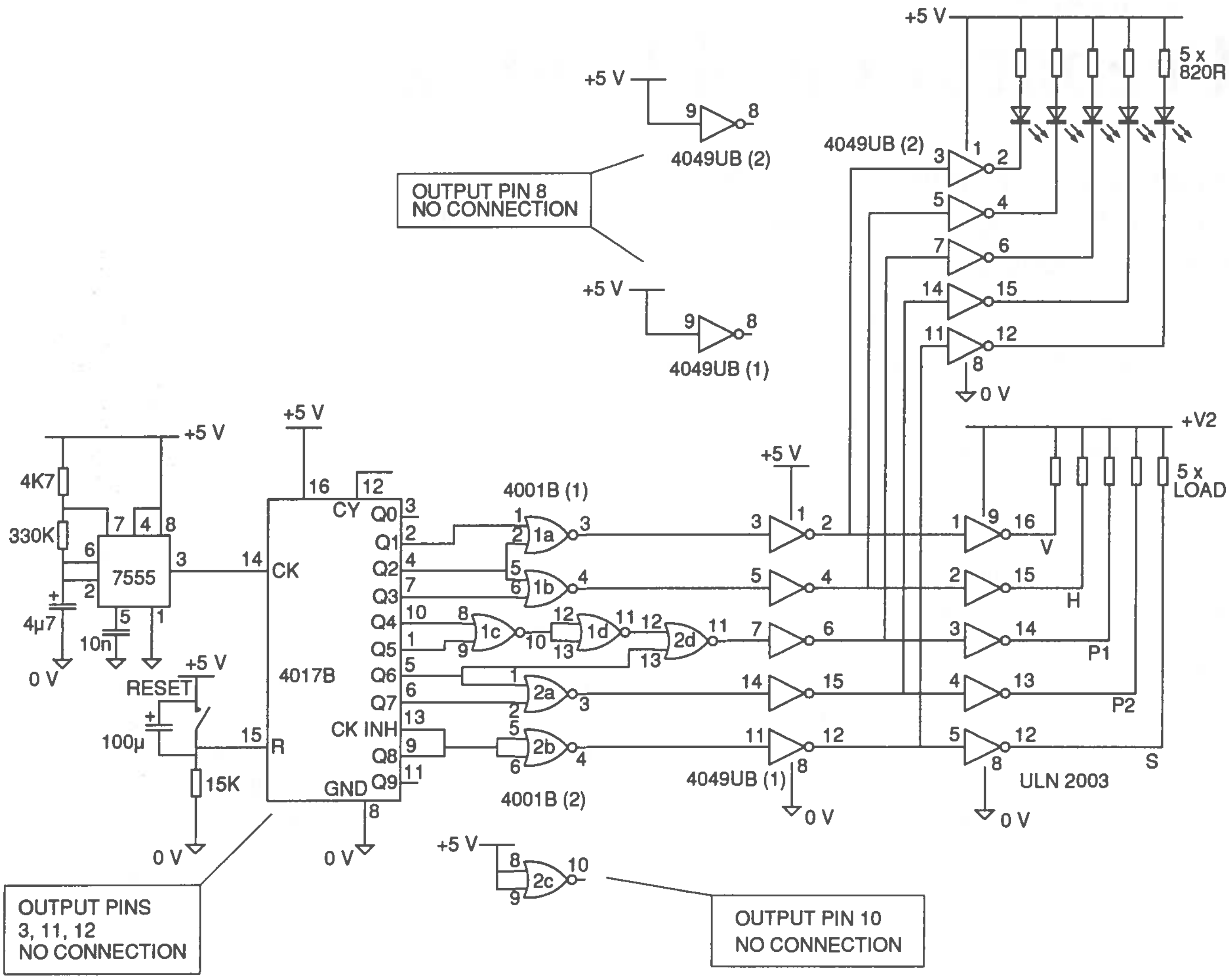
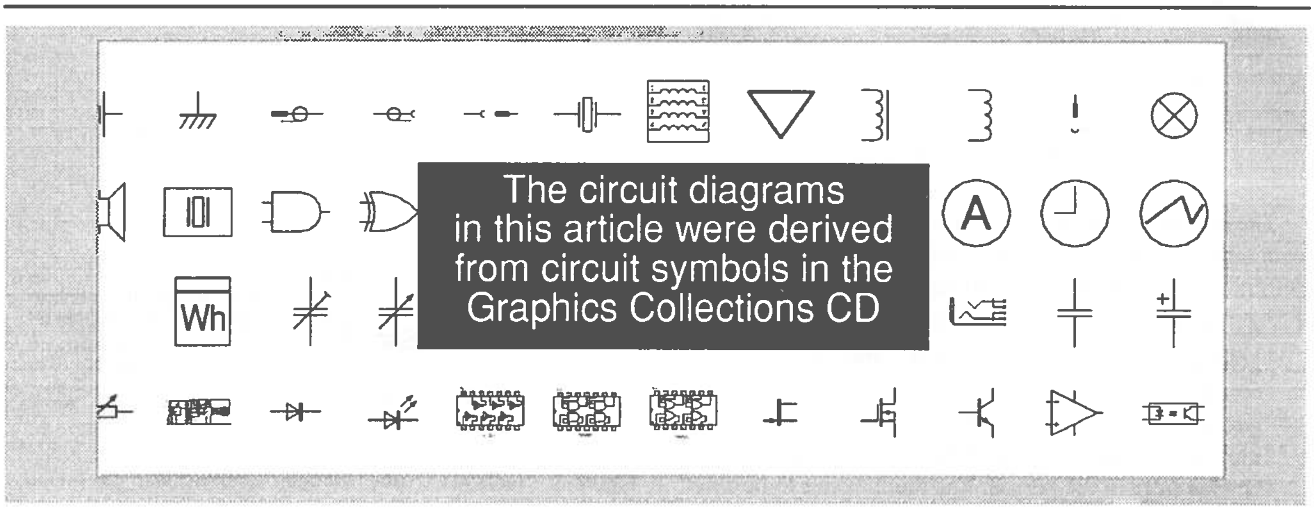


Figure 7. Metal gate CMOS 4000B series circuit with integral counter and decoder device.
In this arrangement an inverting buffer has been placed after the 4000B gate to drive the Darlington transistor in the ULN2003. The control lines are monitored by LEDs sinking into separate buffers.

