Science & Technology Equipment News

For Primary Schools and Teachers of S1/S2 courses

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STS National Support Services in Science, Technology and Safety

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Much of this issue is devoted to magnets and magnetism - a subject on which we have had several recent enquiries. Magnets are mysterious and good fun, most children, and not a few adults, enjoy playing with them and discovering what magnets will 'stick' to, that they stick to each other one way and try to escape from one another when one of their ends is reversed. First questions that could be asked of pupils include : What are magnets? Are they natural or can we make them? What do magnets 'stick' to? How strong is our magnet? Are there useful things we might do with them?

See our first attempts at an interactive News in part of our Web site : http://www.vtc.scet.com/links/sserc/inform.htm

Mandarins and magnets

Magnetism occurs naturally in materials such as magnetite (also known as lodestone or magnetic iron ore). Can magnets also be made? In the tenth century AD a Chinese engineer showed that an artificial magnet could be made by cooling a steel bar while it was lying in a North-South alignment. We do not need to go to such lengths. A piece of iron can be made into a magnet by a much simpler method. Figure 1 shows a magnet and an iron nail picking up a few paper clips, a well loved demonstration from many textbooks, but how does it work?

When the magnet is removed can the nail still pick up the paper clips? It appears we may have 'made' a magnet, but Figure 2 shows a more positive method.

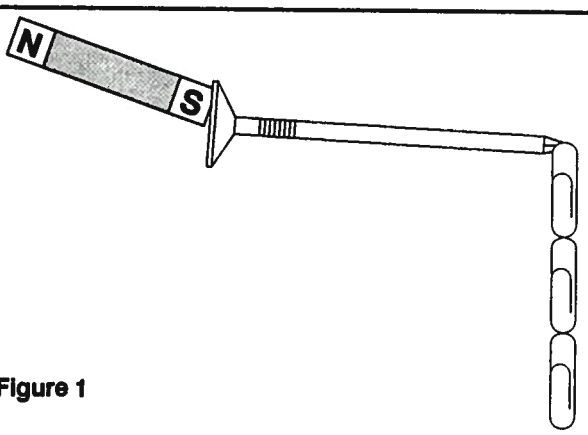

Figure 1

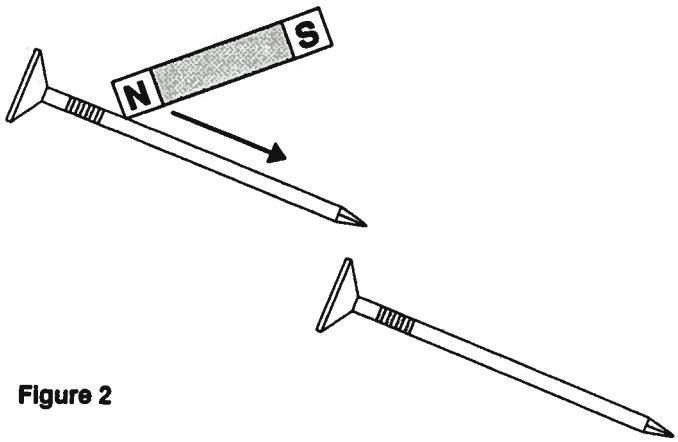

Figure 2

Now which end is the North pole ?

Now suspend a magnetized nail (best made with the method shown in Figure 2) from a thread, so that it can move freely. Note the direction it points to as it comes to rest. All being well one end should point to magnetic North. This is called the North pole of the magnet, the other, surprise surprise, is called the South pole. The magnet is attracted to a strong area of the Earth's magnet field which happens to lie not far from the geographic North Pole. Strangely this discovery is attributed to a Dr Gilbert who was physician to Queen Elizabeth I of England, rather than to the much earlier discoveries of the people of the Far-East.

Some children may realise that if like poles repel and unlike poles attract, there is something illogical in the naming of the poles. The real reason is probably common laziness in everyday speech. Rather than call one end of a magnet the *North* Pole, we should describe it more fully as the *North Seeking* Pole.

We have shown a wire nail being made into a magnet but other iron objects can be magnetised in a similar way. But for those children with some experience of electrical circuits there is another way of magnetizing the iron nail. What's needed is a length of insulated copper wire, a battery and a nail - see Figure 3. Does the nail stay magnetized when the connection to the battery is broken? If you have a small steel screwdriver you could try this in the coil. Does it stay magnetized when the connection to the battery is broken? This is a very important phenomenon in the use of magnets, of which more later.

Do not leave the coil connected for too long a time as this will shorten the working life of the battery.

