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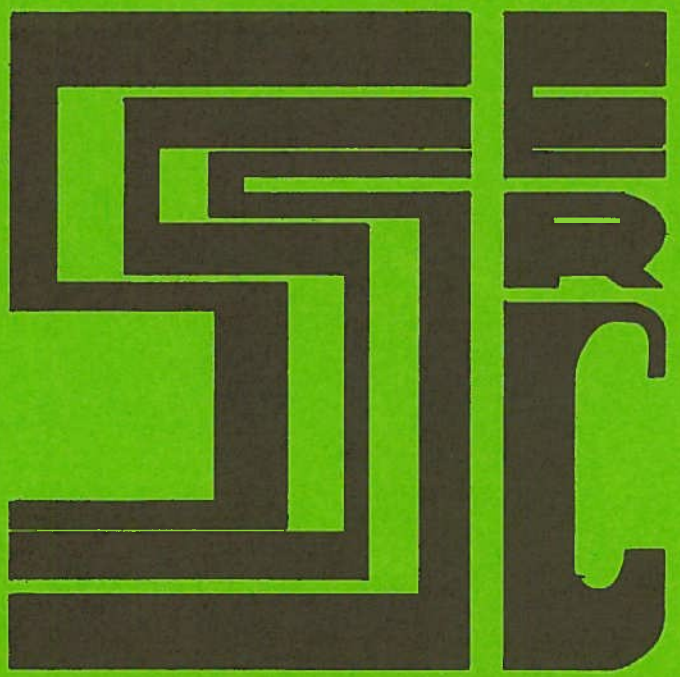
SCOTTISH SCHOOLS SCIENCE EQUIPMENT RESEARCH CENTRE



Bulletin No. 157

May 1987

ergy Conversions

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* * *

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EDITORIAL

Learning Outcomes

"A paradox, a paradox,
a veritable paradox!"

Gilbert and Sullivan.

"Bulletin" articles are occasionally, deliberately controversial. I admit that the temptation to ascertain whether anyone reads these pages can become irresistible. One way to find out is to say something heartfelt if unconventional. It also livens things up if we stray into areas which in establishment terms are "none of your concern".

However, the "Opinion" article in Bulletin 156 seems to have caused a disproportionate stooshie. It is rumoured that several folk were in my hot pursuit at the ASE Annual Meeting in Culloden. They were disappointed. I had not taken to the field, whereupon my sassenach blood could so fittingly have been spilled. No, this was not cowardice. It was merely that SSSERC business had kept me in Edinburgh.

The irony is that, despite a reputation as a bit of a heidbanger, I did not write that particular piece. Obviously, as Director and editor I take the responsibility for its publication. I thought it well written and that it made a valuable, if unfashionable, point (of which more later). It was drafted by one member of the Centre staff encouraged by that ubiquitous, modern, political phenomenon - a gang of four.

We have had letters, much verbal comment and even a little abuse. Interestingly not everyone was outraged by the piece. Some were actively encouraged and in turn encouraging. "Keep that going" was one typical positive response.

I am intrigued, but not surprised, by these divisions. They throw into relief, and thus highlight, the paradox more subtly identified in the original article. As one correspondent pointed ɔut the article apparently had elements which made t self-destruct:

"Dear Sir,

In Bulletin 156, "Opinion" is amusing but contradictory. If, as you agree in the text, the learning outcome is a logical necessity then the rest of your argument falls. Pupils and teachers do need to know, as they demand with each new syllabus, the "depth of treatment". If this is not supplied by learning outcomes or something similar, it has to be derived from the first five years exams. This is much more difficult and may incur some pupil casualties on the way.

I have over many years experienced the sadness, not to say despair, of pupils and teachers when examiners venture beyond the previously accepted boundaries of a course. The feeling that "no matter what you teach, they will ask for something else" is a very frustrating one for a teacher who may try to compensate for a moving target by a scheme of work which grows by a process of continual creation after each years papers.

To be subjected to vague, salacious, indulgent and wanton syllabus specifications is not fair if you are on the receiving end and does a disservice to education."

In the use of that last word "education" lie both nub and rub. The original "Opinion" complained of learning outcomes that "they trivialise our prime function, which is to educate". Its agreement that "The learning outcome is a logical necessity.", was also qualified thus - "If we have a public examination of candidates from all parts of the country,....". It is important to avoid the trap of simply equating schooling and exams with education.

Syllabuses without particulate and trivial learning outcomes may be educationally sound if you see as matters of critical and overriding import the retention of interest, the excitement in things scientific and the encouragement of creative and imaginative activities. After all, if pupils desert school science because they see it as dull and sterile then the whole game is up. God forbid that we ever get around to producing only dull and imaginatively sterile scientists.

We should not allow crude necessities of assessment to force us into producing pupils who know a great deal of the what of science and technology but precious little of the more complex elements of the how. It is easier to formulate discrete and assessable learning outcomes for the 'what'. However, I never saw it my duty as a teacher to make life easier for any examiner. I regarded it as my primary, professional responsibility to teach and theirs to assess what was taught.

I question any system which requires that we teach only that which is assessed. That way lies the chants and boos of students in some countries where they protest vociferously, even on occasion violently, if the teacher strays one syllable off the syllabus.

Arguments over proper roles for assessment are not new. However it would seem that they are always ducked, never settled. If we can't solve the problem of national, external assessment perhaps it is time we changed the problem.

Contrast the letter of mild complaint, quoted in full above, and the following from another correspondent, a trainer of teachers of science in general and of physics in particular:

"Dear Sir,

I have just finished reading "Opinion - on learning outcomes", Bulletin 156. I enclose two copies of the 'Physics Preamble' prepared for a recent C.N.A.A. Committee visit. The first was a draft and the part beginning "It is fashionable..." was considered unfashionable for presentation to the C.N.A.A. Perhaps you will be as pleased as I was to discover another voice crying in the wilderness.

P.S. The first draft was sent back by an internal (college) committee."

I need hardly add that the second, acceptable, draft had the usual "Aims" and "Objectives" conferring repectability and in my opinion is not worth quoting. The first, totally expunged, draft version ran as follows:

"It is fashionable to carry out a meticulous analysis of separate objectives and outcomes of teaching and learning so that they can be assessed in tests. Taxonomies of educational objectives grew in the work of Bloom and others in the United States twenty years ago. This exercise was a valuable revolt against careless, vague planning and testing. But it concentrates attention on aspects that are clearly measurable and there is danger of missing some of the important factors in our hopes for lasting benefits from our courses - those motivational and attudinal factors which we recognise in the term "professionalism".

Also expunged was most of an excellent series of common-sense, general aims for the course. All were amenable to simple, informal assessment by the exercise of professional judgement. All had been written in plain, jargon-free English. All but one had got thrown out.

Ah, well - c'est la educational b....y vie!

* * * * *

I N T R O D U C T I O N

One short of a full load

We are, sometimes and in some circles, so idiomatically labelled. Here though, the context is that of the number of Bulletins during the 1986-87 session. We were aiming for our usual six issues and that would have meant publishing two this term.

Since January it has certainly felt like we were on that road which such good intentions are said to pave. One or two staff think we have already reached its end! The major reason for our heavy workload is activity to provide technical resource support for the separate science courses at Standard Grade. We are doing development work, attempting to draft experimental guides for use by teachers and technicians and preparing equipment lists to accompany those guides. Something had to go and that something was one issue of the "Bulletin".

So, Scottish readers and hopefully subscribers furth of Scotland we will, eventually, make it up to you.

We will announce it when the first of the guides is ready. That could be some considerable time yet. Please, in the interim no individual enquiries on that particular matter - you may postpone the dawn.

Energy conversions

This is the major theme throughout the more technical bits of this bulletin. We have examples from biology, chemistry and physics. They largely result from our recent development work in support of the new Standard Grade courses. Some have technological, design and quantitative aspects in addition to merely illustrating scientific principles. Some are also good fun. After the last two years we could all do with a laugh. Because they are fun, practical jokes you might say, they might be banned in some schools.

