SSERC
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

Science & Technology Equipment News

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For teachers in Primary schools and of S1/S2 Science & Technology courses

This, *new look*, Newsletter results from advice and comments from a number of practitioners. We have adopted more of an activity based approach embedding some advice and information on equipment, components and, where relevant, safety. Issue 4 features batteries as power supplies for primary science and technology followed by, we trust, interesting and enjoyable investigations. Attainment targets are not formally identified but we think that we have shown how the exercises may lead naturally on to other key features described within the 5 to 14 document on Environmental Studies.

Batteries and cells

A common source of electrical energy for work in schools is a battery or cell. These names are frequently used as if they were interchangeable. This is not so. A cell is a unit of a battery, thus a battery is made from a number of cells. The commonplace 'battery' for our torch or electric clock, is more often than not a primary cell, across which a voltage is produced and, through a chemical action, from which a current can be drawn. A standard[1] primary cell has a nominal voltage of 1.5 V. If we have a disposable battery giving 9 V it must be made from 6 such cells. It might though be interesting to know how many scientists would ask their local newsagent for a *cell* for their camera or torch. Figure 1 shows a range of cells and batteries commonly associated with school work.

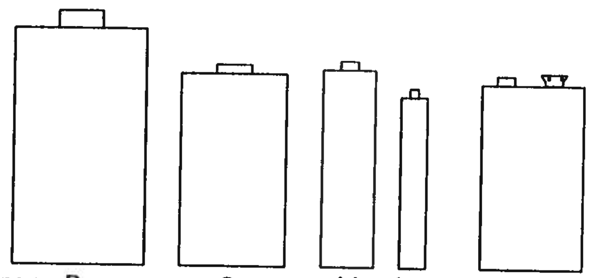


Fig.1 Scale : half size. Other codes - AM, MN etc also used

Secondary cells or batteries, unlike primary cells, have to be charged before any current can be drawn, and are rechargeable. Everyday examples are car batteries and rechargeable cells or batteries used in calculators or in the ubiquitous *Walkman*.

Disposable cells can be either standard or alkaline. Standard[1] cells are known as zinc carbon or zinc chloride - indications of the chemicals used in their manufacture. Alkaline cells are manufactured using the chemical, alkaline manganese.

Should a high or moderate current be drawn from such a cell or battery over a short period of time, the output voltage will fall. However if the cell or battery is rested it can recover to give almost all of its original voltage. The reason this happens with such a cell is a phenomenon known as *polarisation*. This is to do with the chemical composition of the cell. Put simply it means that the chemical changes within the cell cannot keep pace with the amount of current being drawn.

[1] "Standard" in the catalogue description, not the calibration, sense.

This doesn't happen so markedly in alkaline cells and not at all with rechargeable nickel cadmium (Ni-Cad) cells. Alkaline cells can release more energy than carbon-zinc types, deteriorate less with age and are not as prone to leakage. But, they also cost more.

The commoner rechargeable cells contain nickel-cadmium. As there is no polarisation, large currents can be drawn over reasonably long periods. While in many cases this is a useful feature, for primary schools it may be a major snag. Should there be an accidental *dead short* circuit, where the positive end of the cell connects directly with the negative end, a very large current can be drawn. This current can cause wire, cable or components to become exceedingly hot. We demonstrate this by shorting a cell with a piece of tinned copper wire which glows red hot, melts and parts. Components used in primary schools are unlikely to be permanently damaged, but fingers may receive a sharp if not serious burn. Also, the cost of rechargeables can be high depending on usage. A proper battery charger will be required and probably twice the number of cells will be needed as some will be on charge while others are in use.

There have been reports, happily infrequent, of both alkaline and rechargeable cells bursting or leaking, sometimes in spectacular fashion. Manufacturers aware of this problem use venting seals which enable any build of gases to escape to atmosphere. All the same we do not recommend rechargeable Ni-Cad cells or batteries for use in primary schools.

There are commercially available rechargeable low voltage power supplies with built-in Ni-Cads. Commercial units we have tested have integral safety devices. All give an audible warning of overload or short circuit and the output current folds back i.e. is reduced to almost zero output, thus preventing damage to the wires, components or fingers[2].