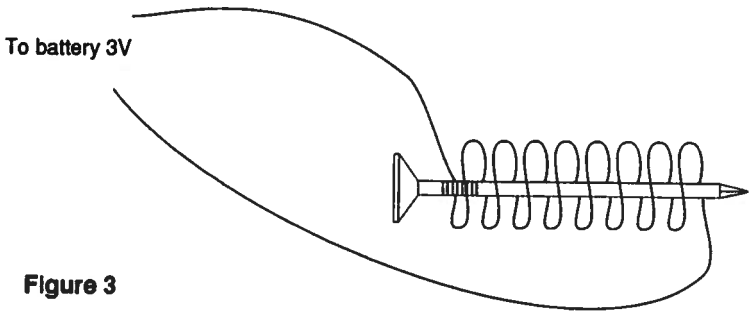

Figure 3

Attractive investigations

What do we discover when we try our magnet on various materials? The first reaction from many pupils is that metals will be attracted to the magnet. But, are all metals so attracted?

Should you try this with everyday objects remember not to judge a *banana by its skin*. 'Brass' drawing pins are attracted to a magnet not because brass is magnetic but because the pins are made from steel plated to look like brass. Old 1p coins are not attracted to a magnet but more recently made coins may be. Is this another form of sterling devaluation? Why do you think this is? Again during play children will attempt to lift various objects and quickly discover that although the magnet sticks to, say, a can of beans it will not lift it from the table.

Forces

This may be a good time to visit or revisit the subject of forces. Fix a magnet to a toy car, truck or train and investigate the effects of bringing a second magnet close to the first. Depending which way round we hold the magnet it will either be pushed or pulled, with an invisible force at work. What is happening here?

How can we measure the 'strength' of a magnet? The paper clip method is the simplest - how many paper clips can we hang from our magnet? Does the number of times we stroke the nail with the magnet make a difference to its 'strength'? Could we devise a more scientific way to measure the strength of a magnet? Figure 4 shows one way using a metre rule and a plotting compass.

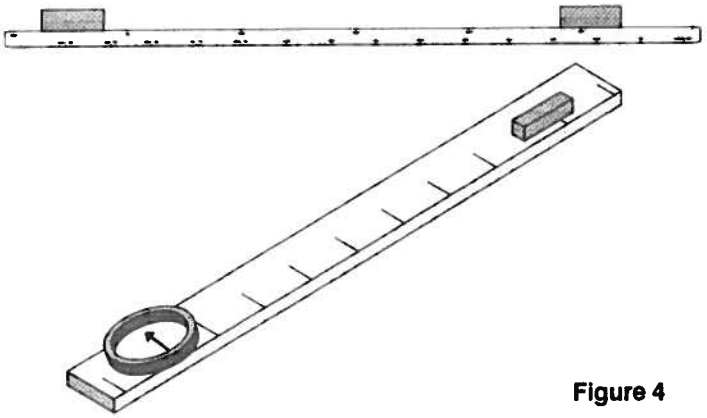

Figure 4

Early applications

There are no definitive records of when the first piece of magnetic ore was used to help people find their way around the Earth's surface. Magnetism was used by soothsayers and geomancers to help in their divinations. Many of them also used movements of the constellations and planets to lend weight to their prophecies. We can only speculate that someone eventually became aware of the directional property of this strange iron ore - lodestone. If a piece was placed on a smooth, shiny surface, it tended to move to a North - South alignment.

A Chinese book - the *Louen Hang* - dated 83 BC describes just such a device used in geomancy. A *bas relief* in the Zurich Museum and dated 114 BC shows a spoon shaped object made from lodestone placed on a plate of polished bronze. The handle of the spoon would turn to point in the same direction, North, regardless of where the bronze plate was positioned. To the Chinese this would have been a most useful invention enabling them to ensure that their houses were built on the line most efficacious for long life and good fortune.

This is part of so-called *Feng Shui* currently so fashionable in the West. Exactly when the compass proper was invented is open to question, but by the 9th century AD they were in common use in China. These were proper compasses with a floating pointer in a bowl of liquid, or a pointer suspended from a thread or balanced on a needle. The first note of such a compass in use in Europe does not occur until the 12th century. We tend to think of compasses being used mainly by mariners but the Chinese had vast distances to travel over deserts and open uncharted country to bring silk and spices to their borders for trading with peoples from the then relatively uncivilized West.