Saturday morning closure

As usual, over the school Summer holiday period we will be suspending Saturday morning openings. The last occasion on which we will open this school session will be the 13th of June having also been open on the morning of Saturday the 6th. We will open again on Saturday the 5th of September and again on the 12th and on the first two Saturdays of the month thereafter until further notice.

The Centre will be open weekdays 9 a.m. to 5 p.m. right through the Summer. Staff will be taking leave on rota. If you wish to see a particular specialist, a preliminary telephone call to the Centre is advised.

Comment

It was way ten issues back, in Bulletin 147, that we aired the joke on the unit the millihelen. It was then also that we asked for units derived from the clytemnestra. We had no response to that but we did get, in time for Bulletin 148, an offering of a unit of conceit derived from Millikan. We have now been chastised for misleading our readership, apparently having given an incorrect definition of the 'kan'.

Bill Gould of Boroughmuir High called at the Centre not so long ago and left a note for my attention. It read:

"It is twenty-five years since I first heard the millihelen joke. I thought it had gone down with the ship. A kan is in fact a container for holding one thousand drops of oil. There is no actual price but they can be had for a small, discrete charge. This is liable to double or treble, so buy now".

No Comment

"Science Education"

"After over a century of techology, science and engineering still possess a disreputable image, and it is costing this country dear. Furthermore, it is possible that it is already too late to do anything about it.

There is a profound, but seldom defined feeling in this country that engineering, together with any occupation concerned with selling, comes slightly below house-breaking as a career that one might recommend to a high-flying school-leaver.

Further, although teaching is (or was) considerably more respectable as a profession than any kind of engineering, a teacher forced to confess to being of the scientific persuasion immediately loses several points in the upwardly mobile section of society. Even if this is unimportant to a dedicated imparter of knowledge, what is important is that the equipment needed to teach science or engineering properly is in extremely short supply. Books are scarce, money (both for supplies and salaries) is short and, if it were not for the shower of computers recently and inexplicably rained on astonished teachers, the feeling of being in the wrong century must be overpowering".

[From an editorial in the May 1987 issue of "Electronics & Wireless World"].

* * * * *

RESOURCE NEWS

'shooting your Beeb

We all feel like it occasionally but the shooting referred to here is kindly rather than malevolent. The Open Tech Unit of the Microelectronics Educational Development Centre (MEDC), at Paisley College of Technology, has recently published a guide to mending bent BBC microcomputers. The book is based on the experience and investigations of a team of technicians at MEDC. It is entitled:

"Troubleshooting the BBC Micro Model A & Model B".

The price is £10.00 but, with most commercial repair centres charging upwards of £25 per hour plus parts, you could recoup the cost of a copy on a single repair. Further details and copies of the book are available from Mr.L.Benyon at the MEDC address given on the inside cover of this bulletin.

Schools Affiliation Scheme

In recent years a number of scientific societies and institutes have announced special publications deals for schools. The latest to announce such a scheme is the Institute of Biology. It costs £35 per school to join. For that the school will receive five mailings each year containing Institute publications including a new newsletter specially written for participating schools - "Offshoots". There will be other material on careers in biology and opportunities to obtain other publications at a discount. Further details from the Institute at the address on the inside cover of this bulletin.

Salters' Institute Awards

The Salters' Institute is again offering awards to support the development of innovations designed to improve any aspect of chemistry teaching of pupils in the age range 11-18. Applications, each for up to £750, from individuals or groups should be made to the Clerk of the Salters' Institute not later than 16th October 1987.

SAFETY NOTES

AIDS: Addenda

Cell samples

In Bulletin 156 [1] we gave notice of the availability of an advisory booklet published by the Scottish Office [2]. This was entitled:

"AIDS: Guidance for Educational Establishments in Scotland"

Since publication of Bulletin 156 the Laboratory Safeguards Committee of the Association for Science Education (ASE) published its own note in "Education in Science" [3]. This drew attention to a second advisory document [4], issued primarily by the Department of Education and Science (DES) but published also in the names of, and endorsed by, all three other Central Government Offices with responsibility for education - the Welsh Office Education Department, the Scottish Education Department and the Department of Education Northern Ireland. This second Government publication is entitled:

"AIDS: Some Questions and Answers - Facts for Teachers, Lecturers and Youth Workers".

In that publication the advice pertaining to school science goes further in restricting the range of practical activities which use material of human origin. In addition to advising against the taking of blood samples it states that the taking of other cell samples should also be discontinued. The relevant section of "AIDS: Some Questions and Answers..." is on page 7 where there is the following question and answer combination:

> "Is blood sampling in class safe?"
>
> **"NO.** Taking blood and cell samples for science demonstrations could carry a risk: therefore **this practice should be** discontinued."
>
> (Emphases in the quote are as in the original).

As far as we aware, this quoted portion is the basis for the advice given to ASE members in the April edition of "Education in Science" (EiS). It should be noted that EiS has fleshed out the original somewhat in specifying "cheek cell scrapes". However there is little doubt that this is the activity to which the advice from Government, recommending proscription, relates.

Nowhere within the booklet issued solely by the Scottish Office was anything said about the taking of cheek epithelial cells or any other human cells. Our advice in Bulletin 156 had been framed accordingly. When we published that article we had not been forewarned as to the additional inclusion of cell sampling in the later, joint document. We apologise to readers for any confusion which may have resulted.

Given that the Secretary of State for Scotland has endorsed the joint publication, Scottish schools should heed the advice therein and discontinue the taking of human cheek cells for microscopic examination.

Disposable toothbrushes

In our article on AIDS in Bulletin 156 [1] we mentioned the possible use of disposable toothbrushes. This was not because of any significant risk of infection from saliva but because gum diseases, such as gingivitis, which render gums prone to bleeding are not all that uncommon in children.

We neglected in that article to give any source of supply for such brushes. This is the type of item sold by Chemist's wholesalers. For example in our locale, the Edinburgh area, we found that we could purchase a minimum quantity pack of 48 disposable toothbrushes for £2-40. That's 5p each including the tothpaste. Our source was Scotus Wholesale Supplies. If you do not wish to send an order to Edinburgh, your local Yellow Pages may provide the answer.

HSE Publications

Recently we obtained two HSE publications which should be of direct interest to science advisers and safety officers and may prove useful to teachers as background material:

"Health and Safety Policy Statement" [5] is a combined set of notes and pro-forma style booklet. It is set out rather like a household insurance policy but with many blank spaces. These are to be filled in once the accompanying notes have been read. It was designed for use by smaller firms in manufacturing and office work. We agree with HSE though that it is readily adaptable to "fit other kinds of work and also to suit your particular circumstances".

We know that Scottish EAs have framed and published both general and specific Health and Safety policy statements. The scale of this document is different. It would be useful in assisting individual Principal Teachers or Department Heads to think through and review the safety arrangements they have made and to document them clearly and concisely. We know also that some school and FE science courses now include units or topics on Health and Safety.

This document could provide useful background and study material for such courses. £2 per copy from any HMSO bookshop.

In recent years we have fielded a number of enquiries on suitable first aid arrangements. "First aid at work" [6] an HSE HS Series booklet provides much useful material on this subject. This was originally published as guidance to the Health and Safety (First Aid) Regulations 1981 but the last reprint was in 1985. A lot of the booklet is only really relevant to large, often industrial, undertakings. However, there is much other material and advice aimed at smaller workplaces and of direct interest to educational establishments. The booklet is available from any HMSO bookshop at £3-80 per copy.

'National Grid Experiments'

We are informed that the HSE in Scotland has recently sent a circular to Scottish EAs with warnings and conditions relating to such demonstrations. These usually involve the use of step-up and step-down transformers in a model of a transmission line. There are number of published descriptions of such demonstrations where either or both designs and suggested precautions are less than adequate.