The final system is therefore quite complex. This is in part a reflection of the inferior specification of 4000B series logic compared with modern logic families such as 74HC. When all the systems are compared, the least complex is clearly the second HC version (Fig. 6).

Reference

1. *Case Study No. 3 : The automatic dishwasher*, Case Studies, Higher Grade Technological Studies, SCCC in association with SSERC, 1991.



TECHNICAL ARTICLE

Preparation of hydrogen

Gases can be prepared with simple home-made apparatus held together with string and sealing wax. The generators feature fast reaction, small dead space and on-off control.

This article describes different forms of apparatus for preparing gases where a liquid reagent is reacted with an insoluble solid. The preparation of hydrogen from dilute acids and impure zinc is such an example. The parts needed are either recycled or inexpensive bits held together by string and sealing wax, or other sorts of everyday stuff.

Whilst working on this subject we were visited by Subarna Pradhan and Shuba Lakshmi Pant from the Janak Materials Education Centre near Kathmandu. Both of our visitors have a great interest in the construction and provision of equipment for practical work in science. Subarna constructed and demonstrated to us a very simple generator made mainly from wide bore vinyl tubing.

Traditional generators

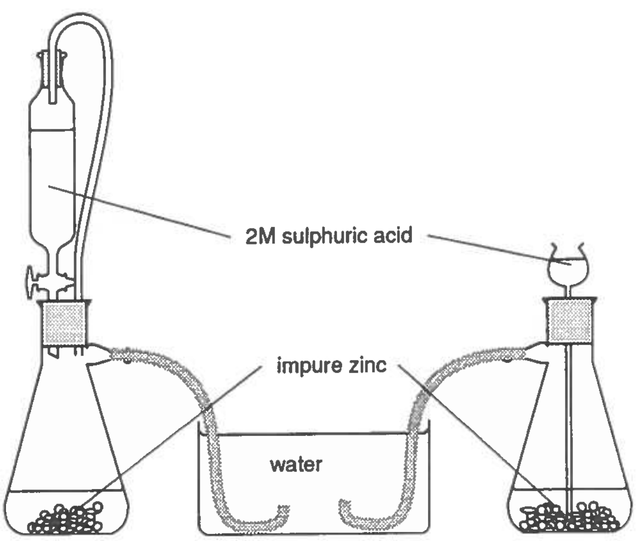


Figure 1. Traditional hydrogen generators : George Andrew's version and method with thistle funnel.

The commonly used generator based on a flask fitted with either a thistle funnel or a dropping funnel (Fig. 1) suffers from two major disadvantages.

1. All chemical reactions are initially fast and the rate gradually falls as the solutions become less concentrated; this is fine if you are collecting several gas jars or many test tubes for later use by a class. It is inconvenient and a waste of materials if some gas is needed later in the period. It is much better to be able to switch the gas supply on and off as can be done with a Kipp's generator.
2. The dead space in the flask is large and the reaction needs to be running for a long time before all the air has been displaced.

Further to these, sudden small surges of backpressure can cause the acid to back up the thistle funnel and bubbles driven back can cause a splashing of the acid from the top of the open thistle funnel.

DIY gas generators with gas on tap

There are many variants of this model. It can be in a wide bore glass U-tube, or in vinyl tubing, which is the method used in Nepal by Subarna. Alternatively it can take a more flexible form with adjustable reservoirs.

Common to all the gas preparation designs below, the delivery tubing must not be too narrow or pressure could build up. 6 mm o.d. tubing is suggested as a minimum. Eye protection should be worn because of the corrosive effect of acid.

(a) Subarna's U-tube model :

A length of wide bore flexible vinyl tubing roughly 400 mm long is bent to form a U-shape, kinking at the bend (Fig. 2). We used 25 i.d. tubing, but the dimension is not critical. When the vinyl is bent, it forms a 'V' rather than a 'U' and the kink acts to trap the granulated zinc on one side. A short length of small bore, hard tubing is positioned at the bend as a canal to ensure free movement

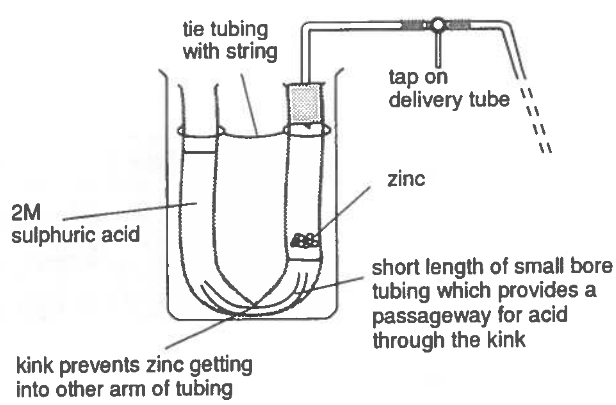


Figure 2. Subarna's U-tube hydrogen generator with gas on tap.

of the acid. There needs to be some means of holding the arms of the wide bore tubing vertical, i.e. tying the ends of the tubing together with string, or jamming the tubing in a beaker, or preferably by both such means.