Compasses in use in the West from the 12th century up to the beginning of the 18th were magnetic pointers that were placed on the map or chart. North was indicated by a *Fleur de-lis* - a practice still to be seen on marine charts to this day. One problem with magnetized pointers was that over a relatively short period they became demagnetized. This was unfortunate when sea voyages could last several years. In 1745 an English engineer Gowan Knight perfected a process for magnetizing 'hard steel' which had a much longer magnetized life and which then became the norm for compass pointers.

These days, navigators use satellites to give them an accurate plot of the position of their ship or aircraft. Even mountaineers, walkers and owners of small boats can now buy for a few tens of pounds a hand held electronic instrument that gives their position anywhere on earth accurately to within 20 metres or so.

Magnets and communications

Nowadays we all take for granted that dramatic events, which may take place anywhere the world can be shown on our television screens almost as they happen. In the past, communication between countries was usually by word of mouth. News could take a long time in coming. It is only over the last 150 years or so that rapid communication between countries has become commonplace. This is due, in no small part, to our increased knowledge about, and use of, magnetism. Earlier in this issue we described a method of magnetising an iron nail in a coil. Making use of the same circuit, we can conduct a further investigation. Remove the nail from the coil, place a small compass close to the coil then connect the battery (see Figure 5). What happens to the compass needle? (It will be deflected from its rest position. Note : Do not leave the coil connected long after any movement of the compass needle is noted, else it will shorten the working life of the battery).

The magnetic effect when a current flows in a coil[1] was noted by both Cooke and Wheatstone towards the end of the 19th century. This marked the beginnings of the electrical telegraph. Loudspeakers and telephone handsets are two further examples of the use of magnetism in communications. Can you think of any others?

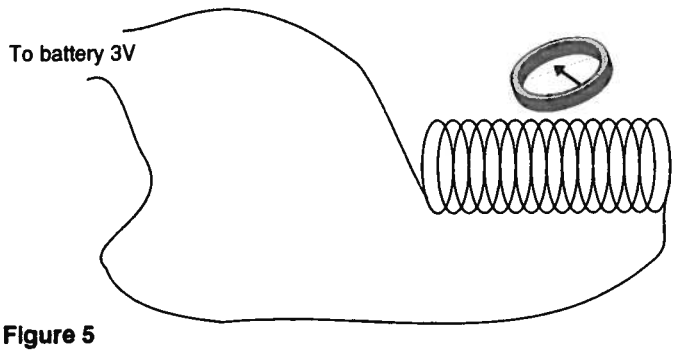

Figure 5

1. It is also possible to show the corollary - if a magnet is moved in and out of the coil an electrical current may be produced. At primary this is tricky to show without a fairly sensitive meter. Don't believe the books - you can't light a bulb this way.

Magnets and motors

The close link between magnetism and electricity was instrumental in the development of both the electrical generator and the electric motor. We shall not delve too deeply into the theory. It is sufficient to say that a coil of copper wire rotating between fixed magnets will produce an electric current. Conversely, a current passing through a coil between fixed magnets can cause the coil to rotate. Figure 6 (below) illustrates one way to demonstrate this using two small electric motors and a signal lamp. These small motors are somewhat special in that they are of open construction. If you look carefully at the real things the *brushes* can be seen.

It is through these brushes - special connectors which still allow the shaft (or rotor - the part that rotates) of the motor to turn freely - that the electricity from the battery is taken to the windings of the rotor.

If the children are allowed to handle and investigate the motors they should discover that they contain magnets. Our small motor generator pack consists of two open construction motors, tubing and a small signal lamp. The completed model is shown in Figure 6. Children may question the notion of driving the motor generator in this way, but they should be asked to imagine the generator is being driven by a car engine, a water wheel or windmill or any other driving force they can envisage.

Magnets and games

Magnets lend themselves well to uses in fun themes or topics such as fairgrounds. One of the simplest games using magnets is the old fashioned fishing game. This uses a *fishing rod* and line with a magnet instead of a hook. This bait is dangled in a bowl containing paper or card fish shapes of different sizes each with a paper clip attached at the head. In one version each fish has a number and the winner is the person who gets the highest score in a given, fixed time (possibly these days too competitive to be entirely PC?).

Another possibility is to mount figures on magnets - for example we have used skaters or penguins - and fix a second magnet to the end of a ruler or stick. The figure is placed on top of a reasonably smooth level surface and the magnet on the stick is manipulated underneath so that the skater skates or the penguin waddles. *DIY dodgems* is a further idea with magnets fixed to model cars so that they repel one another. Magnets on sticks model metal detectors in a sand box or can provide a magnetic version of a *Lucky Dip*. For other ideas for games or fun applications see texts such as *Spotlight on Science* (Book 8).

