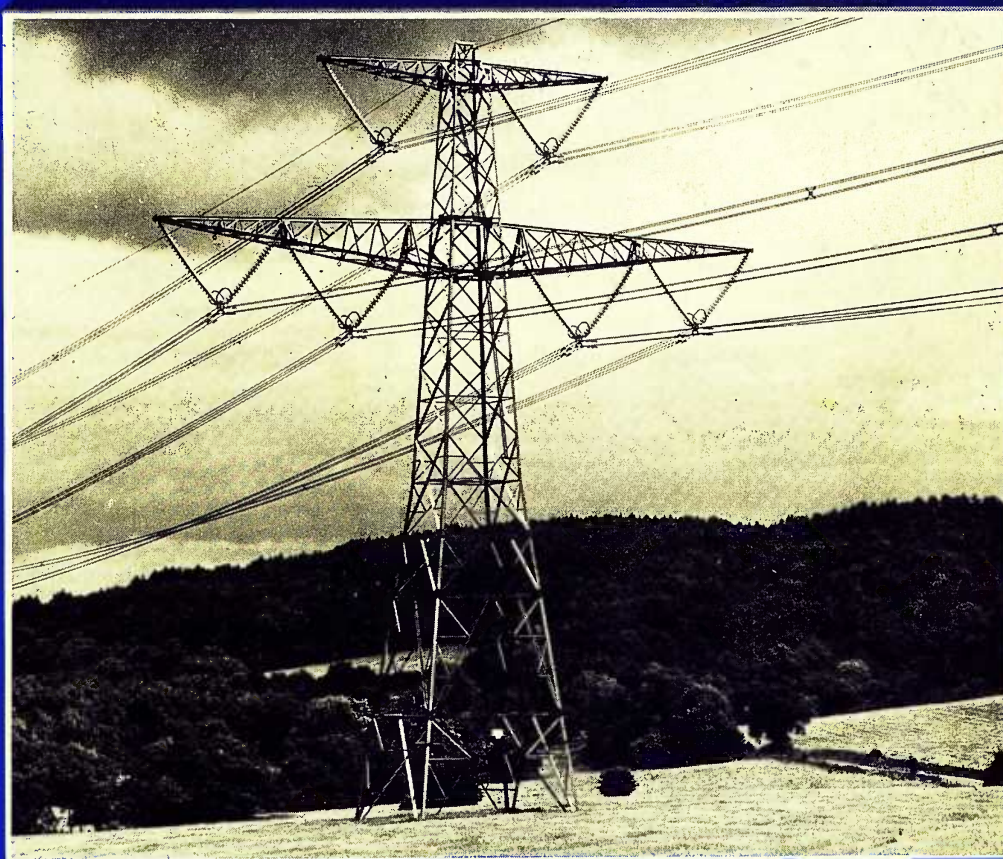


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SCIENCE AT WORK



Domestic Electricity

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This book from an original manuscript by
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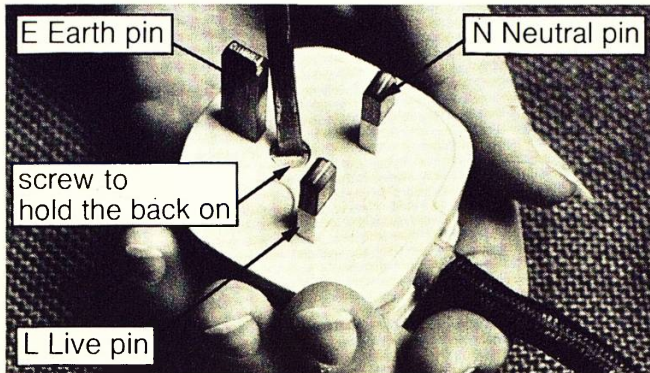
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1 Plugs and sockets

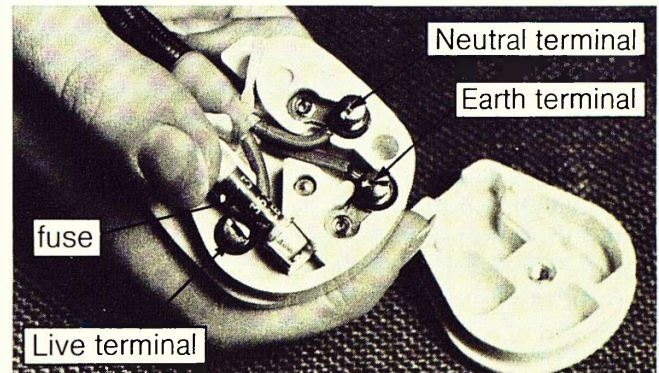
Information: Plugs and sockets



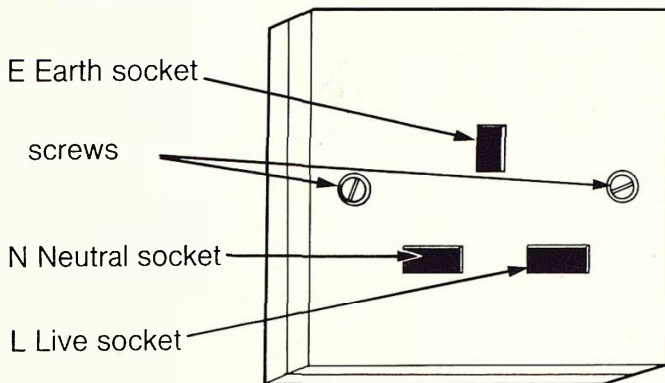
A 240 volt shock can kill you. You **must** disconnect the appliance or switch off the supply at the meter before you do any work on mains voltage equipment. In the experiments in this book a low voltage supply must be used.



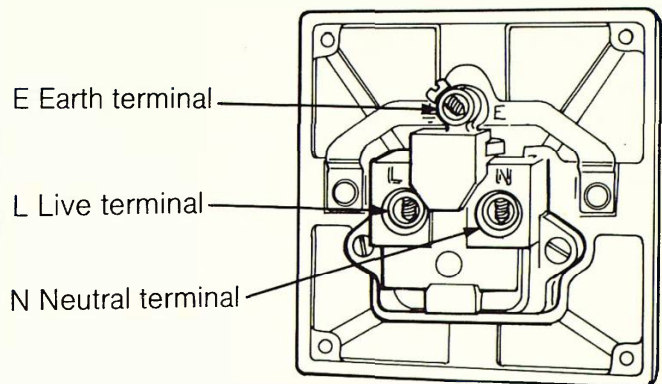
The outside of a plug



The inside of a plug



The outside of a socket



The inside of a socket

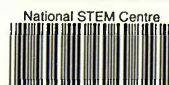
The mains voltage (240 volts) is connected to the **Live** and **Neutral** wires. These are the wires that supply **current** to an **appliance**. The Neutral wire is connected to **Earth** at the electricity sub-station. This means it is at the same voltage as Earth. The Live wire is at a high voltage (240 volts). The Live wire is dangerous to touch. The Earth wire is only for safety. It is connected to earth at the building to which the electricity is supplied. Any appliance that has a metal case, such as an iron, should have an Earth wire connected to its metal case. If the metal case is properly connected to the Earth wire, it is impossible to get a shock from it.

Colours of wires in cables

System now	Old system (before 1975)
brown = Live	red = Live
blue = Neutral	black = Neutral
yellow/green = Earth	green = Earth

- Q1** What is the voltage of mains electricity in this country?
- Q2** Which two wires supply the electric current to an appliance?

- Q3** What is the Earth wire connected to?
- Q4** What is the Earth wire for?



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Plugs and sockets

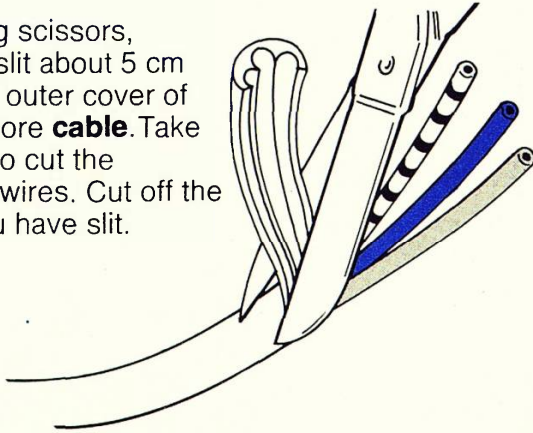
Connecting a flex to a plug and socket

Apparatus

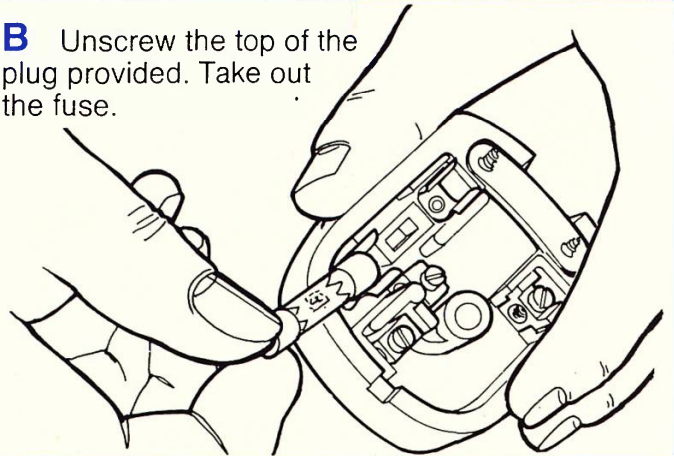
- ★ 3-core flexible cable
- ★ 3-pin plug
- ★ socket
- ★ screwdriver
- ★ scissors
- ★ wire strippers

You are going to wire up a plug and a socket. Your plug and socket may look different from these, but they all work in the same way.