The operation of this is self explanatory; the gas which is still being generated at the moment the tap is closed drives the acid down below the support for the zinc (the kink in the tubing) and into the open limb. The reaction soon stops. If too much extra gas is produced the acid may be driven up to the top of the open limb and overflow. Therefore the U-tube should not be more than half full. The small plastic tap of the type sold for use with syringes can be used. Note that these 3-way taps operate in a peculiar way; the arm to which the tap lever is pointing is closed while the other two are open.

The reason for Subarna's choice of materials was that in Nepal vinyl tubing of a variety of bores is readily available and glass often is not. We were very interested to see the novel use of such materials.

A wide bore glass U-tube could be used instead of the vinyl with a plug of glass wool about one third of the way up one limb to support the zinc.

(b) Adjustable reservoir model

This one is also simple and the use self-explanatory (Fig. 3). It has an advantage over flask-based generators in having a small amount of dead space. This is somewhat less than the volume of the plastic syringe used as the reaction chamber added to which is the outlet tube to the tap. A fairly large amount of granulated zinc can be stored in the reaction chamber thereby giving a fast rate of supply when needed. A further advantage is the extra adjustment of the reservoir height to give a reasonable head of acid. When raising, take care not to drive the acid itself over into the gas delivery tube. When the need for further supply of hydrogen is over the teacher or technician can lower the acid reservoir so that the acid could never reach the zinc, even if the gas delivery tap

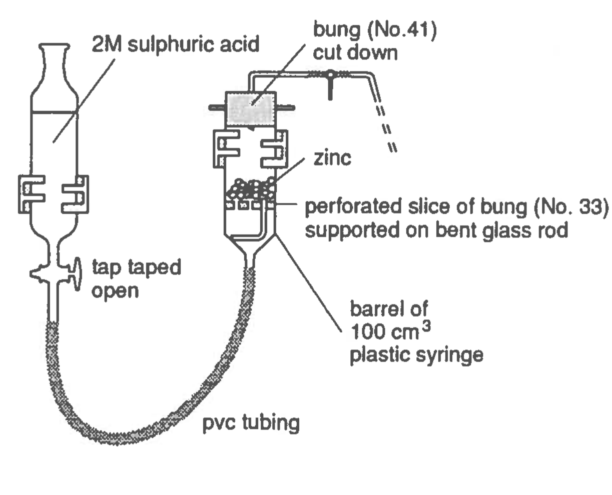


Figure 3. Adjustable gas generator.

were left open or other connections leaked. Finally the whole apparatus should be used and, if left charged with acid, stored in a plastic pneumatic trough or basin, just in case of a leak.

Note the small spaces above and below the zinc in the reaction chamber. The top space is needed to prevent the acid from frothing over into the delivery tube. The bottom space provides a small reservoir for storing a little hydrogen. This space is created by supporting the zinc on a disc made from a slice of a perforated bung (several holes bored out with a number 2 or 3 cork borer in a slice of a no. 33) which is held about 2 cm above the syringe outlet on a short length of glass tubing. It is sensible to attach the standard CHIP "corrosive" label to the reservoir.

If a dropping funnel is used, the tap must be taped in the open position to prevent it being inadvertently closed, which would lead to a build up of pressure. Various alternative reservoirs can be used, e.g. stiff plastic bottles, etc.

There will often be a blow back of hydrogen bubbles through the reservoir. Usually this is not too large.

(c) Adjustable reservoir model with gas storage

This variation (Fig. 4) has all the advantages of that above - fast reaction, small dead space and extra control afforded by being able to adjust the reservoir height. In addition it can store a few hundred cubic centimetres of gas.

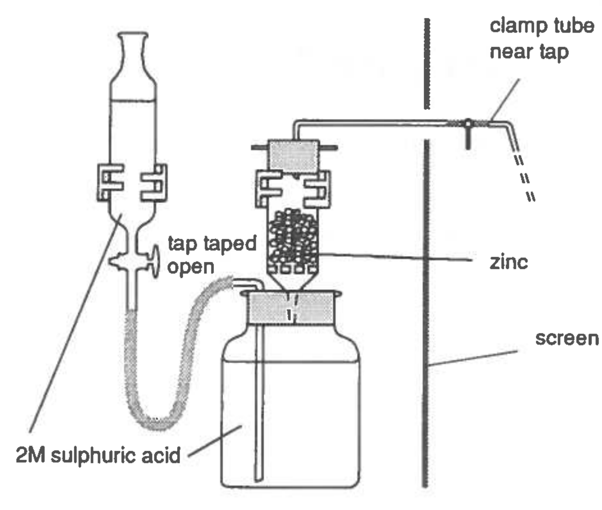


Figure 4. Adjustable gas generator with reservoir. If pupils draw off gas, then shield apparatus with a screen.

With respect to the set-up, zinc sits on the bottom, resting on a perforated bung. The nozzle of the syringe should not be below the bottom of the bung, i.e. not protruding into the gas reservoir otherwise all the air cannot be displaced by the acid. The delivery tube for acid should descend almost to the bottom of the gas reservoir.