We have been aware of the problem for some time and have been carrying out development work. We hope soon to publish a design which will operate well within the voltage limits advised by HSE. We already have in operation a prototype. Our aim is to produce a design safe even for pupil use rather than only for demonstration by a teacher.

* * * * *

References

1. Safety Notes: AIDS and school science", SSSERC Bulletin 156, March 1987.

2. "AIDS: Guidance for Educational Establishments in Scotland", Scottish Office; HMSO, 1987.

3. "Blood Sampling and AIDS" in "From the Laboratory Safeguards Committee", Education in Science, No.122, April 1987.

4. "AIDS:Some Questions and Answers - Facts for Teachers, Lecturers and Youth Workers", DES,WOED,SED and DENI, HMSO, 1987.

5. "Writing your Health and Safety Policy Statement - How to prepare a safety policy statement for a small business", HSE, HMSO, 1986 ISBN 0 11 883882 2.

6. "First aid at work", HSE Health & safety series booklet HS(R) 11, HSE, HMSO, 3rd reprint 1985, ISBN 0 11 883446 0.

Zany energy conversions

Abstract

An energy conversion series, unusual in a biological context is described, viz.: chemical energy - light - electricity - kinetic energy. A major aim is to enliven Topic 2 of the proposed Standard Grade Biology Syllabus "The World of Plants".

'Start' Motor

The "Start" is the keep-fit fanatics' favourite breakfast cereal. The activity is a bit of fun to be indulged in after pupils have the done the bits about starch being formed in photosynthesis and how light energy has been converted into and stored as chemical energy. The question is, can we get light energy back out again and can it be converted further? Can it be used to do work? Just as important from the teacher's standpoint, can we avoid having to do again the custard powder explosion; which they will all remember anyway from S1/S2?

A piece of the 'Start' cereal is placed in a watch glass or Petri dish and tested for starch in the usual manner with iodine in potassium iodide solution. A convincing positive, blue-black coloration results. This stuff obviously has a high starch content. Can we get light back out of it? Well we can burn it and obtain a flame. A flame is merely a body of gas so hot it emits light. In addition to starch the Start has a sugary coat and ignites easily. A whole piece is stabbed with a mounted needle, being very careful not to stab also the fingers. A Bunsen flame is then used to ignite the cereal. As soon as it is burning well it is placed carefully between a curved, plastic mirror and a solar cell mounted as shown in figure 1.

The voltage developed across the solar cell can be displayed on a meter. (See Fig. 2.). More convincing is the cell driving a low current motor. A suitable type is a Portescap precision motor available from SSSERC and stocked as Item 373 at £4-50.

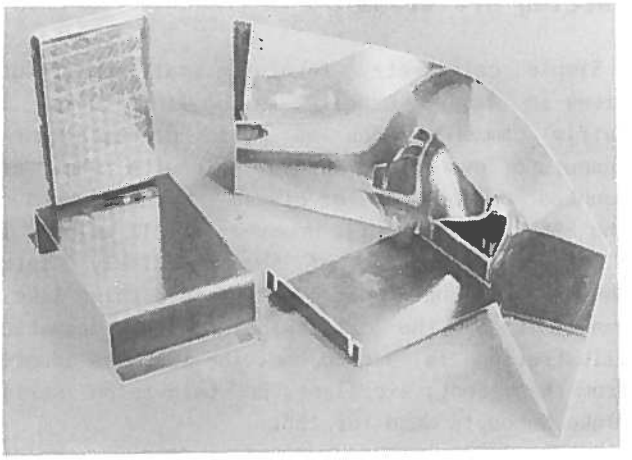

Fig.1

The energy from the burning cereal will not drive any appreciable load, but the motor should be seen to turn. (Contrast this with the higher energy output from an oily or fatty food such as a peanut, [see "Peanut power" below]).

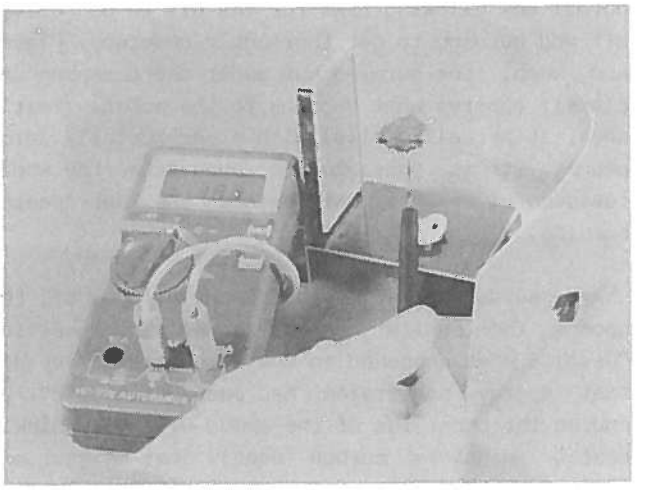

Fig.2

Other breakfast cereals such as Sugar Puffs and Honey Smacks will also give positive starch tests. However they do not yield as good a flame as Start. You will get a reading on the meter attached to the solar cell with Puffs and Smacks but you will be lucky to see the motor turn.

Peanut power

Letting off steam

Simple calorimetry involving small temperature rises in water, usually in boiling. tubes, is fairly commonly done as pupil practical work. Peanuts or oven-dried bread, biscuits etc. are mounted on needles or placed in wire baskets of the SSSERC pattern [1]. However, if all we need is a simple experience of the relatively large amounts of energy stored within a thing like a peanut then the following, more dramatic, illustration is a good one. The idea was adapted from the recent, excellent, BBC television series "Take Nobody's Word for It".

First, crudely insulate the end of the handle of a teaspoon. One simple way to do this is to cut a slit in a cork and push the spoon handle into it. A little tap water is then placed in the spoon. By all means, if you wish to be more quantitative, use a measured quantity of water (our teaspoons have a capacity of about 2.5 cm). Mount a peanut on a needle and ignite in a Bunsen flame in the normal way allowing time for the oil to be driven off and burning to get thoroughly underway. Place, and keep, the burning nut under the teaspoon and closely observe what happens to the water. Fairly soon, it actually boils! With a particularly large peanut it is possible to evaporate the whole teaspoonful of water well before the nut ceases burning.

Afterwards, inspect the undersurface of the spoon. The pupils can be posed the question "Despite what happened to the water, would you say that energy conversion had been efficient?". Of course the underside of the spoon will be thickly coated in unburnt carbon (soot). That is just one reason why teaspoons are better than small boiling tubes for this exercise - metal spoons are easier to clean.

The teaspoon as a mini-kettle illustration could, of course, lead in to more conventional calorimetry. Pupils could be asked to design and carry out a more rigorous, quantitative investigation on energy content of foodstuffs. The culmination might be a demonstration with a pukka food and fuel calorimeter if the school possesses such a device.

As a shorter alternative to such an investigative follow up, the more numerate of pupils could be supplied with the basic data and asked to estimate how much energy a peanut yields in boiling off a teaspoon of water. Remembering to allow for the latent heat of evaporation of water I make it ca. 6.5 kJ - and note that combustion is neither efficient or complete. As the BBC team on "Take Nobody's Word for It" suggested, it is instructive to make a further guesstimate. Suppose that amount of energy were used at 100% efficiency to do work: How far off the ground could a typical adult elephant be lifted?

Hoist on its own petard

You will recall that the cereal could start (sorry!) a motor turning, but only just. Now, a given mass of an oily or fatty food should yield about two-and-a-half times as much energy as the same mass of carbohydrate. Can we use light energy from a peanut to drive a motor which will lift another peanut? Indeed, we can, if we use a low-current, precision motor with a 6.3:1 gearbox (SSSERC Item 417, £5) and pulley as shown in figure 3.