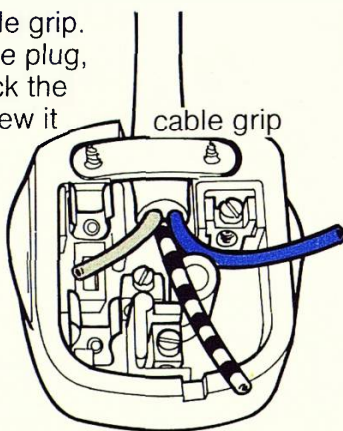
A Using scissors, carefully slit about 5 cm down the outer cover of some 3-core **cable**. Take care not to cut the coloured wires. Cut off the cover you have slit.



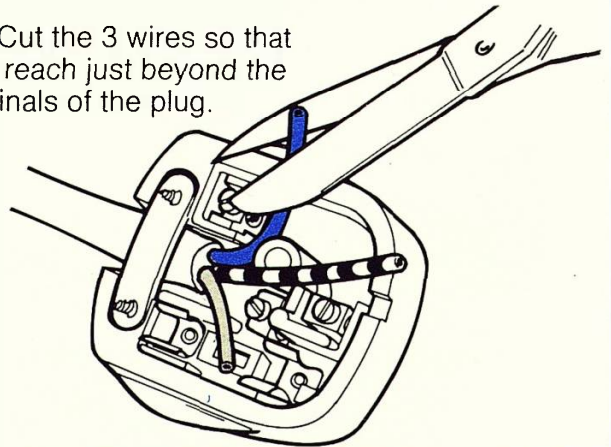
B Unscrew the top of the plug provided. Take out the fuse.



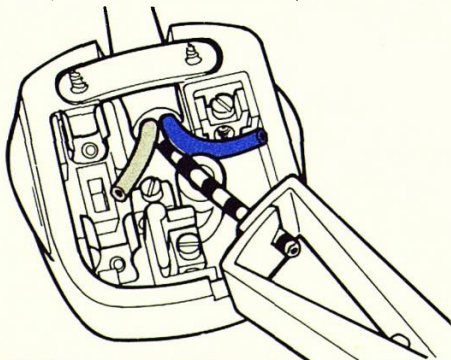
C Undo the cable grip. Put the cable in the plug, as shown. Put back the cable grip and screw it tight.



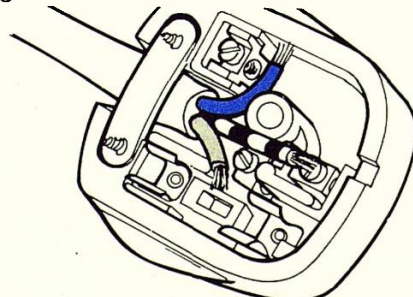
D Cut the 3 wires so that they reach just beyond the terminals of the plug.



E Using wire strippers, strip about 1 cm of the **insulation** (the coloured cover) from each wire.

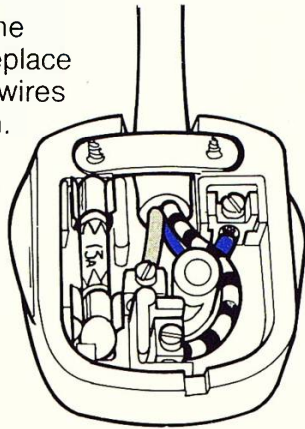


F Make sure the brown wire goes to the Live terminal (the one with the fuseholder). The green/yellow wire goes to the Earth terminal. The blue wire goes to the Neutral terminal.

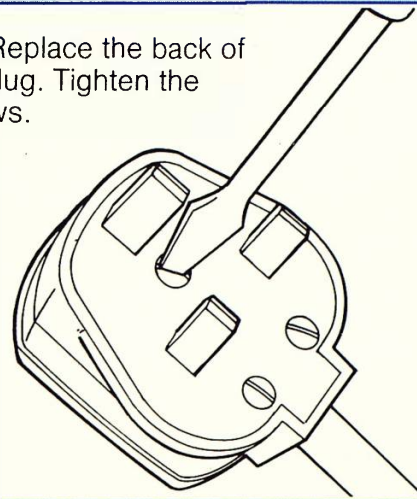


Plugs and sockets

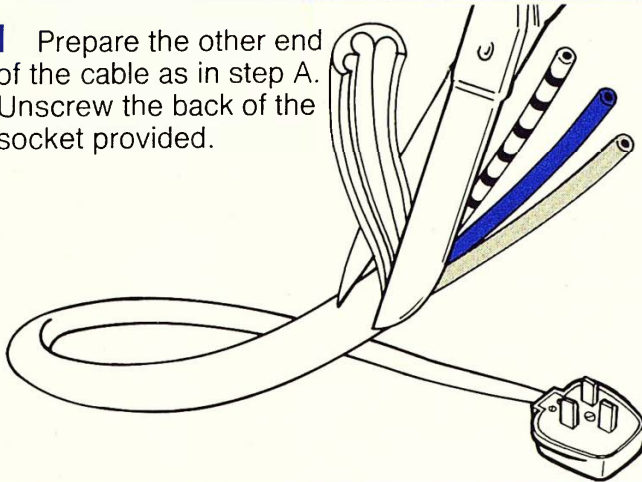
G Twist each wire. Attach the wires to the correct terminals. Replace the fuse. Check the wires are firmly screwed in.



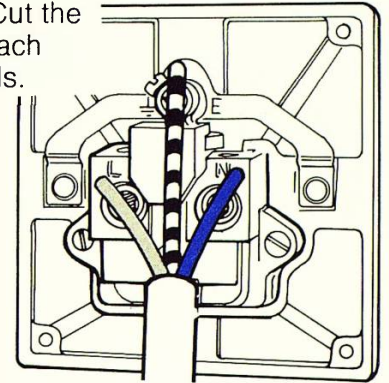
H Replace the back of the plug. Tighten the screws.



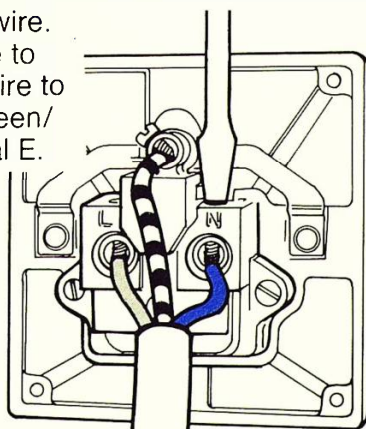
I Prepare the other end of the cable as in step A. Unscrew the back of the socket provided.



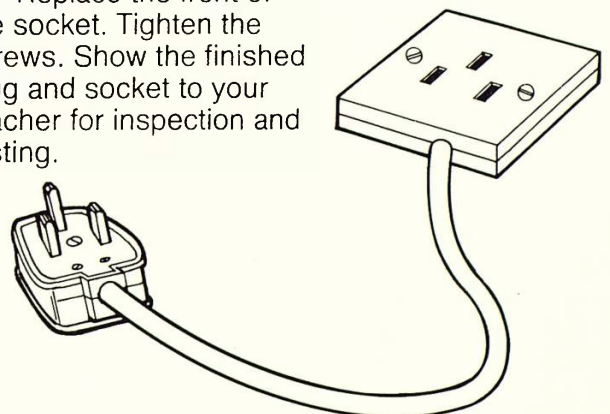
J Thread the cable through the inlet in the back of the socket. Cut the wires so that they reach just past the terminals.



K Strip 1 cm of insulation from each wire. Attach the brown wire to terminal L, the blue wire to terminal N and the green/yellow wire to terminal E.



L Replace the front of the socket. Tighten the screws. Show the finished plug and socket to your teacher for inspection and testing.



Q5 What does the letter **N** on the inside of a socket mean?

Q7 Which colour wire does not usually carry electricity?





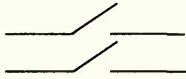
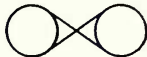
Q6 Which colour wire carries a high voltage when the electricity is switched on?


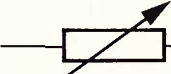
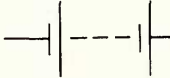
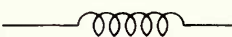
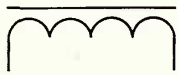

Plugs and sockets

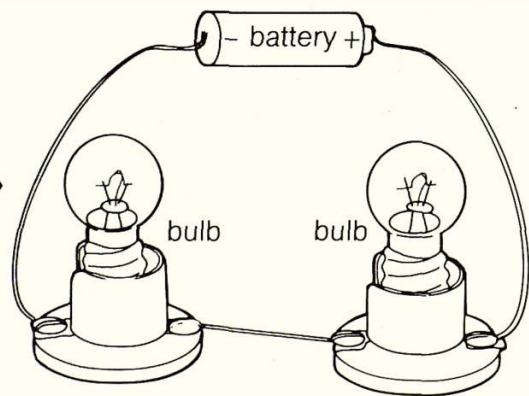
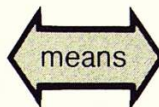
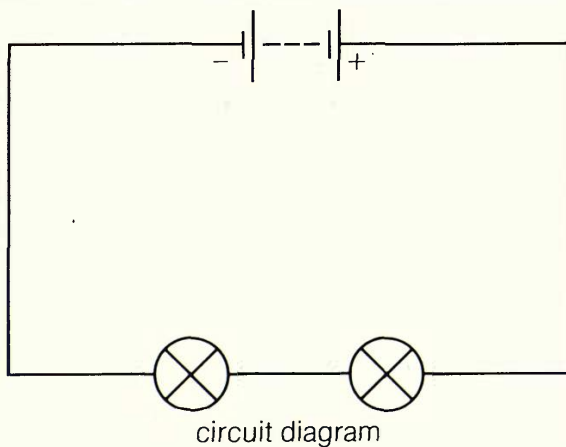
Information: Circuits and symbols


A **circuit diagram** is a quick and easy way of showing how to connect up a circuit. In a circuit diagram, a different **symbol** is used for each electrical **component**.