A sturdy, old, square shaped plastic, wide-mouthed bottle can serve as a gas reservoir. A wide bung (a slice of a number 41 rubber bung with two holes bored in it fitted ours) was suitable for an old 500 g sodium hydroxide pellets bottle. The charge of zinc can be larger here. A perforated bung slice (no. 33 fits inside the 100 cm^3 plastic syringe) placed on the bottom prevents pieces of zinc from falling down into the acid.

If pupils are themselves filling test-tubes with hydrogen, it would be sensible to have the whole apparatus behind a screen with the delivery tube and tap being supported in a clamp on the outside of the screen. All samples of hydrogen should be ignited at the far side of a ventilated room.

The apparatus can be kept set up, but any stored hydrogen should be bled off and the reservoir lowered. If desired the apparatus can be very simply drained by syphoning the acid out of the reservoir as shown (Fig. 5).

All the parts needed for constructing any of these DIY generators can probably be found knocking about the lab or prep room. Failing that, some sources are listed in Table 1. The specified taps need to be modified by having the flange cut or filed off the female end.

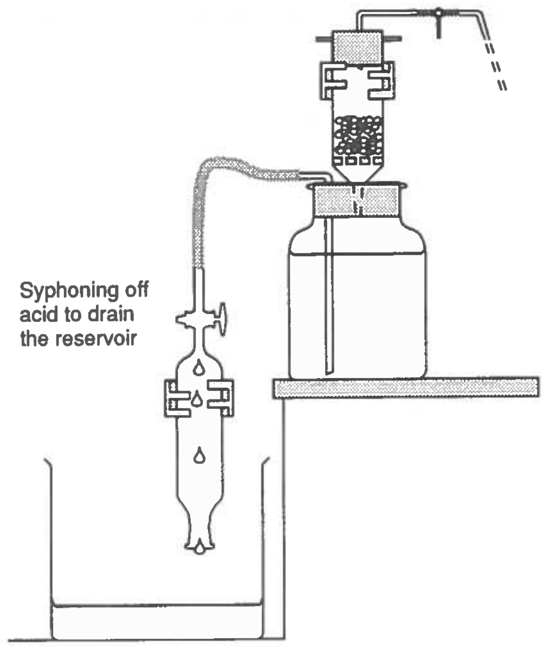


Figure 5. Draining the system.

polypropylene syringe, 100 cm^3	Harris	Y65050/2	£5.72
plastic syringe, 60 cm^3	Harris	Y65010/1	£2.32
3-way taps (pack of 5)	Harris	Y65300/9	£7.98
PVC tubing, 25 mm i.d., 3 metres	Merck	275/1250/86	£26.01

Table 1. Materials for gas generators.

TECHNICAL TIPS

Hot to touch warning labels

Aldrich and Sigma supply self-adhesive, waterproof, plastic coated labels which change from black to orange and display the word "HOT" in red letters once the temperature of the surface to which it is stuck exceeds 50°C. It returns to black when cool. The manufacturers say it can withstand temperatures up to 110°C. This will be useful for any vessels containing hot water, e.g. water baths.

At higher temperatures the adhesive may fail or the liquid crystals be damaged. Therefore this label cannot be stuck directly on the actual hotplate of a heater, which may easily reach 250°C. One possible way is to stick it on the pressed steel casing a short distance from the actual hotplate. As the casing is not completely thermally isolated from the hotplate some heat leaks into it by both conduction and radiation; thus the temperature of this casing follows that of the hotplate, but at a lower level. We found the temperature of the casing on our Voss hotplate/stirrer to be 70°C when the hotplate surface was at 250°C. Thus this heat label stuck on the casing would serve as a useful warning. However on the Stuart model the casing only just exceeded 50°C, presumably due to better insulation. A label on this would be a less satisfactory indicator.

So if the steel casing of your hotplate becomes very hot to the touch, then this label will act as a useful warning indicator. On the other hand, if the casing on your hotplate stays relatively cool other reversible temperature strips which change at lower temperatures will be satisfactory. The self-adhesive strip from Merck, which changes between 30°C and 60°C in steps of 5°C, should be satisfactory (10 for £6.96, Cat. No 268/0384/03). The temperature of the casing which is found to correspond to an unsafe hotplate surface, say above 100°C, can be marked.

Labels reading "HOT" are available from Sigma or Aldrich, at £7.90 for a pack of 40, catalogue number Z-25278-6.

Sigma Aldrich Still in stock £8.90 pack of 40

DCPIP - colour change and other notes

We had enquiries recently on the nature of the colour change to expect with this redox indicator in the presence of ascorbic acid (vitamin C). Apparently some confusion has been caused by a description of a sixth year studies project which attributes a colour change of blue to pink to DCPIP (dichlorophenol-indophenol or phenol-indo-2 : 6-dichlorophenol) in the presence of ascorbic acid. Teachers and technicians rang us to ask about this since only some had ever witnessed such a reaction in the presence of citric acid (2-hydroxypropane-1,2,3-tricarboxylic acid to any IUPAC pedants out there!).

As well as looking up this topic in some reliable references, we also tried things out again for ourselves at the bench. In all of our trials a blue to pink change was not observed but that is not to say that DCPIP can't be made to turn pink. Any confusion there might be seems to have arisen because the colour changes shown by this particular redox indicator are pH dependent. This type of behaviour is not all that unusual in dyes used as indicators (eg phenolphthalein). In the case of DCPIP, at a pH of ca.6 and above the oxidised, coloured form is blue and the reduced form is colourless (hence the description 'leuco' form). At pH values below about 6 however the oxidised, coloured form becomes more reddish in hue going to a deep red/purple at pH2 or 3. The degree of redness depends to some extent on the dilution. Adding ascorbic acid to an acidified solution of DCPIP (using, say, a drop or two of ethanoic acid) results in a change from purple/red to colourless. There may well be an intermediate pink solution but in our experience the final reduced form is always colourless (or at most a pale yellow or straw colour). This pH dependency of the DCPIP colours would explain the observed behaviour with citric acid. Similarly, if an acidic citrus fruit juice is added to a DCPIP solution the colour change sequence may include a pink or reddish intermediate hue but in the presence of ascorbic acid the end point will be a colourless solution.