We would suggest for pupil work with electricity that on balance it is preferable to use alkaline cells or low voltage rechargeable power supplies. If the school is fortunate to have proprietary equipment with the necessary battery holders e.g. LEGO, then alkaline cells should certainly be used. They have larger capacities, lower internal resistance a much longer shelf life than standard disposables and they last longer when left unused in a holder. For any disposable cells and batteries it is a good idea to buy from a reputable dealer or even your local supermarket. The reason is that shelf life problem. Both standard and alkaline disposables have finite shelf lives. Most makers print a use by date on the label or on the metal base of the cell[3].

[2] We can advise on suitable models.

[3] Old stock is not a good buy and beware bargains with exotic names from exotic places.

C cell	Voltage	Internal Resistance	Capacity	Cost
Standard	1.5V	1 ohm	1.8Ah	40p
Alkaline	1.5V	0.2 ohm	4Ah	80p
Ni-Cad	1.25V	0.1 ohm	2.2Ah	£3.50

Table 1 All values and costs approximate.
The higher the capacity the longer each cell will last.
The lower the value of the internal resistance the larger the current that can be drawn.

Juicy currents

So, after that brief look at cells and batteries, what next? Let's continue the theme of a chemical action giving an output voltage and a current; can this be easily demonstrated? Yes it can. All we need are two different metals and a little acid. Health and safety buffs might frown on primary school pupils working with mineral acids. Parents too may be a trifle concerned.

Luckily this is not necessary. What we do need is a lemon, potato or grapefruit and two pieces of metal - ideally one of copper the other of zinc. Any of the first three items can be bought from a local shop. SSERC can supply the copper and zinc. Figure 2 shows the components of our fruit cell. The design for the demonstrations illustrated used a grapefruit but a lemon or large potato would do equally well.

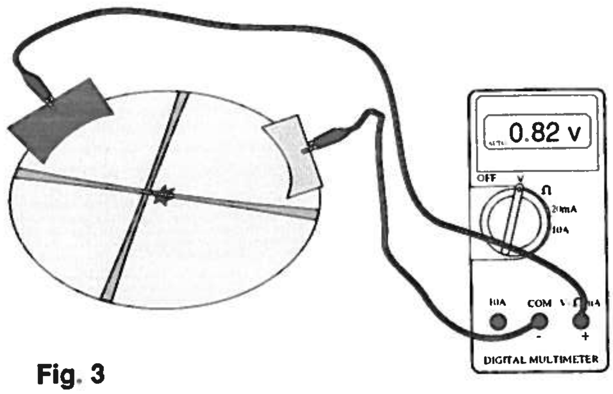


Fig. 3

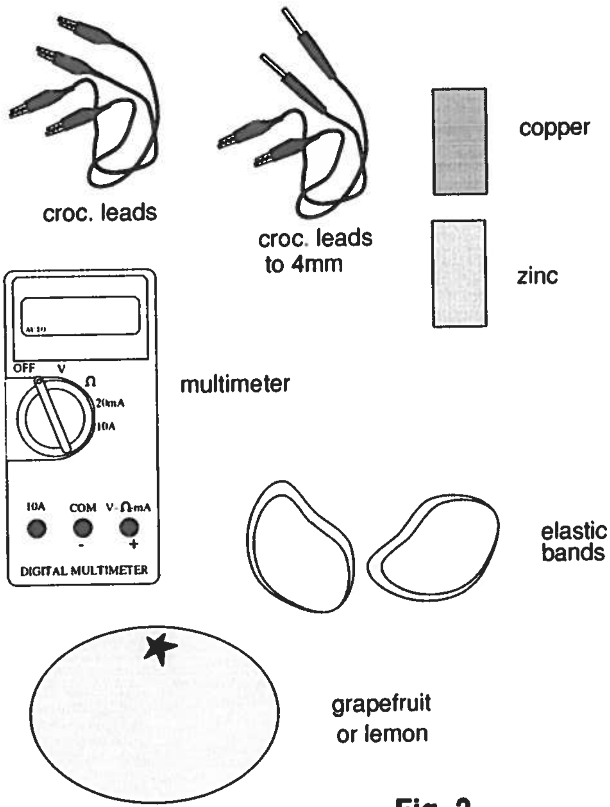


Fig. 2

Time of fruitfulness.