Here are some common symbols and the components they represent.

Symbol	Description
	bulb (or lamp)
	ammeter
	voltmeter
	switch
	rocker switch
	fuse

Symbol	Description
	resistor
	variable resistor (rheostat)
	a battery (d.c. power supply)
	coil
	electromagnet
	a.c. power supply



Q8 What does the symbol  stand for?

Q9 Make a drawing of the circuit diagram above, using an a.c. power supply in place of a battery.

2 Fuses

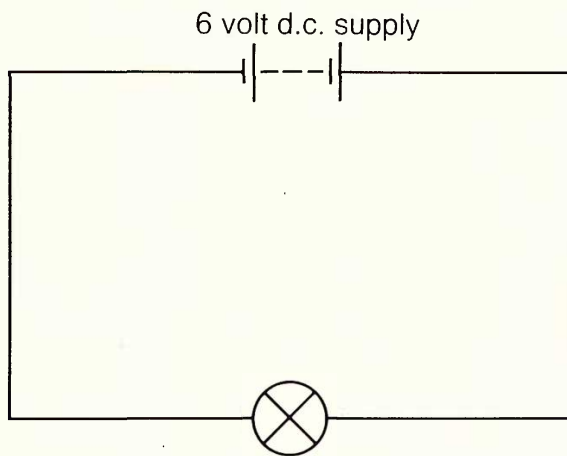
Checking a fuse

Apparatus

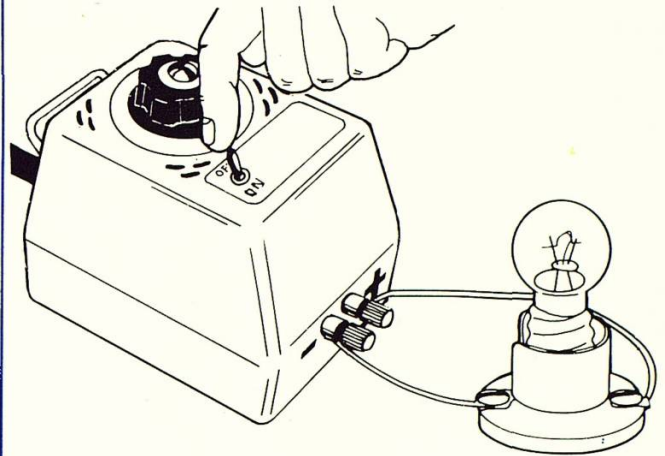
- ★ fuseholder
- ★ 1 A fuse
- ★ 12 V.0.1 A lamp in holder
- ★ wire
- ★ low voltage power supply

You are going to build a circuit to check a fuse.

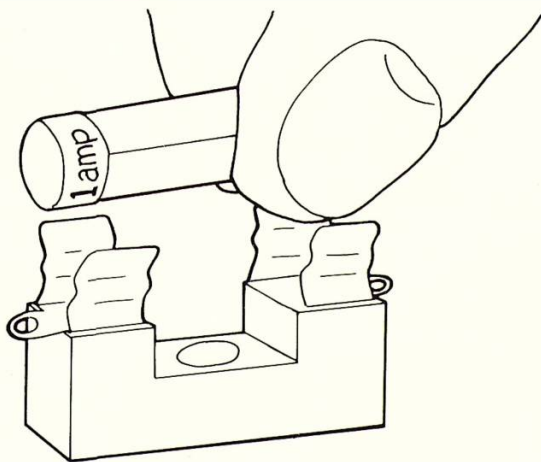
A Build this circuit. Use a low voltage power supply, set at 6 V.



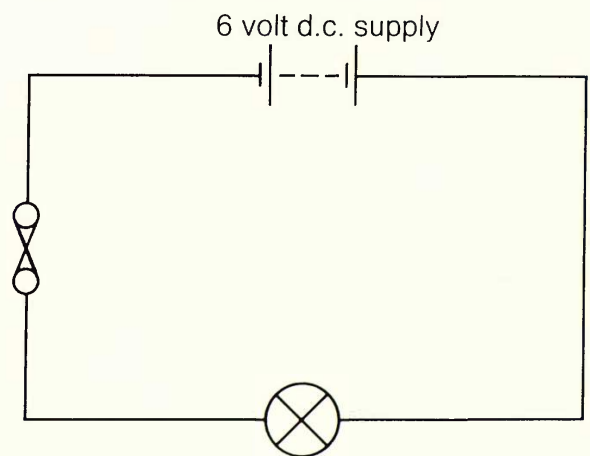
B Switch on the electricity. The lamp should light.



C Switch off the electricity. Put a 1 amp fuse into a fuseholder.



D Build this circuit. Switch on the electricity. Watch what happens to the lamp.



Q1 Draw the final circuit diagram.

Q2 If the fuse was **blown**, what would happen when the electricity was turned on?

Q3 What could you use instead of a lamp to check the fuse?

Fuses

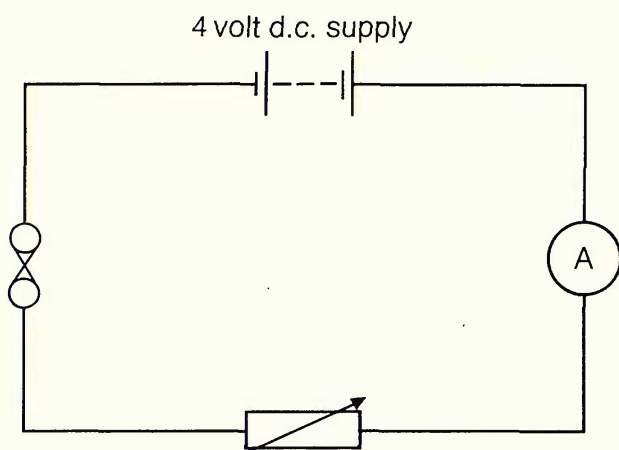
Finding the current at which a fuse blows

Apparatus

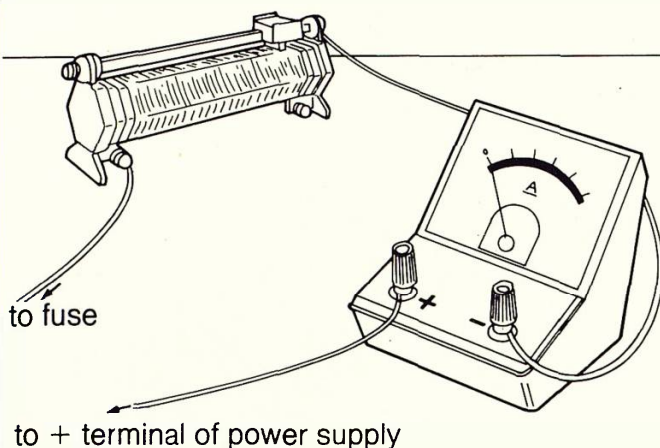
- ★ fuseholder
- ★ 1 A fuse
- ★ ammeter
- ★ rheostat (variable resistor)
- ★ wire
- ★ low voltage power supply

You are going to build a circuit and find the current that blows the fuse.

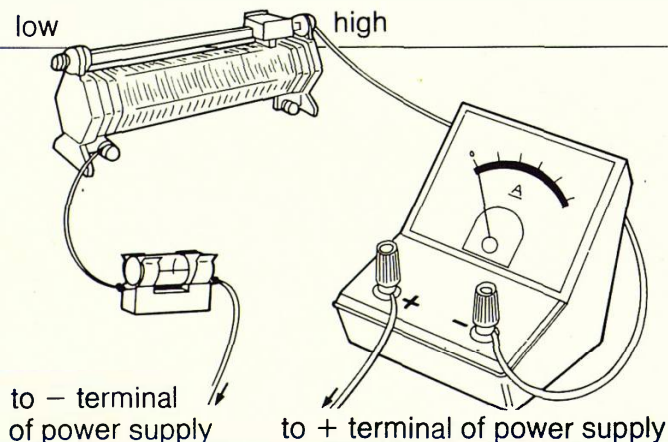
A Build this circuit. Do not switch on the electricity yet. Use a low voltage power supply, set to 4 volts.



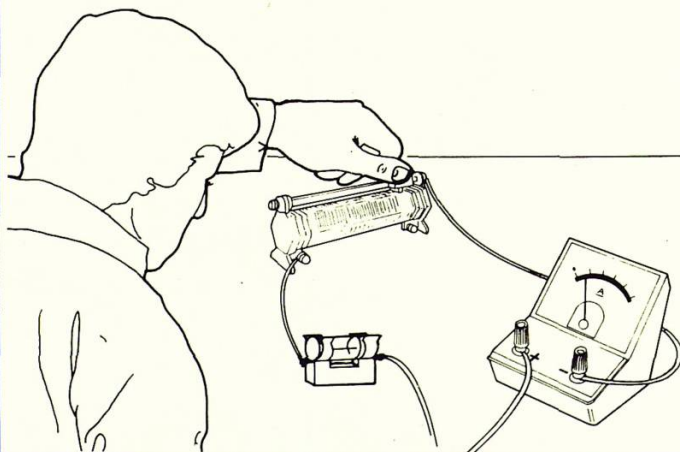
B Make sure the ammeter is wired up correctly, as shown.



C Set the rheostat to the highest resistance. Switch on the electricity. Move the slider on the rheostat a **short** distance. Read the ammeter.



D Reading the ammeter all the time, slowly move the slider to a lower resistance. When the fuse is overloaded, it will blow. Note this reading on the meter.



Q4 What happened to the reading on the ammeter when the fuse blew?