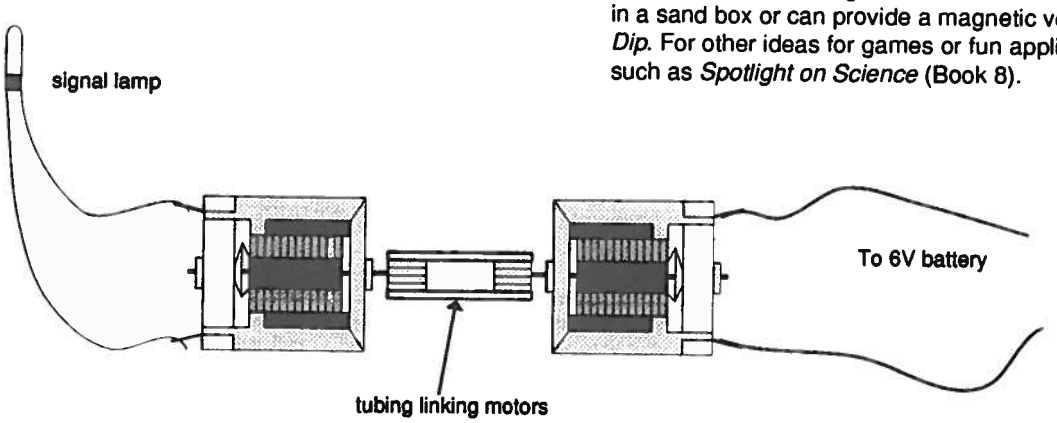

Figure 6 Two coupled motors - one working from a battery as a motor driving a second device acting as a generator.

Additional notes for teachers

The accounts we have given are necessarily much simplified. For example a number of materials other than iron or its alloy steel (eg other metals such as molybdenum and neodymium) can exhibit powerful magnetic properties. Magnetism, like electricity, is caused at the sub-atomic level by charged particles known as electrons. Whilst electricity is usually explained as a flow of electrons, magnetism is said to be the force generated by their spinning. Electrons around atoms generally tend to form pairs of opposite spinning partners - when their magnetic forces will cancel out. If they cannot pair up with one another - eg because an atom has an odd number of electrons - they readily join up with electrons in other, different, atoms. This is the very stuff of chemistry! Indeed, since about 1985 chemists have been seeking to produce *designer molecule* magnets with their free electrons all spinning the same way. In more conventional magnets (eg in a block of magnetised metal) it is the inability of free electrons to either pair with each other or with those of other substances which make their magnetism felt [1].

1. Adapted from an account from The Economist (31 Aug.1996) in "*Molecular magnets*", Chemistry in Action, Winter 1996-97.

Resources

SSERC can supply several of the items needed for the investigations described. Parts lists are given below. For other components, materials and kits see the listings on the back page of this issue.

Parts for simple investigations on magnets :

Plotting compass
Length of copper wire
SSERC Item 691 MES battenholder (lampholder)
Item 789 MES bulb 3.5V for above
Item 824 ceramic magnet poles on face*
Item 823 ceramic magnets, poles at ends

* Secondary colleagues should note that whilst we do stock neodymium magnets and sell these to schools we don't consider them generally suitable for use at the primary level.

For the motor/generator demonstration :

2 off SSERC Item 621 miniature motors
1.5V signal lamp
polythene tubing
Item 730 AA cell holder (for 4 cells)
Item 788 crocodile clip leads (optional)

Components & Materials

593 Miniature motor, 1.5V to 3V, 2mm dia. shaft **30p**
614 Miniature motor, 3V to 6V, 2mm dia. shaft.
Both motors above can be used for project work but they run at fairly high speeds, some form of gearing will be required. See worm/gear, item 811 **45p**

621 Miniature motor, 1.5V to 3V, now with 8 tooth pinion. The open body of this motor makes it ideal for showing how such a motor is constructed. **25p**

798 Pack of 24 gears, 6 each of 12, 20, 30 or 40 teeth, dia. 15, 22, 32, 40 mm. 12 tooth gear fits motor shaft and 40 tooth gear is push fit in cotton reel **£2.00**
799 Pack of 24 cams, 6 of each of 4 shapes **£1.00**
800 Pack of 100 wheels, 39 mm diameter, assorted colours, 3 mm axle hole **£5.25**
811 Worm and gear, gives a 34 to 1 speed reduction. **35p**
817 Axles 3 mm dia.,nickel plated, round ends. push fit on SSERC plastic wheels, gears and pulleys: 70 mm long, per pack of 4 **40p**
818 As above but 95mm long, pack of 4 **40p**
819 As above but 120mm long, pack of 4 **40p**