In summary : In neutral or alkaline conditions ascorbic acid and other reducing agents will turn DCPIP from blue to colourless. In acidic solution DCPIP is purple or reddish violet. Reducing agents will then turn it from red to colourless. In the absence of such reducing or oxidising agents, altering the pH of DCPIP will shift the colour of the dye reversibly between blue and reddish hues.

Other points

Neither ascorbic acid nor DCPIP solutions have long shelf lives. Many teachers and technicians are probably already aware of this but it is probably still worth emphasising that, in any of these assays, it is important to use freshly prepared samples and indicator solutions.

Further reading

The "reliable" references mentioned above include the old, unrevised edition of the Teacher's Guide to Nuffield Biology Book III (out of print). This describes in much useful detail a procedure for the estimation of ascorbic acid concentrations using DCPIP. It also has a method for the use of the red form of the indicator in the estimation of vitamin C in urine which includes a step for acidifying the DCPIP with a drop or two of ethanoic acid. This procedure may be of interest to teachers but these days would probably only be acceptable using simulated urine samples (cf. Standard Grade practicals on urea) or as a CSYS activity after carrying out a suitable and sufficient risk assessment.

A second, more accessible, source is Freeland's Teacher's Book on Investigations for GCSE Biology [1]. This has two protocols using DCPIP which are of interest. One is similar to the Nuffield description for an assay of vitamin C concentration and the second uses the wells in agar technique (Figure 1). Briefly, this involves adding the dye before pouring an agar plate. Standard wells are removed used a heated cork borer. Samples containing vitamin C in known, or unknown, concentrations are added in equal small volumes to the wells. As the ascorbic acid diffuses out into the gel a colourless zone develops. The diameter of each cleared zone after a given time is taken to be dependent on the original concentration in the well. The system can thus be roughly calibrated and concentrations of vitamin C in samples of unknowns estimated.

Reference

1. Investigations for GCSE Biology : Teacher's Book, P.W.Freeland, 1987, Hodder & Stoughton, ISBN 0-340-40526 (Investigations 5 and 15B).

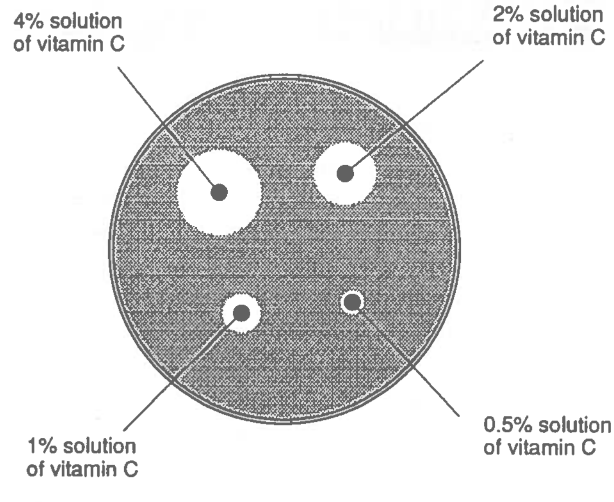


Figure 1. Appearance of the DCPIP agar plate after vitamin C has diffused from the wells (after Freeland).

TECHNICAL TIPS

Skin sensitivity

Dennis Belford has some honorary mentions elsewhere in this issue. When Dennis was assisting us recently with one of the training days for our Nepalese visitors he brought in a slim volume which he had written and entitled *Plastic Biology*. His abstract describes this as "A guide to the construction of biological apparatus using excess plastic and other wares which are normally discarded". Among the fifteen or so ideas described is a "skin sensitivity disc". This provides a neat answer to a number of enquirers who questioned the wisdom of continuing to use dividers or similar metal implements for the purpose of testing the varying sensitivity to touch or contact of human skin at different sites on the human body such as the back of the hand compared with the upper arm.

We have in fact mentioned before this particular use of waste plastics but that account was perhaps somewhat cryptic (Bulletin 136, June 1983). The idea is illustrated more clearly and with suggested dimensions in Figure 1 opposite. This figure is full size and acts as a template for the cutting out of the real thing in plastic from a flat sheet such as the lid of a used ice cream container or margarine tub. The discs are made from circles of plastic of approximately 50 mm radius. Use them to determine the distance apart of the skin receptors in various, non-naughty, regions of the human body.

Generous as always, Dennis has told us that we can make all of the ideas in *Plastic Biology* freely available.