Q5 How much current will a 1 amp fuse let through before it blows?

Using a fuse with too high a current rating

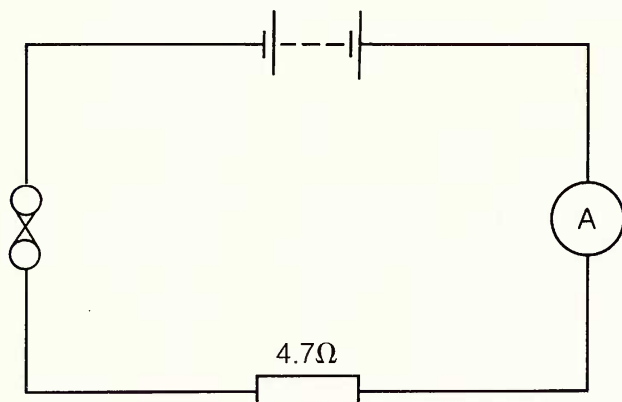
Apparatus

- ★ fuseholder ★ 5 A fuse ★ ammeter ★ 4.7 ohm resistor ★ wire
- ★ low voltage power supply ★ 2 crocodile clips ★ heatproof mat

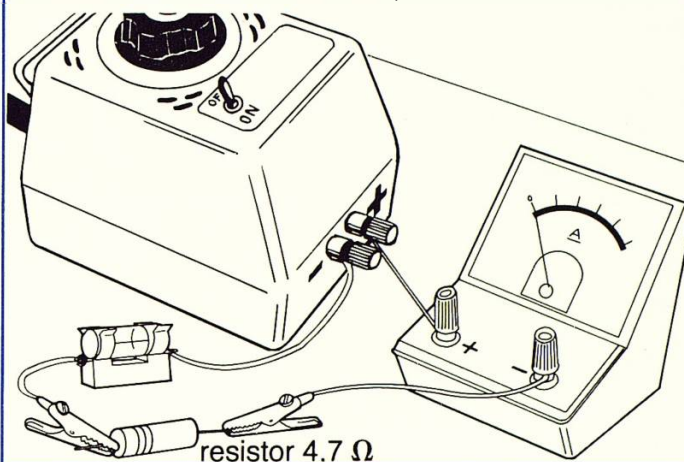
You are going to find out what happens when you use a fuse with too high a current rating.

- A** Build this circuit. Do not switch on the electricity yet. Put a 5 amp fuse in a fuseholder.

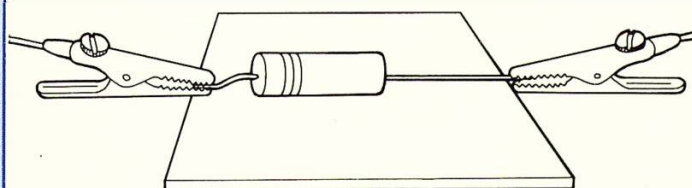
12 volt d.c. supply



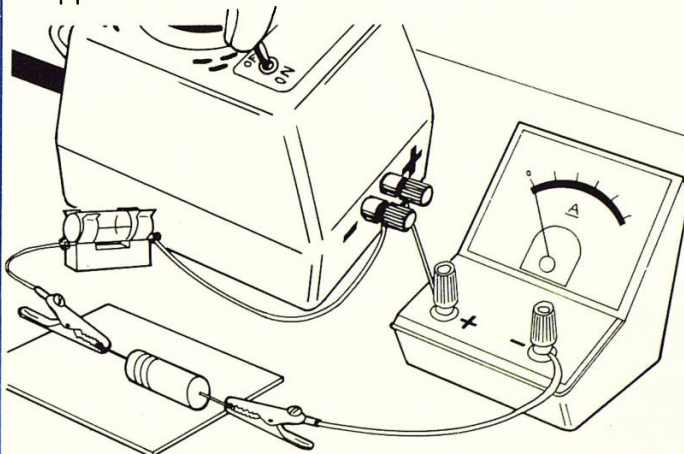
- B** Check that the voltage is set to 12 V. Make sure the ammeter is wired up, as shown.



- C** Put a heatproof mat under the resistor.



- D** Switch on the electricity. Watch what happens to the ammeter and resistor.



Q6 Draw the circuit diagram.

Q7 How much current flowed around the circuit when you switched on?

Q8 What happened to the resistor?

Q9 Did the fuse protect the resistor?

Fuses

Information: Fuses

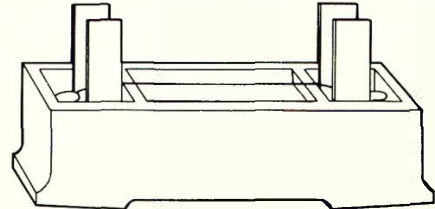
Fuses are put into electrical circuits for safety. Under normal conditions, a fuse does not affect the current flowing in a circuit.

A fuse is a thin piece of wire. It melts if too much current passes through it. This stops the current flowing to the appliance. A 5 amp fuse will **blow** (melt) if more than 5 amps pass through it. The level at which a fuse blows is called its **current rating**.



cartridge fuse

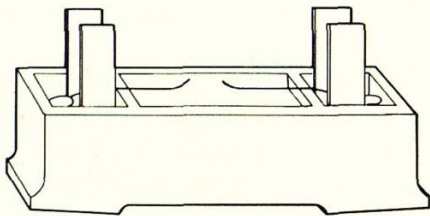
There are two types of fuse. One is a cartridge fuse. If this blows it has to be replaced. The other type has renewable fuse wire.



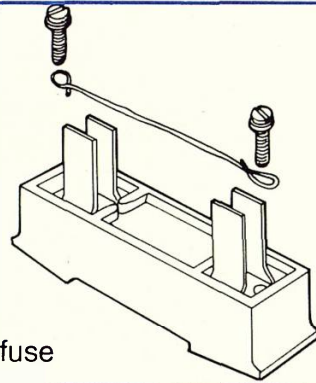
fuse with renewable wire

In modern houses, fuses are found in plugs (cartridge fuses) and in the fuse box (several renewable fuses).

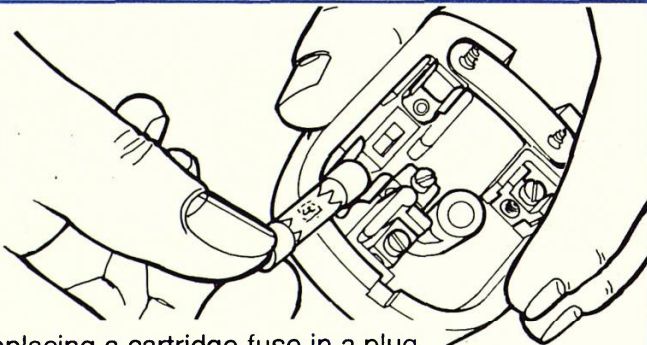
Replacing a fuse



blown fuse



repairing a fuse



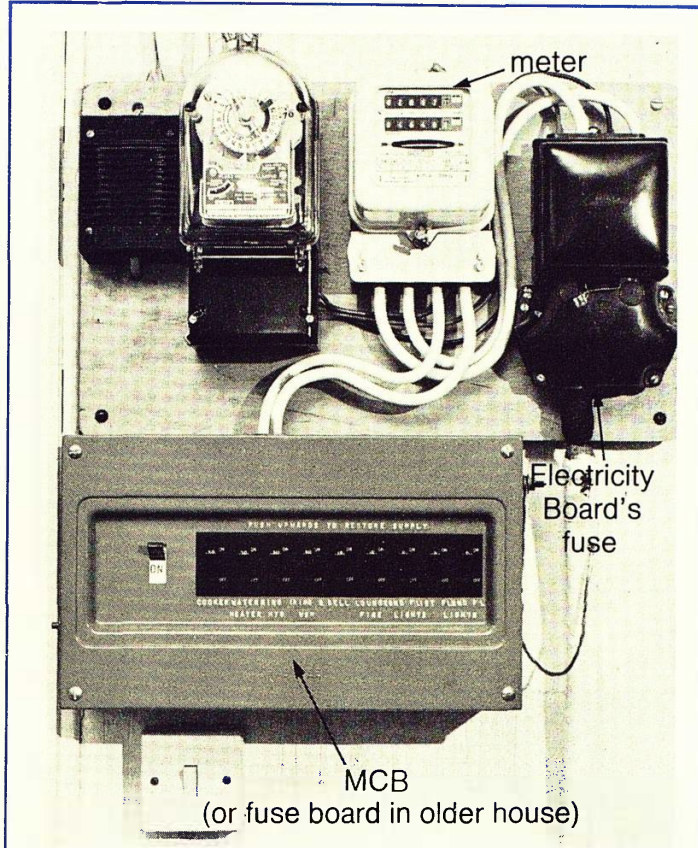
replacing a cartridge fuse in a plug

A fuse blows if something is wrong with the circuit. For example, the circuit may be overloaded with too many electrical appliances. When the fault has been put right, the fuse can be replaced or repaired.

Q10 What is the job of a fuse?

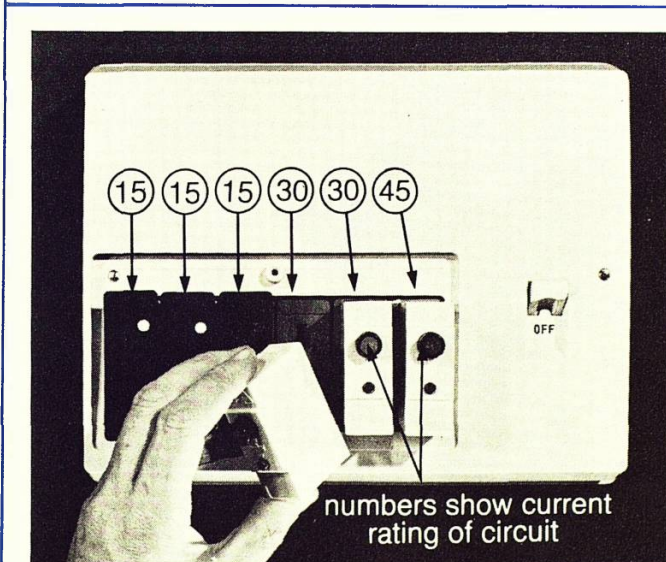
Q11 What would happen if a 5 amp fuse was used to protect an appliance which took 7 amps?