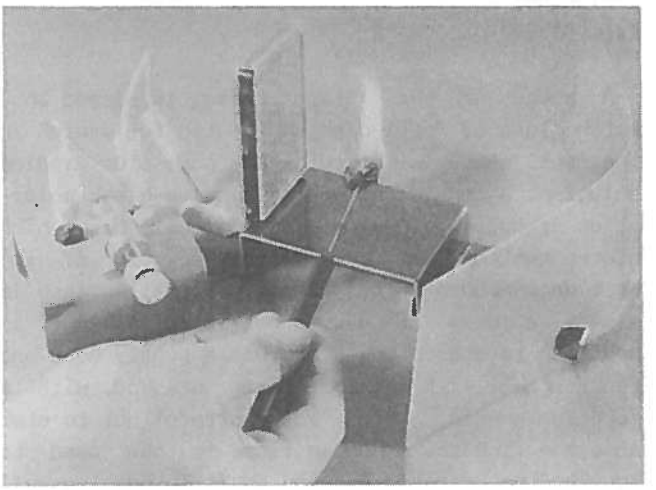

Fig.3

A peanut is carefully threaded on light cotton or nylon thread. The thread is then fixed to and wrapped around the pulley. (It will pay to first use a lamp to illuminate the cell to establish the direction of rotation of the pulley). Affix a second peanut, of similar size to the load peanut, to a mounted needle.

Ignite the needle mounted peanut and carefully position it between the curved plastic mirror and the solar cell. Stand back in amazement!

Technical odds and ends

The solar cell shown in the photographs is an inexpensive type, a G400 module Order Code 440-400 ca. £1-50 each from JPR Electronics.

We usually mount such components on sections cut from plastic drainpipe, in the now almost traditional manner. However because of the heat involved in this application, we substituted 2 mm thick metal sheeting for plastic. The metal was bent up on a simple sheet bender to make a bridge shaped mount. The legs or uprights were about 25 mm to give clearance for the output terminals. These were standard 4 mm sockets.

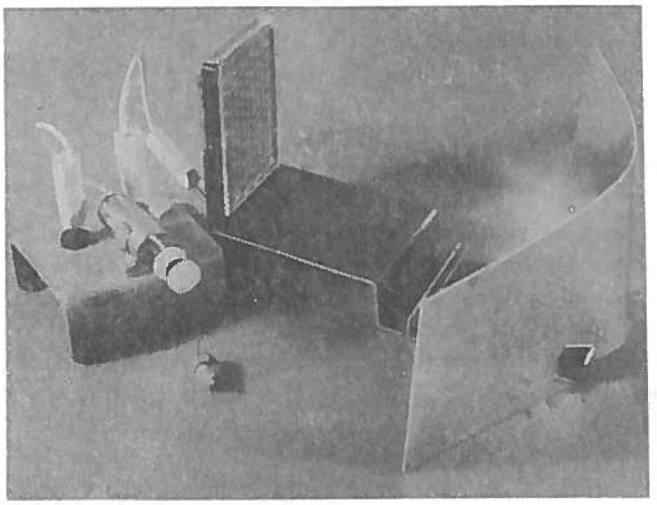

Fig.4

Because of the heat generated by the source in this particular application, we added token further protection to the solar cell capsule. This was just a single methacrylate sheet (e.g. 'Perspex') preventing direct contact of the flame with the face of the cell.

For the peanut lift, the pulley was about 12 mm from front to back with an external diameter of ca.12 mm (½" if you like) grooved with an inner flat about 1 mm deep. We turned ours from nylon rod but other plastic materials or even wood would do. It must however, be lightweight. The inner face has to be drilled to take the drive from the gearbox.

References

1. "Biology Notes", SSSERC Bulletin No.63, May 1973.

and for further applications of low current motors see "Chemistry Notes" and "Physics Notes" in this Bulletin issue. The article in Physics Notes also provides some clues to the solution of the elephant problem set above. For another illustration see the "Chemistry Notes" for a relationship between oil-derived fuels, mountains and a bag of Maris Pipers.

* * * * *

On fruit and fuel (light, luminescence and lemons)

Abstract

Energy as a permeating theme of chemistry is briefly discussed. Three specific, and somewhat unusual, practical illustrations of energy conversions are described.

Introduction

As in the "Biology Notes" the aim here is to suggest some activities which may help to enliven parts of the proposed new Standard Grade syllabus. Again some are old favourites in new clothes but none the less interesting for that.

Energy as a chemical theme

There can be few chemical reactions which occur without significant changes in energy forms. Most often given out or taken in is heat, but sometimes light, sound or electrical energy may be involved. If there are gaseous products in large volume there may be work done in causing expansion against atmospheric pressure.

Shifts in forms of energy associated with chemical changes are often large relative to those accompanying physical transitions. They are thus often more readily detected. For example, the heat of combustion of octane is approximately 5.5 MJ mol^{-1}. Compare that with the mere 0.04 MJ needed to evaporate one mole of the same substance.

Chemical slaves

It is these relatively large releases of energy, on burning readily available chemical substances and mixtures, which provide mankind with so many fuels or chemical slaves. Consider these performance figures for just one typical oil-derived slave:

> The complete and efficient combustion of 1 mole of octane, that is 114 g or 167 cm^3, will theoretically release enough energy to vertically lift a 25 kg bag of tatties to a height in excess of 20 km - over twice the height of Everest. (This is an underestimate. Our crude calculation neglects the decrease in 'g' as the tatties climb!).

That heat changes occur during any chemical reaction is not at all surprising. Some bonds have to be made, others broken. From the thermodynamicist's point of view a reaction will only 'go' if it involves a decrease in 'free' energy (ΔG). Unless the accompanying entropy change is large, or the reaction takes place at high temperature, most of the free energy is available as a heat change.

$$\Delta G = \Delta H - T\Delta S$$

Chemical products as servants

Just as readily available and, for now, abundant chemicals are used in one particular chemical reaction to release energy meeting man's needs, so an input of energy may often bring about a reaction in which a new and useful material is made.

So, energy is one major permeating theme of chemistry. In the proposed Standard Grade course it is particularly focussed upon in a number of the Syllabus Topics.

Indicator of chemical change

In Topic 1 of the draft syllabus the main purpose of the suggested practical work is provision of a wide experience of a range of chemical reaction types. These the pupils may examine and experience as part of an exciting and stimulating circus of activities and, we hope, increase their ability to recognise chemical change. Experienced chemistry teachers will have their own favourites for inclusion in such a circus. For the experimental guide which we are drafting we have suggested many of these good, old spectaculars. Here we highlight just three which perhaps deserve to be more widely known.

Chemiluminescence

There are many suitably dramatic examples of the release of heat and light during a chemical reaction. There are one two good ones involving absorption of light. Relatively rarer, but pleasing aesthetically, are reactions which involve the release of 'cold' light. Mixing 10 to 20 cm^3 of slightly alkaline solution of luminol (3-amino-phthalhydrazide) with about 2 cm^3 of a suitable hydrogen peroxide solution will give a marked blue glow which will last for several minutes.

Make up the luminol by dissolving 0.02 g in a little 5%, w:v, aqueous sodium hydroxide solution and dilute to 200 cm^3 with deionised or distilled water. The 2 cm^3 of hydrogen peroxide should be about a 3% aqueous solution to which 0.05 g of potassium hexacyanoferrate (III) has been added.

Observing the light from this mixture is best done in a darkened room after allowing some minutes for the eyes to become dark adjusted and the pupils widened. Alternatively the reaction can be carried out using a daylight viewing device. This need be no more than a box with an observation slit in one side. The use of odd shaped vessels and curly tubes adds to the fun and interest (see Fig. 1). The most fascinating part has to be the almost total lack of any heat change. It is also possible to set up this luminol reaction as a chemical clock with ascorbic acid as the delay monitor [1]. Beakers of reagents can be set up to switch themselves on, as it were, at pre-determined intervals.