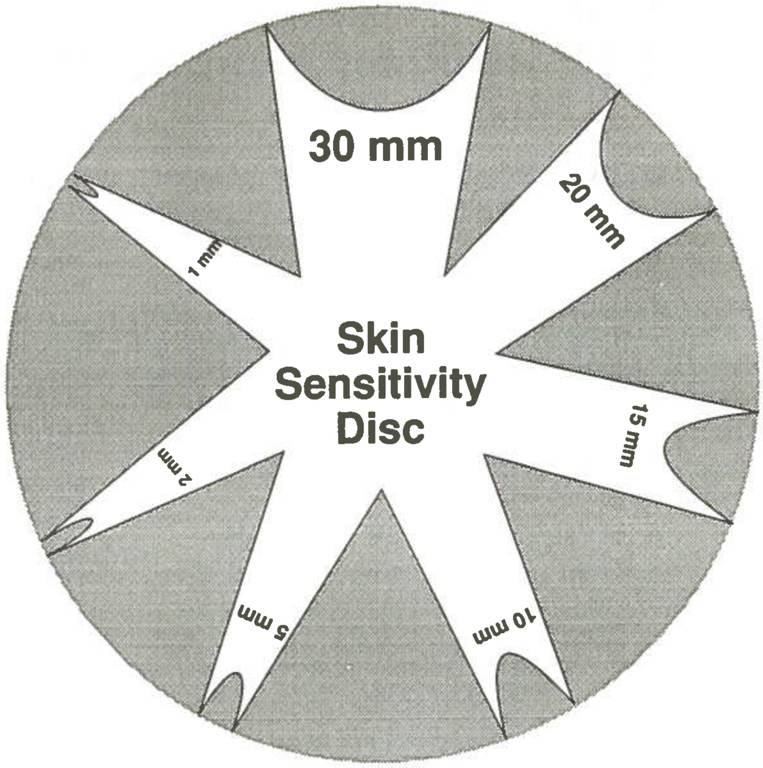


Figure 1. Skin sensitivity disc drawn full size.

As with the skin sensitivity disc we have published short notes on some of these ideas before (e.g. leaf litter sorting trays and tweezers etc.). Others, as far as we know, have never been published. Examples include a soil capillarity demonstration apparatus and a simple microscope using a ball lens of the type described on page 17 of this issue. We would be happy to supply copies of *Plastic Biology* for the cost of photocopying and postage, which we reckon will tot up to the princely sum of £1. Cash with orders please.

TECHNICIANS' NEWS

S/NVQ update

The ASE Project Steering Group has again reported on progress it has made in developing vocational standards for laboratory technicians in educational establishments. In what follows we have done our best to translate the jargon from various papers and minutes. Some of it defies any of our attempts to turn it into plain English.

A second consultative workshop was held at Hatfield in March. This was attended by practitioners who reviewed a draft functional framework and went on to assist in developing a full functional analysis for lab technicians in education. This analysis was then compared with standards and qualifications already developed by the Chemical Industries Association (CIA).

A third consultative workshop is scheduled for early June. This will involve a majority of the participants from the March event. It will concentrate on drafting standards in the area of support for learning and to cross reference these to the CIA and other standards.

Discussions also have begun on a suitable awarding body or bodies as well as on the levels "which the emergent qualification would encompass".

We wish to avoid being overly critical of the Steering Group's efforts to date - especially since we have been prevented by circumstance from assisting greatly in any positive way. Nonetheless we do see significant problems if SVQs for educational technicians are to be based solely on what seems likely to be submitted to the National Council for Vocational Qualifications. Wake up SCOTVEC!?

TRADE AND PRODUCT NEWS

Harris and Unilab

At the end of last year the laboratory equipment manufacturers, Unilab, were bought out by a rival manufacturing company, Philip Harris. There has been no public announcement to this effect. We have been informed that, in so far as customers are concerned, there will be no noticeable difference. Both product ranges will continue to be marketed under their original company logos. Schools will continue to have a choice between products with similar specifications - power supplies, signal generators, and so on. There will continue to be separate catalogues and separate sales teams.

We understand that, from Harris's viewpoint, the total acquisition of Unilab is seen to bring Harris two assets - it gives them a successful range of products for technology education and it gives them a facility for manufacturing high quality products. The factory at Weston super Mare, where hitherto Harris manufactured their own equipment, is to be closed down with production being transferred to Unilab's factory in Blackburn. The biological preparation lab will remain open at Weston. Sales and R and D will all be based at company headquarters at Shenstone. Technical enquiries will also be answered from there. Although Unilab customers should continue to use the Unilab Blackburn telephone number or address, enquiries will be rerouted to Shenstone automatically.

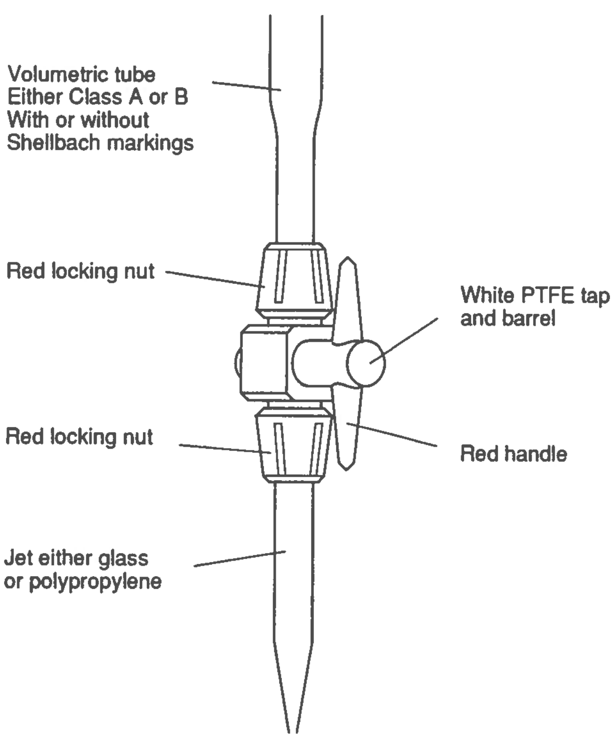


Figure 1. Cowie burette with interchangeable PTFE tap and separate volumetric tube and jet.