Information: Fuses and circuit breakers

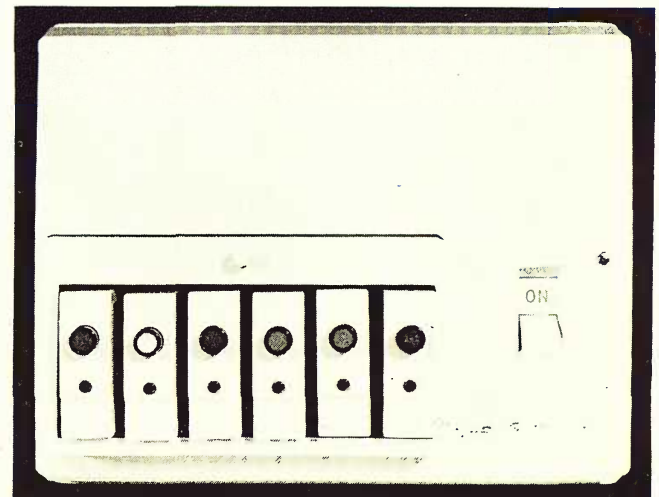


In most houses, there is a set of fuses on a board near the mains switch. In the modern system of wiring, each fuse controls one part of the system. For example, one fuse controls the electricity to all the downstairs lights.

Many modern homes now have **miniature circuit breakers** (MCB) instead of fuses. These are easier to use. If the circuit is overloaded, the circuit breaker will automatically switch off that circuit. The fault in the circuit has to be put right. Then the circuit breaker can be switched back on by hand.



These photos show another type of modern circuit breaker. If a circuit is overloaded, its circuit breaker pops out.



When the fault has been put right, the circuit breaker can be put back into place and the current switched back on.

Q12 What do the numbers on the circuit breakers show?

Q13 Why are circuit breakers easier to use than fuses?

Fuses

Information: Which fuse should I use?

The current rating of the fuse needed to protect an electrical appliance can be calculated. This is done by dividing the power (in watts) of the appliance by the mains voltage (240 V). The power (in watts) is usually given somewhere on an electrical appliance. The result of the calculation gives the current (in amps) the appliance uses.

For example, a 3 kW (3000 watts) heater draws

$$\frac{3000}{240} = 12\frac{1}{2} \text{ amps}$$

The heater will need a 13 amp fuse in the plug. If you are in doubt about the correct fuse to use, read the manufacturer's instructions for the appliance.



Q14 What would happen if a 3 A fuse was used in the plug attached to an electric fire?

Q15 Many plugs are sold with 13 A fuses already in them. Why should you change this fuse if you want to use the plug for a record player?

Q16 With a mains voltage of 240 V, calculate the correct fuse to use with a 2.4 kW storage radiator.

3 Household lighting circuits

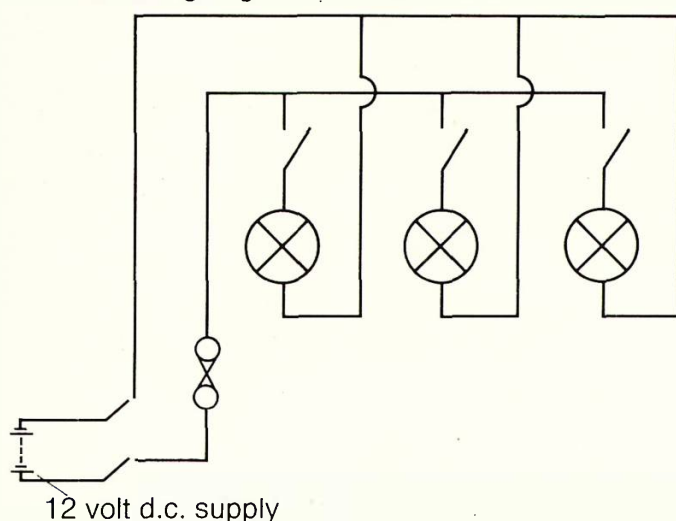
Building a model of a household lighting circuit

Apparatus

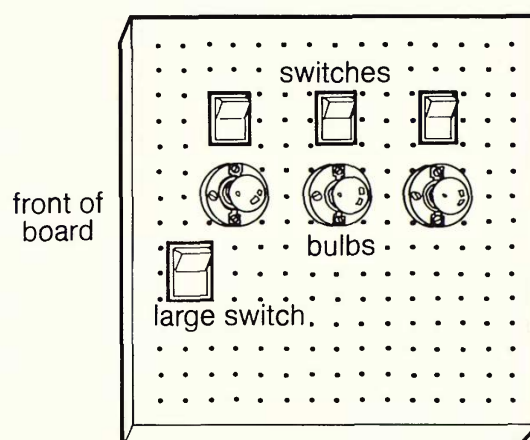
- ★ large circuit board
- ★ three 12 V bulbs in holders
- ★ 1 A fuse
- ★ scissors
- ★ fuseholder
- ★ 3 small rocker switches
- ★ large 2-way rocker switch
- ★ brown wire
- ★ blue wire
- ★ 6 plastic junctions
- ★ low voltage power supply
- ★ wire strippers
- ★ screwdriver
- ★ nuts and bolts

You are going to build a model household lighting circuit. This activity may take several lessons to complete.

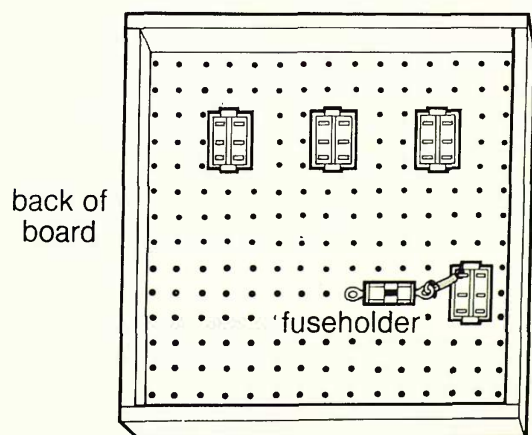
A You are going to build this circuit.



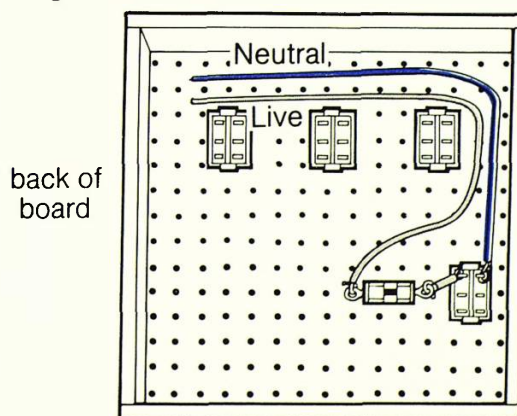
B Put the rocker switches and bulbs (in holders) in place on the circuit board, as shown. Fix them to the board with nuts and bolts.



C Fix a fuseholder in place underneath the board, as shown. Join the fuseholder to the large rocker switch with brown wire.

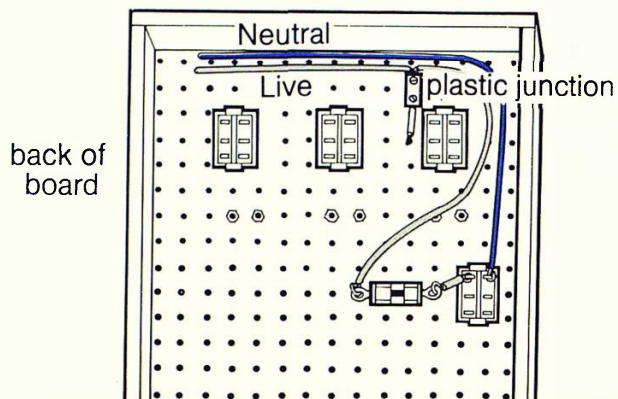


D Fix a piece of brown wire to the fuseholder. It must reach round the board to the last switch. Fix a piece of blue wire the same length to the rocker switch.

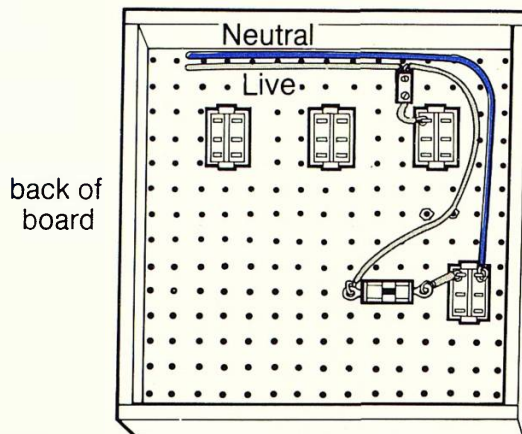


Household lighting circuits

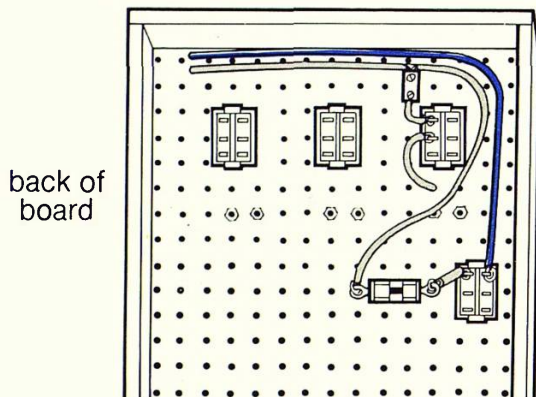
E Cut the Live (brown) wire in front of the first small switch. Fix the cut ends to a plastic junction. Join a short piece of brown wire to the other end of the junction.