'Luminol' is available as catalogue item 12, 307-2 from the Aldrich Chemical Co at £8-70 for 5 g.

The only light source for the photograph shown as figure 1 was the luminol reaction itself. The film was Ilford HP5 and the exposure conditions f2.8 for 5 minutes. Such a long exposure is not strictly necessary useful negatives being obtained at any exposure between 2 and 5 minutes. The print was made on Kodabrome II, F5, RC paper, type 2450.

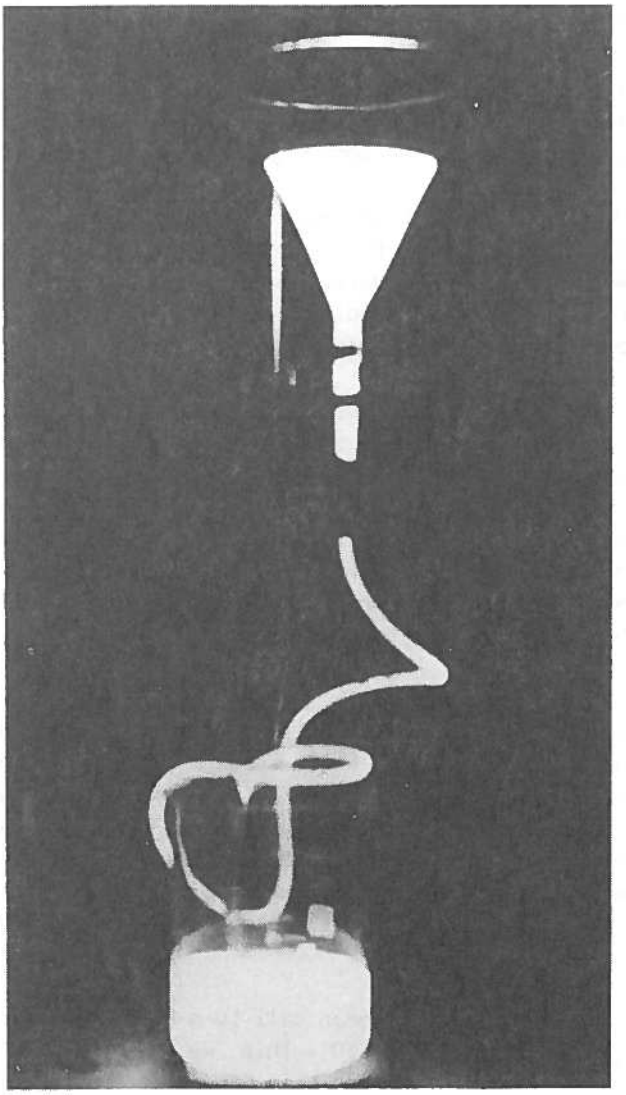

Fig.1

Autophotography with the luminol reaction.

Lemon 'juice'

There are many demonstrations possible of energy changes in reactions between metals and metal salts in solution and in cells. For example, the reaction between zinc and copper sulphate in aqueous solution can be carried out in a small plastic beaker or bottle and the large heat output measured. The same reaction can be arranged as an electrical cell and the electrical output displayed on a meter, used to light a bulb or drive a motor.

Great fun and of interest to pupil and adult alike is an old idea - that of the lemon cell. Plate electrodes of foil or sheet, one of zinc the other of copper, are inserted into slits cut into a lemon. This fruit cell will develop across it a voltage of 0.9 V but gives only a very small current. Connecting such cells in series therefore gives 1.8, 2.7 V etc. Since the inception of the EEC the standard Euro-lemon has been available. This is a perfect fit between the pillars of a Worcester circuit board, and very good news for those many schools who can no longer afford U2 dry cells. You do Ohm's law with lemons.

The key to one very interesting station in a circus of experiments is a low current motor, of the same type as that noted in the peanut power item in the "Biology Notes" of this issue. If you know what you are about, such a motor can be driven from a lemon cell. This is a great improvement on the old demonstration where one usually had to be content with a reading on a meter.

The other secret of success is to have electrodes with as large a surface area as possible. This is best accomplished by making slits in the long axis of the lemon. The two incisions should be placed so as to get the metal electrodes as close together as possible without actually touching. It is possible then for a single lemon cell to yield about 1.5 mA at 900 mV.

We connected our lemon cell to a Portescap motor (SSSERC Item 373, £4-50). This we mounted in a model helicopter as shown in Figure 2. The cockpit and main body were made from polystyrene - a Grifzote sphere. The rotor was a light wooden splint or taper and the rear body and tail of plywood. The splint for the blades was pierced centrally and the resulting hole push-fitted onto the motor spindle with a wee bit of blu-tak added for safety. Our helicopter 'flew' for over a week on one lemon.

During that time we made two interesting observations about lemon power: One was that if the lemon is given a few squeezes the motor accelerates greatly (a piezoelectric effect?). The second was made at the end of the April heatwave when the lemon had dried out. The motor had stopped but throwing a cupful of water over the lemon restored it to its former vigour.

It proved possible to repeat this resuscitation. Have we stumbled on yet another fundamental difference between plants and animals, as specifically exemplified by lemons and dogs?

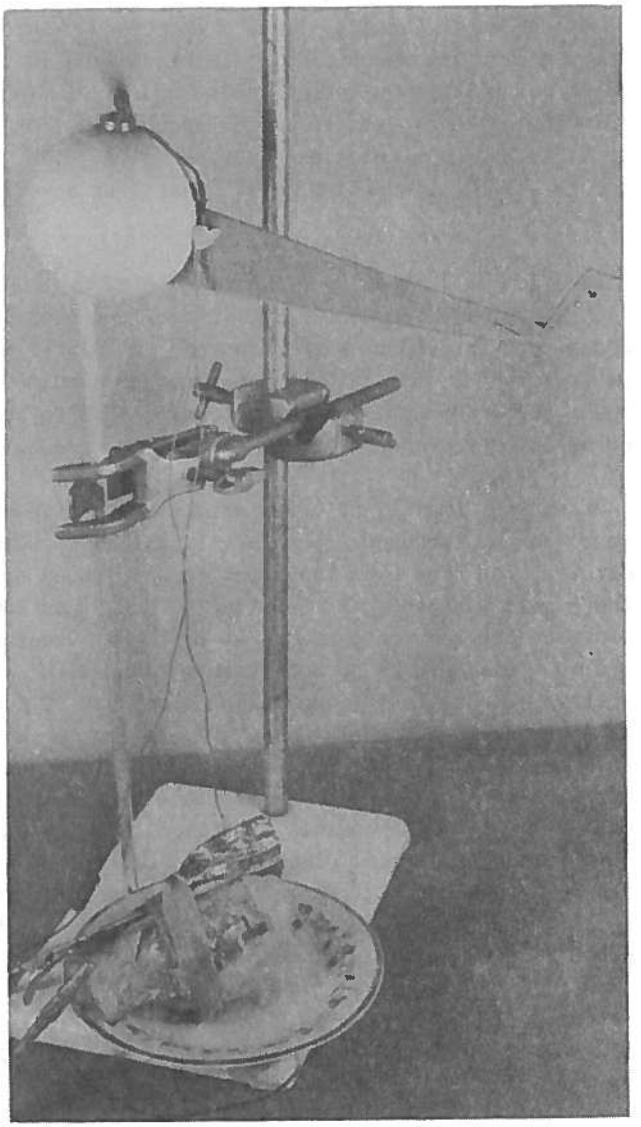

Fig.2

Lemon powered helicopter.

Since we started this fruit and nut power business we have also been receiving reliable reports of grapefruit power, and even of potatoes, driving radios. The typical grapefruit, being larger than the average lemon, can accommodate metal plates of greater area and thus give more 'juice' (groan!).