PTFE taps in burettes.

Glass taps can cause trouble. If you haven't greased them they may leak or jam. If you have applied slightly too much grease the jet may become blocked a few runs later. What fun it is, poking nichrome wire up jets or holding lit matches to the jet to melt solidified microgobs of grease! However forget these troubles. Substitute burettes with PTFE taps.

But even if you have a good maintenance scheme and suffer from neither of these ills, how many burettes end up as dead ones in the store, some with broken jets and some with the stem snapped above the tap? True, they can be sealed at one end and used as gas burettes with the scale running the wrong way!

The answer is to go one step further at the time of purchase and buy burettes with interchangeable PTFE taps and separate jets and volumetric tubes (Fig. 1). We gave this recommendation more than a decade and a half ago. It remains a good bet both on grounds of ease of use and long term costs.

Burettes from the Cowie Technology Group Ltd. seem to be particularly good value. They are cheaper than the older one piece glass tapped types from other suppliers. Furthermore they have the great advantage that a new jet can be fitted quickly without either the skills of a glass-blower or some bodge with a wee length of rubber tubing. Spare parts surgery is easy. Jets (glass or plastic) cost 30p; replacement graduated tubes are £4. Because of the properties of PTFE, the tap key and barrel are virtually indestructible.

The price of one of these burettes (say Class B, Cat. no. 016.9350) directly from its manufacturer, Cowie Technology Group, is £8.70 with free delivery. This is less than the cost of an old fashioned, troublesome, glass tapped Class B one from other sources (typically around £9 to £10.) Only the rubber pinchvalve model from Fisher at £6.40 is cheaper. Other suppliers sell this same Class B Cowie burette at greatly increased prices : Harris (2 times the Cowie price), Hogg (1.7) and Fisher (1.5). This burette is easily recognised by the white tap and barrel with red locking nuts top and bottom and thin red handles on the tap (Fig. 1). The jet may be either glass or polypropylene. The burette is available as Class A for £9.50. Both Class A and Class B models can have Shellbach markings for an extra 75p. This top of the range version will still be cheaper than the plain glass versions from other suppliers.

Cowie specialise in PTFE laboratory ware. Several other products from them are less expensive than the equivalent from other sources, e.g. stirring bars and spin bars. PTFE stirring glands for Quickfit and other groundglass jointed flasks can be used instead of the mercury filled type.

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.

Newer stock items are underlined, so as to be more easily seen. Of particular interest is our limited stock of condenser lenses, which would ordinarily cost £80 each.

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

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.

Don't send cash with orders

We repeat, please do not send payment with your order. Wait until you receive our advice note upon which payment may be made. This saves unnecessary complications e.g. when items are out of stock, failure to make provision for VAT, or if a delivery charge needs to be made. Items of equivalent value may be deducted from your order to balance any shortfall.

Motors

778 Stepper motor, Philips MB11, been stored in damp conditions but unused and retested. 4 phase, 12 V d.c., 100 mA per coil, 120 Ω coil per phase, step angle 7.5°, with 7 mm x 2 mm dia. output shaft. Dimensions 21 mm x 46 mm dia. on oval mounting plate with 2 fixing holes, diam. 3 mm, pitch 42 mm, at 56 mm centres. Circuit diagram supplied. £2.50

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 tachogenerators with 3 mm shafts. Specially supplied to SSERC by Unilab. £1.25

779 Miniature motor, 13.2 V d.c., smooth running, speed governor, no load current 24 mA at 12 V, dims. 36 mm x 39 mm dia., shaft 10 mm x 2 mm dia. £1.25

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

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

621 Miniature motor, 1.5 V to 3 V d.c., open construction, ideal for demonstration, dimensions 19 x 9 x 18 mm, eight tooth pinion on output shaft. 25p

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

811 Worm and gear for use with miniature motors, 34 : 1 reduction ratio plastic worm and gear wheel. 35p

378 Encoder disk, 15 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

642 Encoder disk, 30 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

772 Encoder disk, 4-bit Gray code, 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

Precision motor stock

785 Precision motor with optical shaft encoder, 0.25 to 24 V d.c., no load current and speed 9 mA and 6,600 r.p.m. at 24 V, stall torque 23 mNm, 9 segments. Overall body length including shaft encoder 59 mm, dia. 23 mm with output shaft 20 x 3 mm dia. Back EMF constant 3.6 V/1000 r.p.m. Suggested application - tachogenerator. Data on shaft encoder section available on application. £15

787 Precision motor with attached gearbox, 0.15 to 12 V d.c. With a supply of 3 V, the no load current is 25 mA and the output shaft turns at ca. 20 r.p.m. Gearbox ratio 1 : 365. Overall body length including gearbox 43.5 mm and diameter 16 mm. Output shaft 6 x 3 mm dia. with flat side to maximum depth of 0.3 mm along outer 5 mm length of shaft. Application - any system where a very slow angular velocity is required. £15

Miscellaneous items

791 Propeller, 3 blade, to fit 2 mm shaft, blade 55 mm long. 45p

792 Propeller kit with 10 hubs and 20 blades for making 2 or 3 bladed propellers. 130 mm diameter. Accepts either 2 mm or 3 mm shafts. £3.40

790 Buzzer, 3 V. 55p

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). 50p

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

313 Thermostat, open construction, adjustable, temperature range +10° to +65°C. Rated at 6 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