Ensure that the metal plates (the *electrodes*) are clean - sand them if need be. Make a cut in the skin of the fruit about the same width as the metal. Slide or push the metal plates into the fruit but with the tops showing to attach the crocodile clip. Place the elastic bands around the fruit with enough tension to pull the flesh of the fruit around the electrodes.

If using a voltmeter, choose one giving a reading on the scale of 2 V or 5 V. The multimeter in the drawings is an *autoranging* model. This means that you do not have to worry about the values of the input, the meter automatically ranges through the units being measured and displayed. All you have to do is turn the switch to the symbol for the required unit, in primary work this is likely to be either V for voltage or Ω for resistance, plug in the leads and read the display. A suggested circuit is shown in figure 3.

The meter reading shows about four-fifths of a volt. Can we do any useful work with this voltage ? You could try to light a low voltage bulb or drive a small motor or ask your class what they think could be powered by the fruit cell. Unfortunately it is unlikely you will succeed, there is not enough power in our cell to do much useful work.

But, what if we make a battery ?

You will recall that a battery is made from a number of cells. Try the circuit shown in figure 4. You will need another fruit with electrodes plus a quartz clock, preferably one which runs from an AA or C cell. Remember to first remove the clock's own proprietary cell!

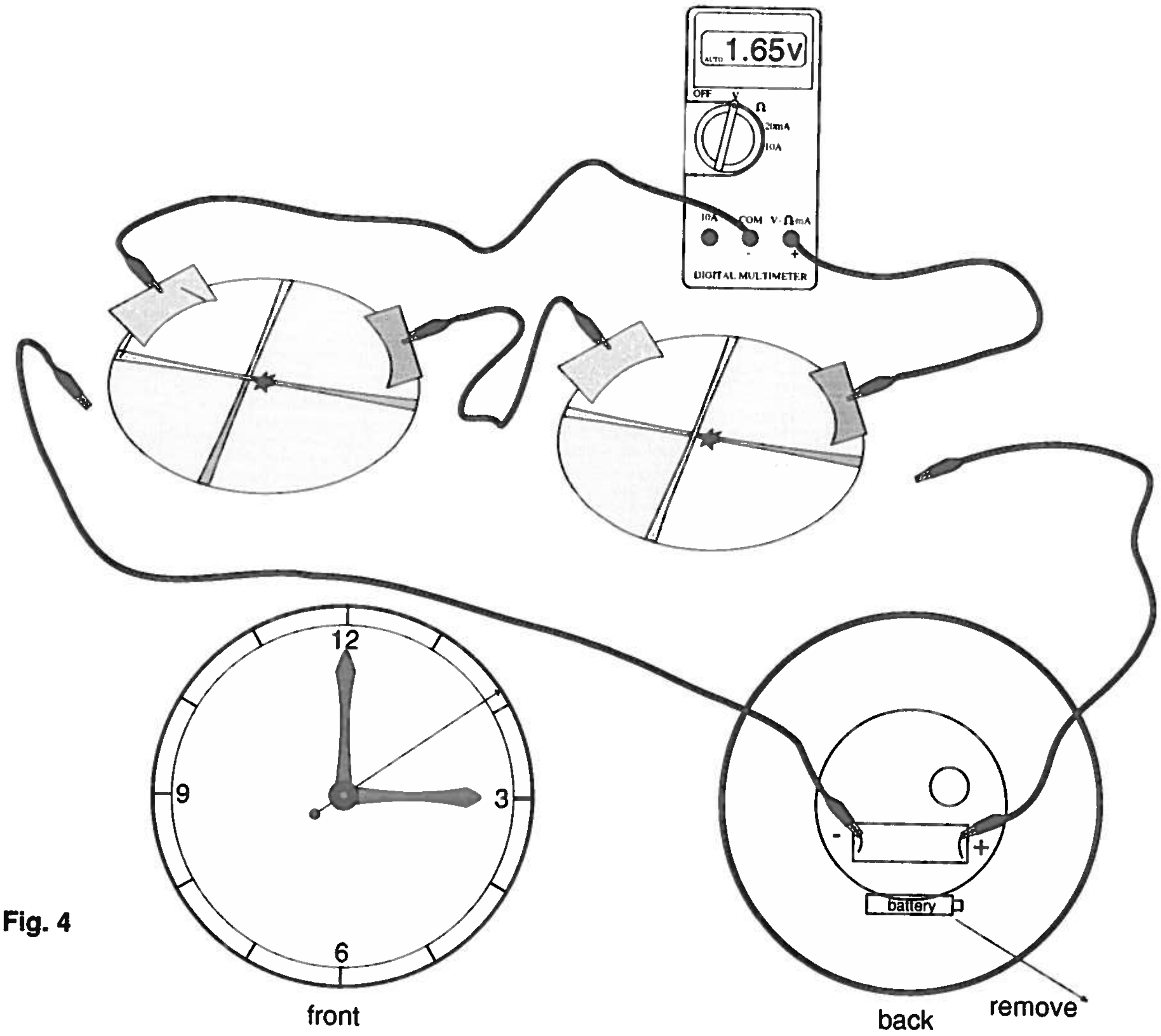


Fig. 4

Hopefully your clock did work from our grapefruit battery. Two things to note, the way the electrodes are connected and the voltage reading. With the electrodes joined in this fashion we have a *series* connection. With cells in series our voltage will double.

Can we arrange our cells to give greater power? Try the circuit shown in figure 5. You can substitute a low voltage, low current lamp for the multimeter. Does the lamp light ?

This time the meter reads the same voltage as with our single cell. But try again with a music module (see list of components over page). With a little help it should play you a tune. Is this a squeeze- or a juice-box?

On this occasion we have connected the cells in *parallel*. With cells in parallel the voltage stays the same but the power we can draw may double.

Should you decide to build such a fruit cell, we would advise that you try one on your own before attempting a pupil activity or demonstration, Murphy never sleeps[1]. If the voltage is a bit on the low side, give a gentle squeeze to allow the juice to contact as large an area of the electrode as possible.

[1] Murphy's law states that: What ever can go wrong will go wrong.

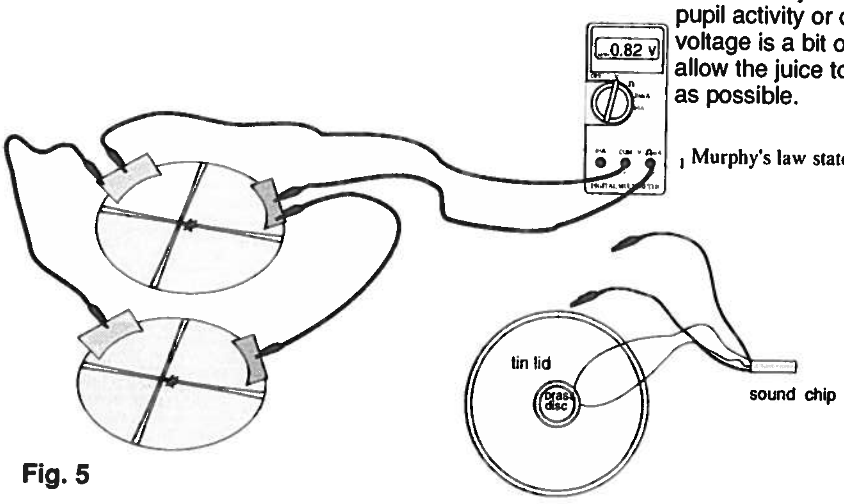
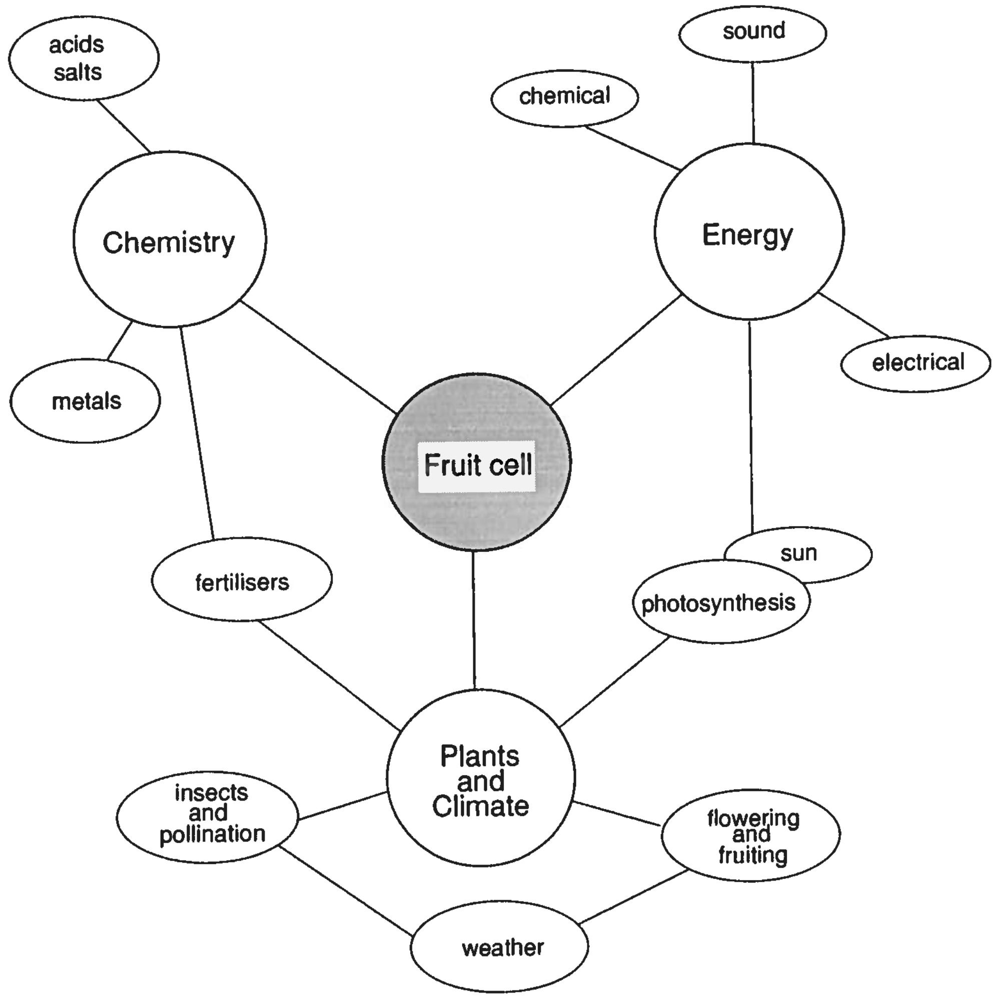