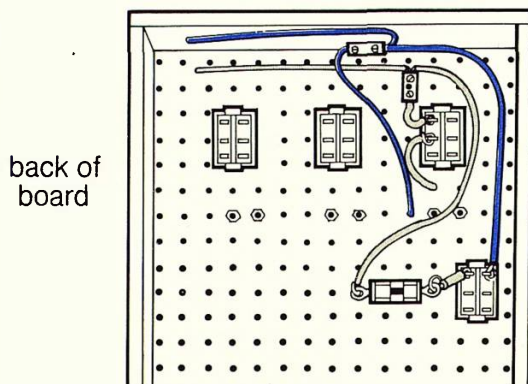
F Fix the other end of the short brown wire to the first small rocker switch.



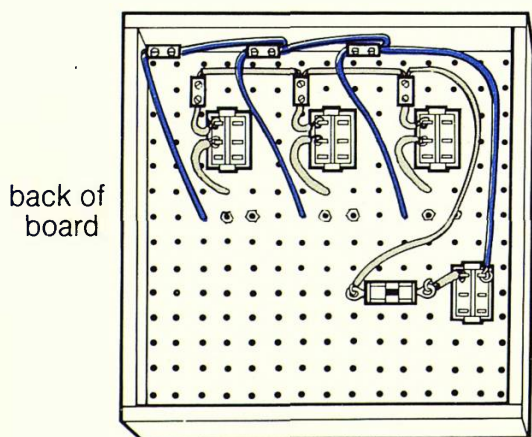
G Join the first small rocker switch to the first bulb with a short piece of brown wire. You will have to thread the wire through holes in the board.



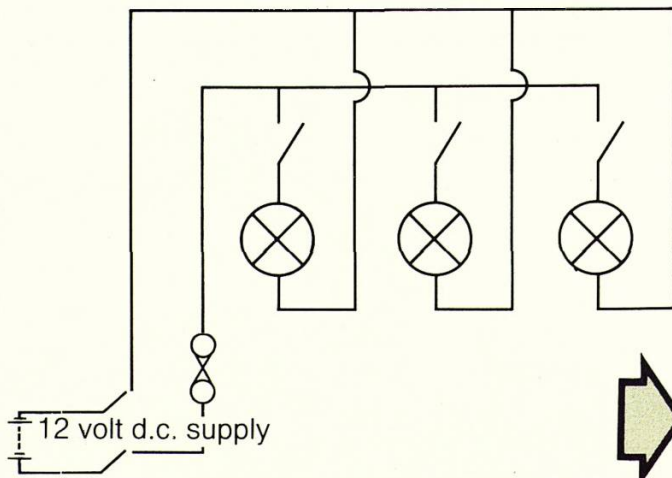
H Cut a piece of blue wire long enough to join the first bulb to the Neutral wire above it. Use a plastic junction to make the connection as you did in steps E and F.



I Repeat steps E to H to join up the other bulbs and single switches, as shown.

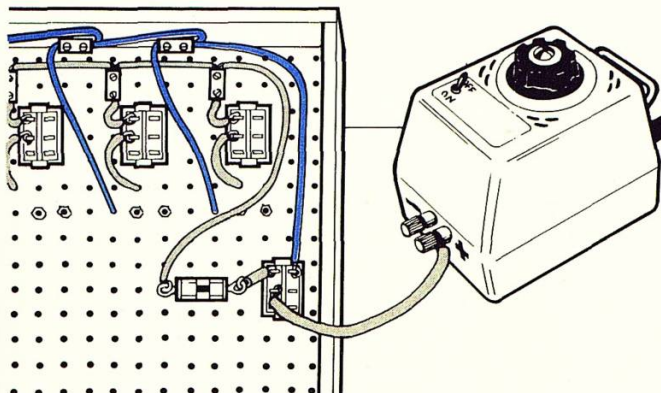


J Check your wiring against this circuit diagram.

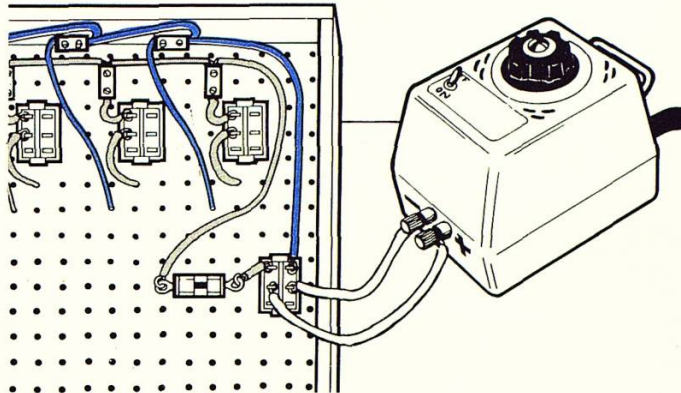


Household lighting circuits

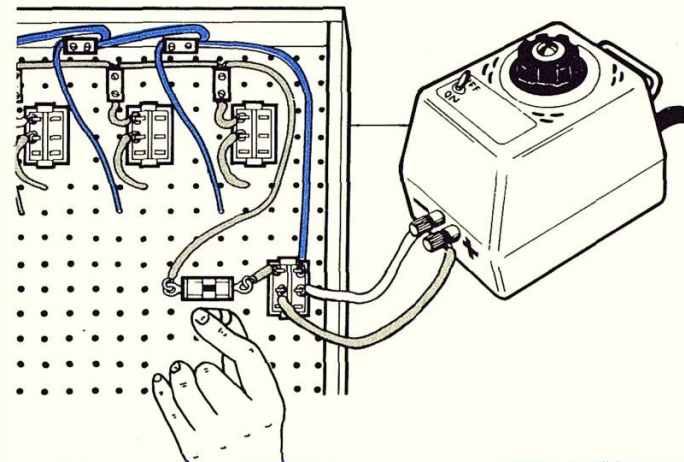
K Set the voltage on the power supply at 12 V. Do not switch on yet. Fix a length of wire from the large rocker switch to the positive (+) terminal of the power supply. Make sure the rocker switches are off.



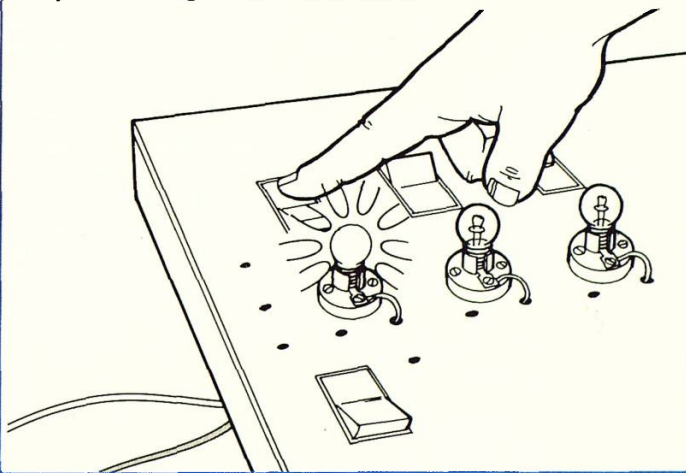
L Fix a length of wire from the large rocker switch to the negative (-) terminal of the power supply.



M Put a 1 amp fuse into the fuseholder. Check your circuit for neatness and accuracy of the wiring.



N Switch on the power supply. Switch on the large rocker switch. Then switch on the small rocker switches, one at a time. Watch the bulbs. Try switching different bulbs on and off.



Disconnect the power supply. Keep the circuit board wired up for the next experiment.

Q1 Draw the circuit diagram of the completed circuit.

Q2 What happens if you turn off the large rocker switch?

Q3 What does it mean if the fuse blows?

Q4 What is the largest current the circuit can take?

Q5 Why should switches always be connected between the bulb and the power supply?

Q6 If you put a 5 amp fuse in place of the 1 amp fuse, would the circuit still work?

Q7 Why is a 5 amp fuse unsuitable for this circuit?

Household lighting circuits

Investigating the lighting circuit (1)

Apparatus

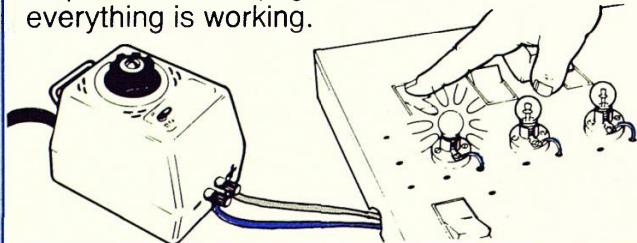
- ★ circuit board from the last experiment
- ★ wire
- ★ ammeter
- ★ scissors
- ★ low voltage power supply
- ★ wire strippers
- ★ screwdriver

You are going to find out how the current flows in a household lighting circuit.

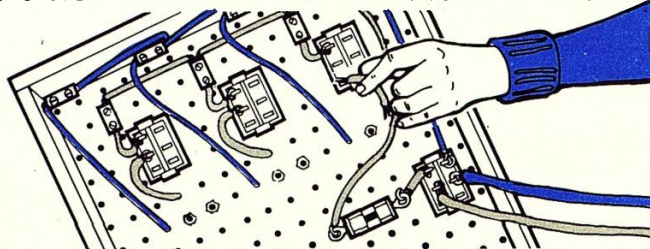
Q8 Copy this table.