Fuels and a fuel cell

In our work for Topic 5 "Fuels", we have suggested including many of the standard energy conversion activities such as:

spirit lamp - steam engine - turbine - light bulb

This brings things full circle and provides the opportunity to remind pupils that the energy from burning chemical fuels originated with light energy. One other type of chemical fuel particularly worthy of mention is that of the fuel cell. Unlike any fossil fuel, this is a potential adjunct to renewable sources of energy (see also Topic 16 and below).

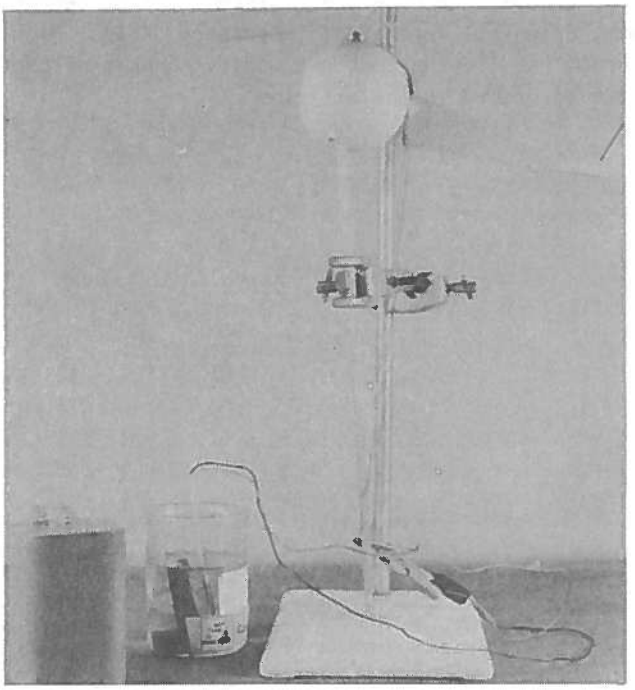

Fig.3
Fuel cell powered helicopter

A pupil voltameter of the type described in Bulletin 156 [2], is constructed but with carbon, rather than lead, electrodes. Either molar sodium hydroxide or sulphuric acid is used as the electrolyte. A current is applied from a laboratory LT supply or a 6 V dry cell or battery. The fuel cell assembly is allowed to electrolyse for a few seconds to saturate the porous, carbon cathode and anode with hydrogen and oxygen respectively.

When the current is switched off the arrangement is then, essentially, a fuel cell. In this fuel cell the hydrogen will be oxidised to water with most of the energy being released directly as electricity [3].

A five second period of electrolysis will generate enough hydrogen and oxygen to then run the system as a fuel cell for three to four minutes. It proved possible to use a model water wheel (see "Physics Notes" in this issue) to provide the electrical input for the electrolysis phase. The output from the system as a fuel cell was then used to drive a low current motor of the type used in our model helicopter (see Fig. 3).

Energy in other Topics

In Topic 7 "Properties of Substances" and in Topic 13 "Using Electricity": the point can be made that here electrical energy is being used in the manufacture of useful products from raw materials, e.g. of metals from ores. This mirrors the energy changes encountered in Topic 10 "Making Electricity".

Topic 15 "Fertilisers" and Topic 16 "Carbohydrates" also provide an interesting contrast in energy terms. The energy input for the manufacture of artificial fertilisers can be contrasted with the output in the form of food or biomass from photosynthesis in crop plants (see "Peanut power", in "Biology Notes"). Fossil fuels in turn can be viewed as stored-up biomass formed over a much longer timescale.

In either Topic 5 or Topic 16 illustrative experiments on biomass as an energy source may be done. The fermentation of sugars with the small scale distillation of the product will illustrate 'gasohol' production. This has the twin virtues of being a renewable source, the first production stage of which returns oxygen to the atmosphere and removes carbon dioxide.

In several places there are obvious links and some overlap particularly with Topics 2 and 7 of the Standard Grade Biology syllabus ("The World of Plants" and "Biotechnology" respectively).

References

1. Journal of Chemical Education, **64**, No.1, January 1987.

2. "Chemistry Notes", SSSERC "Bulletin" 156, March 1987.

3. 'Nuffield' Chemistry, "The Sample Scheme - Stages I & II: The Basic Course, Longmans/Penguin, 1966.

Background reading

A number of other, useful articles on chemiluminescence have been published in the "School Science Review" see numbers:

188, March 1973; 199, Dec.1975 and 242, Sept.1986.

A book generally useful for ideas on, and details of, interesting demonstrations is "The Magic of Chemistry", B. Iddons, ISBN 0 950043966. This is available from BDH Ltd. at £4-50 inc. p.& p.

Acknowledgment

We acknowledge here the assistance of Mr George Amos, Principal Teacher of Chemistry Kelso High School, in trying out and modifying some of the items described in the article.

* * * * *

Hydro power

Abstract

Two designs of model overshot water wheels are outlined. Two applications, one in generating electricity, the other in driving a pump, are described. A calculation of the efficiency in the first application is provided.

Introduction

It was in response to the needs of Standard Grade Science and then to an enquiry from an environmental studies adviser that we first experimented with water powered models. Now we find another, more quantitative context within Topic 6 of the Standard Grade Physics course.

Wheels and turbines

Large overshot wheels are again being manufactured in Britain. Nowadays they are moulded in grp (glass reinforced plastic) rather than fabricated in wood and iron. They remain, though, best suited to exploiting sources of water power with large flow but a small head. Their mode of operation, with buckets filling then falling under gravity, makes for relatively low primary speeds ideally suited for slowly driving large loads.

This mode of operation also makes them a very useful vehicle for teaching elementary physics. Unlike the treatment needed for many other energy conversions, the maths can be kept simple. The complications of kinetic energy are avoided. Efficiency calculations are relatively straightforward even for 'O' Grade and Standard Grade.

Pelton wheels and crossflow turbines, which exploit lower volume flows but from bigger heads, are better suited to electricity generation than traditional water wheels. When well designed they are superbly efficient. They are less good vehicles for teaching elementary physics. Sadly, the physics and the maths of them are somewhat beyond Standard Grade.

Apparatus

The apparatus comprises a header tank with flume, an overshot wheel, and a generator with electrical load (Fig.1). Water is fed from a tap by hosepipe into the header tank, spills over down the flume and falls on the wheel, which drives the generator. The water then drains away.

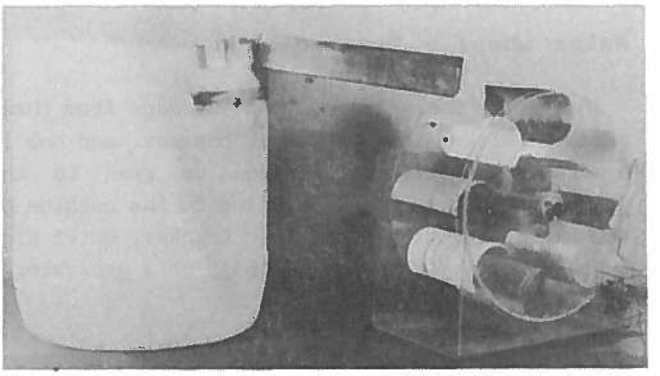

Fig.1

Header tank, flume and water wheel

The apparatus should be sited in a large sink which is at least 70 cm long. If such a sink is unavailable then two plastic washing-up basins should be used; one for the header tank and one for the water wheel. Conventional plastic plumbing outlets should be fixed to the sides of each basin to accommodate output hosepipes. The basins should be sited such that their water outlets can drain into a nearby sink.

We have produced a set of drawings and constructional notes for the system shown in figure 1. We also have a second design, which is simpler to construct. In that design the major components of the wheel itself are two plant pot trays. We will supply a copy of our constructional notes on request to those who wish to copy either of these designs, rather than do their own thing. None of the materials or dimensions quoted in our descriptions are critical. It is possible to use whatever might be suitable. Get technological - modify, diverge, invent or copy!