753 Submersible pump, 6 V to 12 V d.c., 8 litres/min., 0.6 bar, dry operation protected. £5.50

758 Loudspeaker, 8 Ω, 0.5 W, 66 mm dia. 50p

771 Neodymium magnet, 13.5 mm dia. x 3.5 mm thick. £1.30

814 Ring magnet, 24 mm o.d., 6 mm i.d. 20p

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

782 Toggle switch, panel mounting, 3 Amp rating, SPST, mounting bush 0.468 inch, flattened black 18 mm toggle. 50p

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

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

788 Crocodile clip leads, assorted colours, insulated croc. clip at each end, 360 mm long. £1.35

809 Wire ended lamp, 3 V 10p

741 LES lamp, 6 V. 15p
770 ditto, but 12 V. 15p

789 MES lamp, 3.5 V, 0.3 A 9p
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

808 Electrodes for making lemon or other fruit cells etc. 1 pair, comprising 1 of copper, 1 of zinc, each approx. 60 mm square, per pair 50p

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. £2.70

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

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 blueing, etc. 30p

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

752 Shandon chromatography solvent trough. £1.00

804 Evaporating basin, porcelain, 80 ml capacity. £1.00

805 Condenser lens, bi-convex, 200 mm focal length, 75 mm dia. Crown glass. £12.50

806 Condenser lens, plano-convex, 150 mm focal length, 75 mm dia. Crown glass. £12.50

Components - resistors

329 Potentiometer, wire wound, 33 Ω, lin., 36 mm dia. 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, 390K, 470K, 680K, 1M0, 1M5, 2M2, 4M7, 10M. Per 10. 6p

421 DIL resistor networks, following values available: 62R. 1K0, 6K8, 10K, 20K, 150K. Per 10. 30p

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

Components - capacitors

813 Capacitors, polystyrene: 4p
180 pF, 220 pF, 330 pF, 560 pF, 1000 pF, 2400 pF, 3000 pF, 3300 pF, 3900 pF & 4700 pF

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

696 Capacitors, polycarbonate, 10 nF, 220 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. 1p

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

Components - semiconductors

807 Schools' Chip Set, designed by Edinburgh University, comprises the 4 chips and prototype board. £4.00

Edinburgh University support material :
Volume 1 : Teaching Support Material (+£2 p&p). £4.50
Volume 2 : Laboratory Work (+£2 p&p). £5.00

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

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, $\beta = 4200$ 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

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. £1.40

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. 60p
762 Ditto, green. Per 10. 60p

Items not for posting

All of 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

664 Flat bottom round flask, 500 ml. 50p

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

810 Watch glasses, assorted sizes 20p

Chemicals etc.

712 Smoke pellets. For testing local exhaust ventilation (LEV) - fume cupboards and extractor fans, etc. large, 50p, small 35p

NB : Other chemicals are named here as described on supplier's labels. Please order according to our description. Unless coded "A" substances are not Analar grade. Must be collected.

ammonia sol'n, 27% w:w 2.5 l :	50p
barium sulphate (soil tests), 500 g	50p
calcium sulphate (for soil testing), 500 g	25p
decanoic-n-acid (lauric), 500 ml	25p
Keiselguhr acid, washed, 500 g	25p
magnesite, native lump, 500 g	75p
sodium n-butyrate, 100 g	25p
tetrachloroethylene, 2.5 l	50p
urea, 1 kg	1.00

SSERC, 24 Bernard Terrace, Edinburgh, EH8 9NX;
Tel. 0131 668 4421, Fax. 0131 667 9344.

Aldrich, The Old Brickyard, New Road, Gillingham, Dorset, SP8 4JL; FREE PHONE 0800 71 71 81, FREE FAX 0800 37 85 38.

ASE (UK, HQ), College Lane, Hatfield, Herts., AL10 9AA; Tel. 01707 267411, Fax. 01707 266532.

Bulgin Components plc, Bypass Road, Barking, Essex, IG11 0AZ; FREE PHONE 0800 413 875.

Cowie Technology Group Limited, PTFE Labware Division, Coulby Newham, Middlesbrough, TS8 0TQ; Tel. 01642 599190.

Ealing Scientific, Greycaine Road, Watford, Herts., WD2 4PW; Tel. 01923 242261, Fax. 01923 234220.

Griffin & George Limited, Bishop Meadow Road, Loughborough, Leicestershire, LE11 0RG; Tel. 01509 233344, Fax. 01509 231893.

Philip Harris Education:

2 North Avenue, Clydebank Business Park, Clydebank, Glasgow, G51 2DR; Tel. 0141 952 9538;

Lynn Lane, Shenstone, Lichfield, Staffordshire, WS14 0EE; Tel. 01543 480077, Fax. 01543 480068.

Hogg Laboratory Supplies Limited, Sloane Street, Birmingham, B1 3BW; Tel. 0121 233 1972, Fax. 0121 236 7034.

Institute of Biology (Scottish Branch), Organiser, Mr P S Anderson, Adviser in Science, ASDARC, Woodend Road, Cardenden, Fife, KY5 0NE; Tel. 01592 414676, Fax. 01592 414641.

JJM Electronics, The Hedges, Meft Road, Urquhart, Morayshire, IV30 3LG.

Merck (Scottish agents):
McQuilkin & Co., 21 Polmadie Avenue, Glasgow, G5 0BB; Tel. 0141 429 7777, Fax. 0141 420 1223.

SCCC, Gardyne Road, Broughty Ferry, Dundee, DD5 1NY; Tel. 01382 455053, Fax. 01382 455046.

Sigma Chemical, Fancy Road, Poole, Dorset, BH12 4QH; FREE PHONE 0800 373731, FREE FAX 0800 378785.

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