Fig. 5

When the fruit battery is first attached to the sound module, it may be difficult to hear the music, we need to amplify the sound. No expensive electronic devices are needed. A tin lid or empty can will suffice (smooth off any sharp edges). Tape the brass disc of the sound module to the centre of the lid or the centre of the base of the can and everyone can hear the *music*. What other materials could we use for an amplifier? Is metal better than wood? How about the sound box of a guitar and violin? This could lead nicely into a discussion on why this should be so (sound waves travel faster through solids and liquids than through gases) and for a later date, an investigation into sound.



Further investigations could be carried out using the same electrodes but changing the electrolyte.

The electrolyte is the medium in which we place the electrodes and through which the current is generated. We could try vinegar, salt water, tap water, plasticine, anything the children can think of, keeping safety in mind. One other experiment that could be tried, what would happen if you held the electrodes one in each hand? Would we have a reading on the meter?

In connection with safety - note that lemons, grapefruit or other fruits used for this activity will be unfit for human consumption because of contamination from the metal plates and possibly from other sources.

While this is an enjoyable exercise on its own it could fit into topics on chemistry, electricity, natural resources, alternative energy etc. The lesson could be complemented by investigations into solar power or wind energy. A motor with propeller will act as a simple generator, voltages can be read by the meter. This could be part of a simple weather station, reading wind speed. Now all we need is a rain gauge, wind direction indicator and a method of recording temperature.

Things you can buy from SSERC :

zinc and copper electrodes	*50p pair*
crocodile leads	*£1.35/10*
sound module	*£1.00*
3V wire end bulb	*£0.10*

Other items : Multimeters Type HD1200
£12.95 (including pair of 4 mm leads)
from :

JPR Electronics Ltd
Unit M, Kingsway Industrial Estate
Luton, LU1 1LP.

Fuller lists of components can be found in earlier issues. If we cannot supply a particular item we are happy to advise on inexpensive sources.