Bulb number	Current passing (amps)
-------------	------------------------

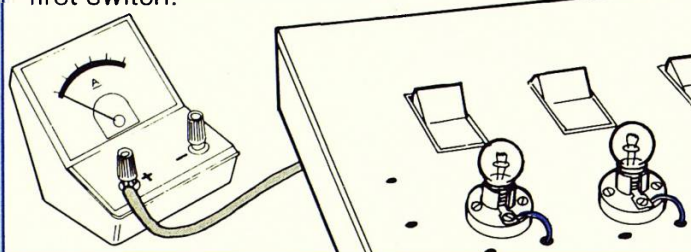
A Set a power supply to 6 V. Connect your circuit board to the power supply, as you did in steps K and L on page 13. Switch on and check everything is working.



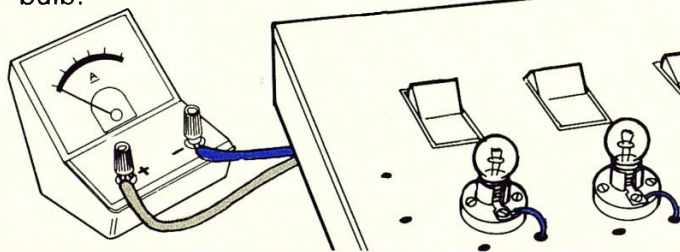
B Switch off the electricity. Switch off all the switches. Disconnect the power supply. Take out the brown wire between the first bulb and switch.



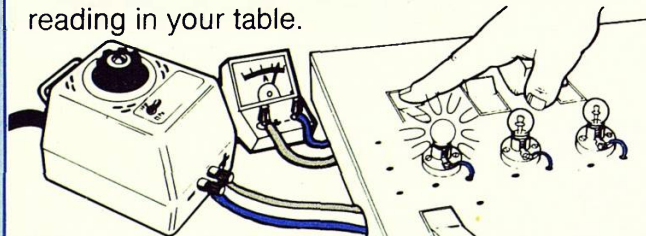
C Use a long piece of brown wire to connect the positive (+) terminal of an ammeter to the first switch.



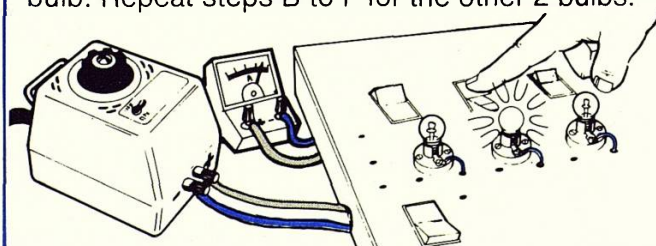
D Use a long piece of blue wire to connect the negative (-) terminal of the ammeter to the first bulb.



E Reconnect the power supply to the circuit board. Switch on the power. Switch on the first rocker switch. Read the ammeter. Record the reading in your table.



F Switch off the electricity. Disconnect the ammeter. Reconnect the first switch to the first bulb. Repeat steps B to F for the other 2 bulbs.



Q9 What do you notice about the three readings?

Q10 What do you notice about the brightness of the bulb when the power supply is set to 6 V and not 12 V as on page 13?

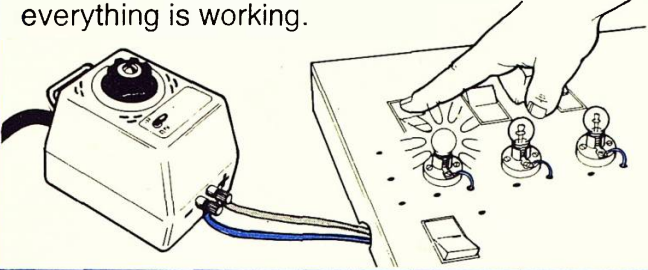
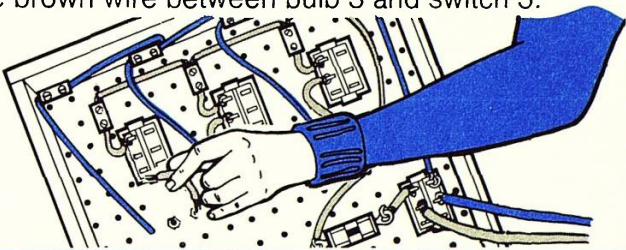
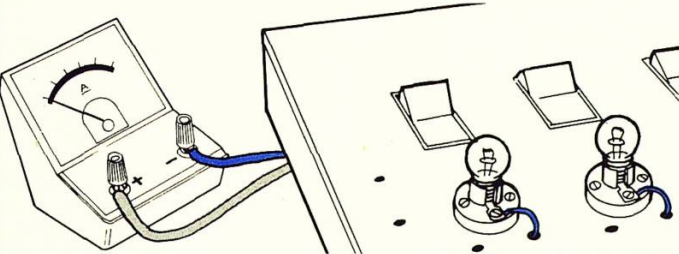
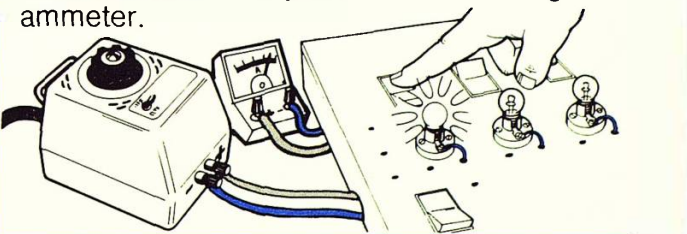
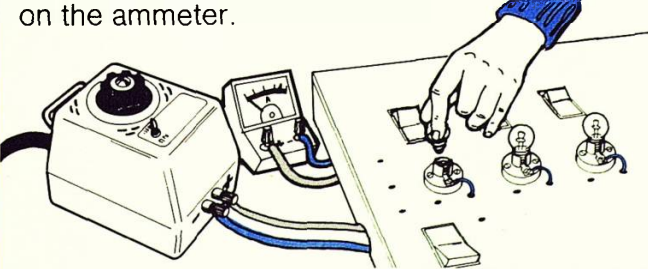
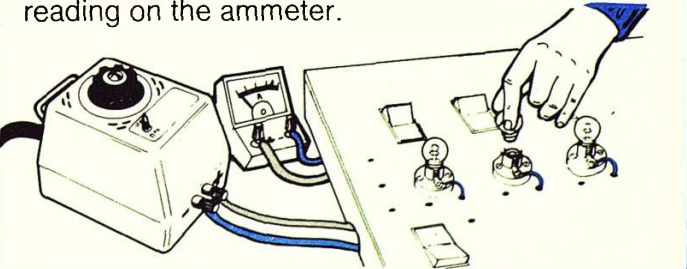
Investigating the lighting circuit (2)

Apparatus

- ★ your circuit board from the last experiment
- ★ wire
- ★ ammeter
- ★ low voltage power supply
- ★ scissors
- ★ wire strippers
- ★ screwdriver

You are going to find out how the current is affected by the number of bulbs connected.

Q11 Copy this table.

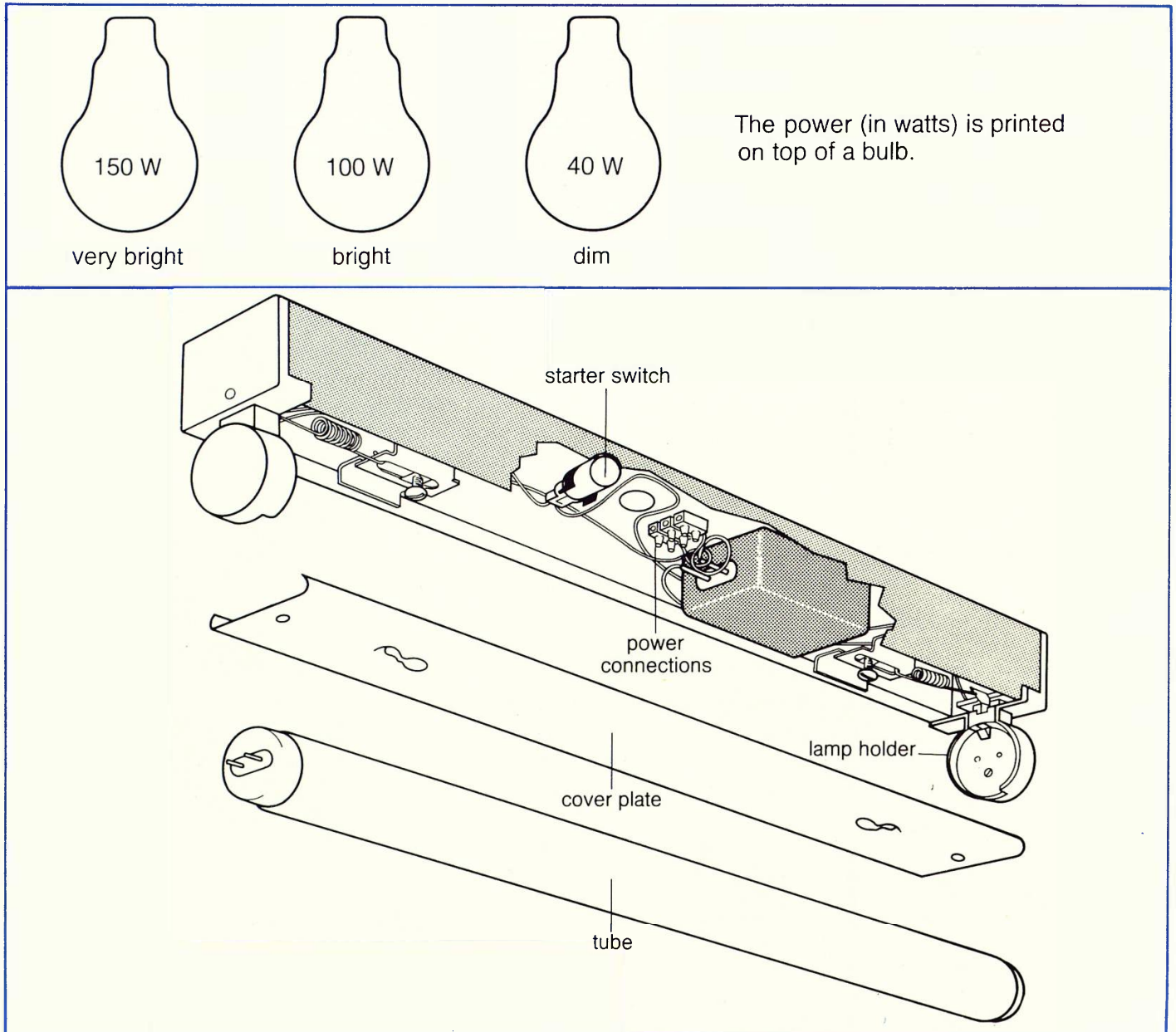
Number of bulbs connected in the circuit	Current passing (amps)
<p>A Set a power supply to 6 V. Wire your circuit board to the power supply. Switch on and check everything is working.</p> 	<p>B Switch off the electricity. Switch off all the switches. Disconnect the power supply. Take out the brown wire between bulb 3 and switch 3.</p> 
<p>C Connect an ammeter between bulb 3 and switch 3 as you did in steps C and D on page 14.</p> 	<p>D Reconnect the board to the power supply. Switch on the electricity and all the rocker switches. Record in your table the reading on the ammeter.</p> 
<p>E Switch off the electricity. Take out the first bulb. Switch on. Record in your table the reading on the ammeter.</p> 	<p>F Switch off the electricity. Take out the second bulb. Switch on. Record in your table the reading on the ammeter.</p> 