Header tank and flume

The header tank was fashioned from a plastic, five gallon drum, whose top had been sawn off level. It thus stands 32 cm high. A slot 2 cm deep and 11 cm long was removed from the rim. Two further cuts, each 2 cm deep, were made to the side of this slot. The flume fits into the first slot and is supported by flanges which tuck into the cuts. The pattern of this flume is important. We used sheet aluminium for ours. The edge over which the water spills must be even and horizontal so creating a curtain of water.

Water wheel - first design

This water wheel (Figs.2 & 3) is made from three perspex disks: two in 2 mm perspex, and one in 6 mm perspex. This last disk can be seen to the reader's right in Fig.2, sitting to the outside of the water wheel proper. This thicker, outer disk bears directly on the drive shaft of a generator.

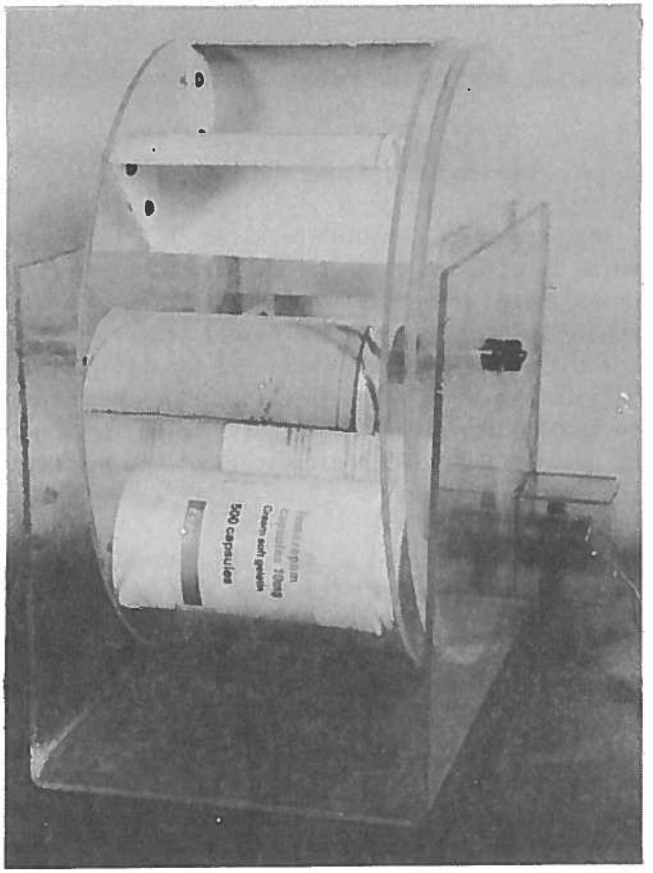

Fig.2. Water wheel MkI.

The generator shaft has a diameter of about 4 mm. Since the diameter of the outer disk is 26 cm the system has a step-up gearing of roughly 1:65. We need a largish step-up like this to turn the generator sufficiently fast to generate useful power. This is one reason why overshot wheels are not the engineer's first choice for the generation of electricity. This gearing up to drive a commercial generator puts a great strain on any gearbox so employed and shortens its useful working life.

The disks are mounted on a steel shaft which sits on brass bushes in the two large wheel support flanges. Two further bushes were used: one to support the left hand disk, the other, the right hand wheel disk and the outer drive disk. These bushes turn on the steel shaft; each has a flange to which the disks are screwed. These flanges were turned on a lathe. Washers should be placed between moving and non-moving parts.

The buckets were made from plastic pill boxes, which we scrounge from pharmacists. The variety used has a diameter of 61 mm and length of 112 mm. The boxes were halved lengthwise and fastened to the left hand disk by two screws per bucket, through the halved lids. The buckets touch the right hand wheel disk, but are not fastened to it.

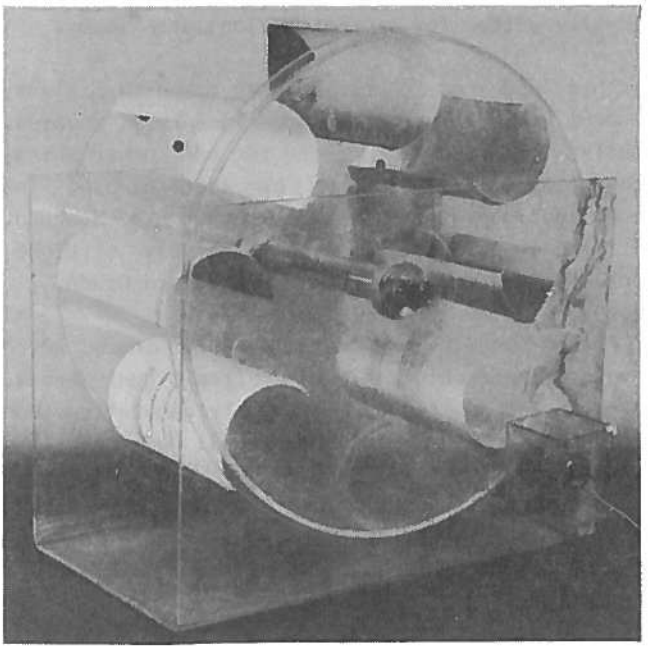

Fig.3. Through view water wheel MkI

A small, ironless rotor, d.c. motor generates electricity. Motors such as this have low friction and are easily turned - this makes them suited to small-scale models of this kind. We have several suitable types of motor in our surplus store.

A 4 mm diameter rubber bung fitted to the shaft of the motor bears on the rim of the outer drive disk and is driven by friction. The motor should be protected from splashing by siting it in a small box which should be fastened to the outside of the wheel support flange (Fig.3).

Water wheel - Second design

There are several technical difficulties in the construction of the first design: cutting disks of perspex, turning bushes, etc. Our second model is altogether easier to assemble.

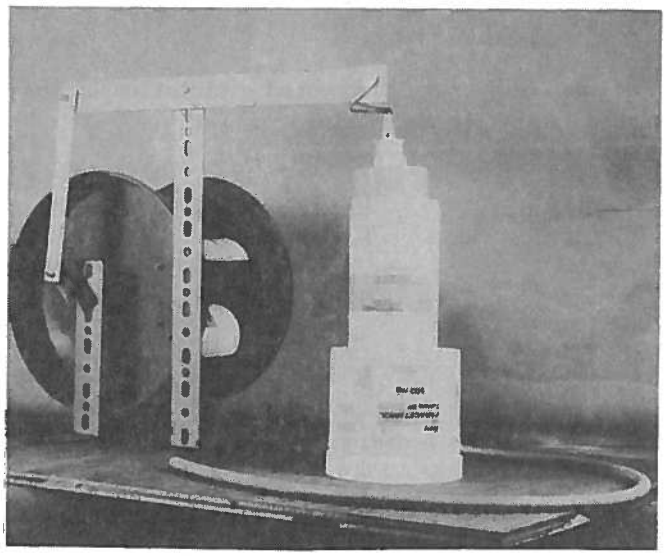

Fig.4

Water wheel MkII and air pump.

The shaft is 0 BA brass rod, which turns on a pair of brass bushes held by angle iron brackets. The whole mechanism we supported on a plywood baseboard. If so using plywood in such wet conditions it is important to choose exterior grade material.

The wheels supporting the buckets or paddles are the plastic trays used to hold 9" flower pots, each secured to the shaft by a pair of 0 BA nuts. There are six buckets made from three halved pill boxes, whose bases are fastened to one of the wheels.

The second model could, like the first, drive a generator. But for variation, we used it to operate an air pump. Our device was an adaptation of an idea seen in a description of a primary technology project [1]. We intend further development in order to drive a lift pump, pumping water. This sounds a crazy idea - using a water wheel to pump water. If you reflect further you should see that it's not quite as daft as at first it seems. It would have the further advantage that we can more easily calculate the efficiency.