820 Worms to fit 2mm electric motor shaft, pack of 5 **£1.00**
821 Reducers 3mm to 2mm enables gears, pulleys and wheels, to be fitted to motor shaft, per 5 **25p**
629 Dual tone buzzer with flashing light supplied with PP3 battery clip. Ideal for model burglar alarms, warning barriers, police car etc. **55p**

710 Sonic switch. Clap your hands, the motor starts, clap again the motor reverses, on the third clap the motor stops. Needs 4 AA cells, not included. **85p**
723 Microswitch miniature, lever operated **40p**
822 Plastic toggle switch, low voltage **40p**
688 Crocodile clips, red, miniature, insulated. **5p**
759 As above but black. **5p**

788 Crocodile leads, assorted colours, insulated croc. clips at ends, 36 cm long. **£1.35**

835 2 x AA Cell ('battery') holder **15p**
845 2 x C Cell ('battery') holder **20p**

789 MES (miniature Edison screw) bulbs 3.5 V. **9p**
691 MES battenholders for above. **20p**
508 LED (light emitting diode) 3 mm, red, per 10. **50p**
761 LED 3 mm, yellow, per 10. **60p**
762 LED 3 mm green, per 10. **60p**

790 3V buzzer. **55p**
846 Sound module with 'melody' chip **£1.00**
838 Solar cell, 100 x 60 mm, 3.75 V per cell, max. **£2.10**
839 Solar motor, body 25 dia.12 mm long with shaft 2 mm dia 6 mm long. **£1.70**
840 Solar pack : one of each solar cell, solar motor propeller (801), and 3 V buzzer - with notes. **£3.75**
836 Motor mounts, plastic, push-fit with self adhesive base pad for SSERC motors 593 & 614,10pk **£1.95p**

801 Propeller, 3 blade, to fit 2 mm shaft. Blade 62 mm long **35p**
792 Propeller kit with hub and blades for ten 3 or 2 bladed propellers. **£3.50**

794 Cotton reels (for making buggies, rubber powered tanks etc.) pack of 20. **75p**

796 Pack of 20 pulleys, 5 of each of 10, 20, 30 and 40 mm diameters. **£2.50**
837 Ring magnet, 40 mm o.d., 22 mm i.d. **35p**
815 Ceramic square magnet, 19 x 19 x 5 mm **15p**
824 Ceramic magnets, poles on face, 25x19x6mm **35p**
823 Ceramic magnets, poles at ends, 10x6x22mm **12p**
825 Forehead temperature strips, liquid-crystal type, 36-40°C (96-104°F), [store in cool cupboard] **50p**
833 Floppy disks, 5¼" double density, box of ten **60p**
834 As above but double sided high density, ten **60p**

Cash with order only when total value is less than £5 and please add £1 for carriage solely to these small orders (except where an inclusive price is indicated eg kits, etc). For orders totalling more than £5 please do not send payment etc but await delivery and then pay on our advice note or invoice.

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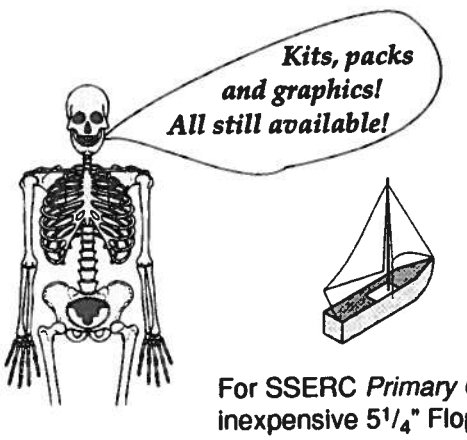
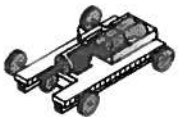


Buggy pack £5 and *Paper Engineering pack* £2. For details see News No. 10. *Solar cell and motor pack* - see Item 840 in the listing above. Copyright free *Skeleton template* £1.25.



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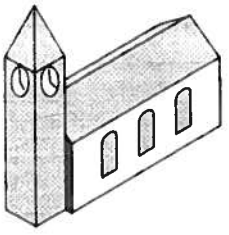
SSERC Graphics - A cut above clip-art



For SSERC *Primary Graphics* - see News No. 13. and for inexpensive 5¼" Floppy Disks (3" sold out) Items 833 & 4.