In our pump driving version an eccentric drive on the shaft moves a beam which raises and lowers a mini bell jar in a pneumatic trough. Each upward stroke draws air, via a one way valve down into the jar. Each downward stroke then pumps air out again via a tube which enters the trough from below and rises up to just above the water level in the trough. Yes, you've guessed it - both bell and trough are yet further old containers, products of the pharmaceutical industry, as is the combined air line chamber and stand below the trough (bottom right, Fig.3).

Efficiency

What makes the water wheel such a lovely gadget with which to teach physics? Will the output power be anywhere near as large as the input power? We won't know till we make some measurements! The output may even be the greater of the two if we have an open mind on the validity of physical laws. It should, and can, be put to the test.

The first model drove a generator which was loaded with five light emitting diodes and a small motor (SSSERC items 373 and 508). Figure 5 shows the measurements.

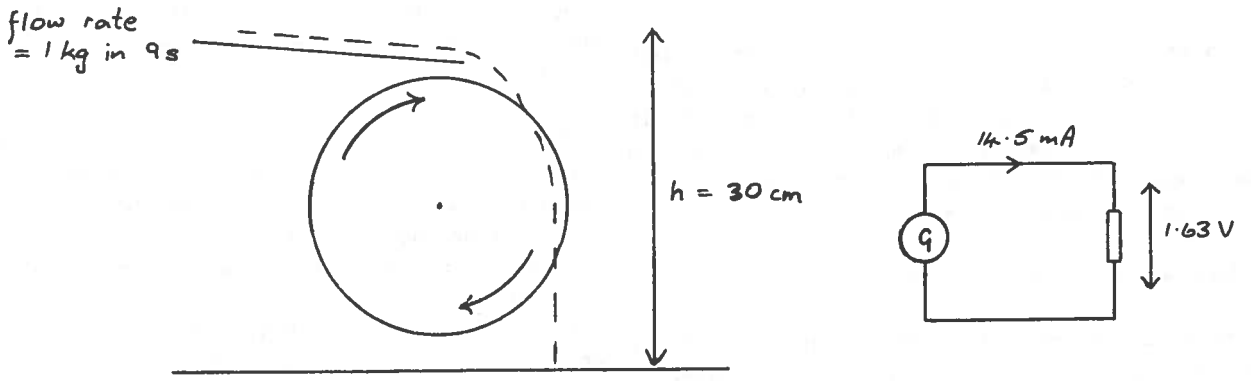

Fig.5 - Measurements with MkI wheel.

The input power was reckoned by finding the rate of delivery of potential energy:

$$\text{input power} = \frac{mgh}{t}$$

$$= \frac{1 \times 10 \times 0.3}{9}$$

$$= 0.33 \text{ W}$$

How does the output power compare? This is determined from the rate of use of electrical energy:

$$\text{output power} = IV$$

$$= 0.0145 \times 1.63$$

$$= 0.024 \text{ W}$$

So we have not discovered a violation of the second law of thermodynamics - as yet!

$$\text{efficiency} = \frac{0.024}{0.033} \times 100\%$$

$$= 7\% \text{ !}$$

Can you produce a design which will do better?

Reference

1. "School Technology", NCST, **20:3**, Issue 81, March 1987.

TRADE NEWS

Harris drop carriage charges

We have been asked to draw the attention of Scottish teachers to the fact that, since January of this year, Philip Harris and Philip Harris Biological ceased charging for carriage. This applies to all orders except those containing living organisms or perishable materials. This should be welcome news for many Scottish schools especially those in remoter corners and in the Isles.

With the letter from the company were copies of an updated version of their leaflet on resources for biotechnology. Shortly afterwards we also received a copy of the latest Harris Biological leaflet "The Key to Modern Biology". Copies of both of these publications are available from the addresses given on the inside front cover of this bulletin.

Get a 'walkover'

AV equipment, microcomputer systems and other mains-powered devices may frequently have to be sited away from perimeter power outlets. That may mean trailing a mains cable across alleyways or other circulation spaces. We often face this problem in setting up equipment, both here in our Victorian premises and in our training courses.

Wherever trailing cables are a potential hazard, the fitting of flexible, walkover, cable protectors is to be recommended. Such protectors are available from the fittingly named Walkovers. They stock three section sizes, all of heavy duty rubber construction. Prices start at £5, for a 2 m length of No.1 which is sized for a single 10 mm diameter cable or several small cables, and go up to £34 for a 3 m length housing 3 cables each up to 21 mm in diameter.

* * * * *

MISCELLANEA

Announcements

New 'Vela' centre

We have before in these columns given publicity to that hard-working lot the organisers of the Vela User Group and publishers of the "Vela Newsletter". Despite that kind of support it is still the case that in many schools with a Vela the device receives little or no significant use.

Now, with the support of the Vela User Group, a Vela Centre for Central Scotland is to be established at the Edinburgh Academy. It will hold some Mk I Velas and a range of sensors. Tentative plans include the possiblity of holding courses and 'get to kow your Vela' sessions. Further details are available from Adrian Watt at the address on the inside cover.

New Napier Degree

Napier College, Edinburgh,have asked us to draw the attention of teachers - and through them senior pupils - to a new degree in Industrial Physics. This is their "BSc in Applied Physics with Microelectronics" which will be offered for the first time at the beginning of the new academic year. The course content is to include: holography and lasers, computing and micro-processors, opto- and digital electronics and environmental monitoring. Features of the course include industrially based projects and the involvement of industrialists in the running of the course.

Further details are available from the The Information Office, Napier College, FREEPOST, Edinburgh EH14 OPA.

Biotechnology Meeting See overleaf.

* * * * *

NOTICE OF MEETING

"BIOTECHNOLOGY IN THE CURRICULUM"

22nd September, 1987 at the Scottish Exhibition and Conference Centre

The Institute of Biology in association with the Society for General Microbiology (Scottish Branches) will hold a three day meeting on **"Biotechnology in Scotland"** in late September of this year.

On the first day (22nd September) there is to be an evening meeting at the Scottish Exhibition and Conference Centre, Glasgow. This will involve talks from eminent specialists and a Careers and Courses exhibition. This evening event is primarily for pupils and parents.

In the afternoon of the same day it is intended to hold a meeting for teachers in schools and non-advanced FE. The theme of this meeting will be **"Biotechnology in the Curriculum"**. Attention will be paid to biotechnology in Standard Grade Biology and Science courses and in SCOTVEC modules. The draft programme for the 22nd of September is:

13.30 Registration & exhibition of teaching resources

14.00 "The Impact of Biotechnology - A review". An appraisal of the social and economic importance of biotechnology by Prof.C.M.Brown of Heriot Watt University.

14.40 "Biotechnology in the Curriculum". A review of the nature and implications of biotechnological elements of courses at Standard Grade and in TVEI schemes. Mr F. Crawford HMI.

15.20-15.40 Afternoon tea.

15.40 Questions/Discussion Session with the speakers and an invited Panel.

16.15 Exhibition of teaching resources and a display of experiments suitable for use in schools and in non-advanced FE.

17.15 Buffet and formal end of afternoon section of meeting.

The specific educational programme will end at or about 17.15 h. Those teachers attending can, if they so wish, go on, via the buffet meal, to follow the remainder of the programme for that day including a visit to the Careers and Courses exhibition which will be open throughout the later session. The draft programme for the evening is as follows:

18.15-19.15 Free Time - Careers and Courses Exhibitions.

19.15 "Biotechnology in the 21st Century" Professors W.D.Stewart and J.E. Smith of Dundee and Strathclyde Universities respectively. [Will be aimed mainly at pupils and parents].

Careers and Courses Exhibitions.

ca.21.00 End of programme.

Teachers who are members of the Institute of Biology and others are of course able to register for the whole of the three day meeting should they wish. Further details on any part of the meeting are obtainable from Dr. B.J. Powlesland at the address given on the inside front cover of this bulletin.

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

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