Q12 What happened to the reading on the ammeter after you removed bulb 1?

Q13 As you took out more bulbs, did the current get bigger, smaller or stay the same?

Household lighting circuits

Information: Light power



Fluorescent lights are glass tubes coated on the inside with a special chemical. When the electricity is switched on it makes the chemical glow. Fluorescent tubes last longer than ordinary lamps. They also give out more light. A 60 W lamp is quite dim. A 60 W fluorescent tube is enough to light a kitchen. The electrical parts needed to make a fluorescent tube glow are quite complicated. If a fluorescent light goes wrong, and the ends of the tube are not blackened, it is quite likely to be only the starter switch that needs replacing.

Q14 How many 100 W light bulbs would it take to use as much electricity as a 1 kW fire?

Q15 What are the advantages of fluorescent lighting?

4 Household power circuits

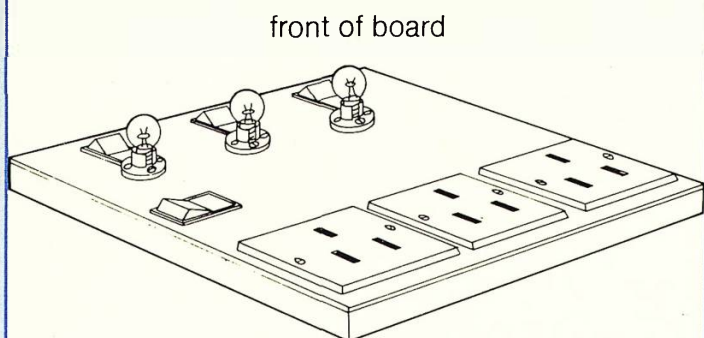
Building a socket ring main circuit

Apparatus

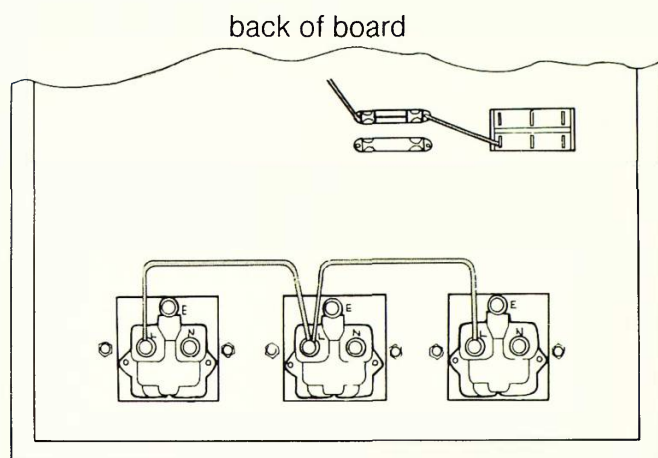
- ★ circuit board with completed lighting circuit
- ★ fuseholder
- ★ 3 amp fuse
- ★ 3 plastic junctions
- ★ 3-core flexible cable
- ★ 3 mains sockets
- ★ blue wire
- ★ brown wire
- ★ yellow/green wire
- ★ wire strippers
- ★ screwdriver
- ★ nuts and bolts
- ★ scissors

You are going to build a model socket ring main circuit.

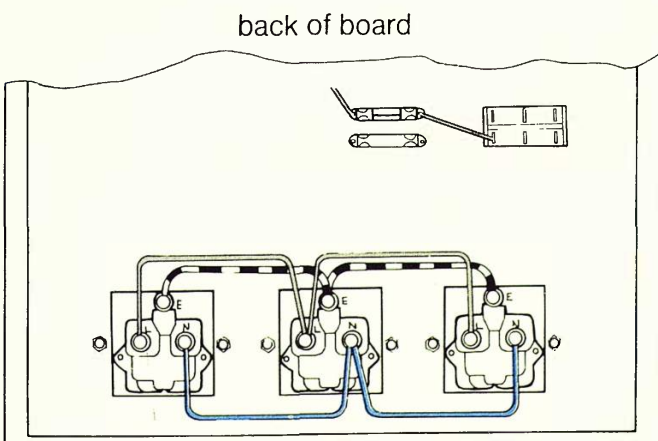
A Fit 3 sockets in place on the lower half of the circuit board. Fix them with nuts and bolts. Fix a fuseholder underneath the board next to the lighting circuit fuse.



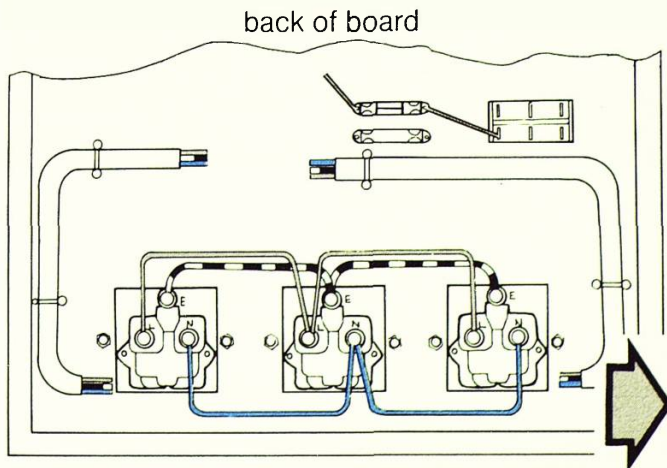
B Take off the backs of the sockets. Join the Live terminal of each socket to the Live terminal of the socket next to it with brown wire.



C Join the Neutral terminals of the sockets together with blue wire. Join the Earth terminals together with yellow/green wire.

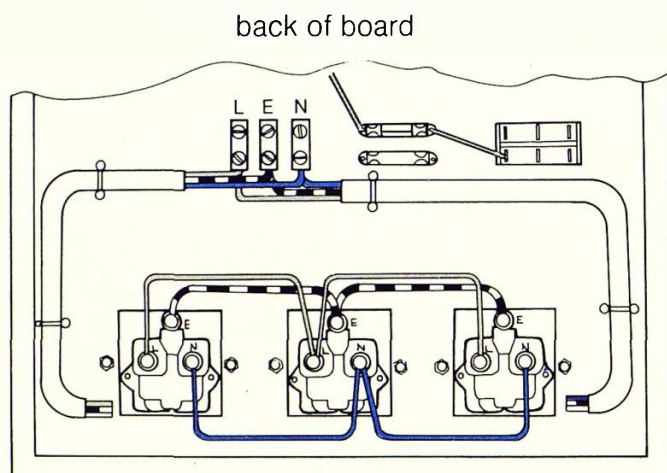


D Cut a length of 3-core cable to reach from the first socket to the fuseholder. Cut another length to reach from the third socket to the fuseholder. Fix the cables to the board, as shown.

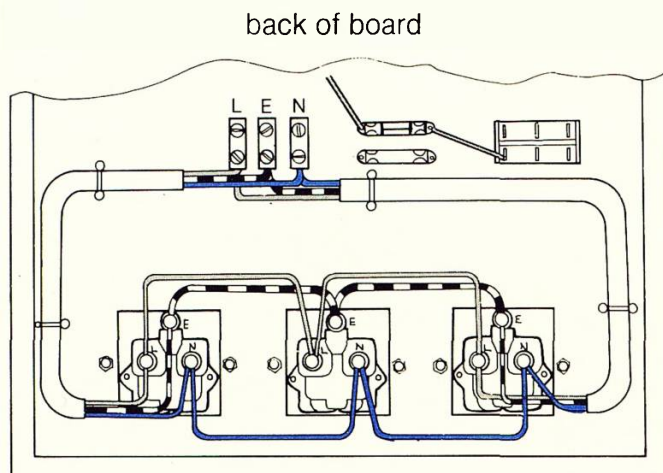


Household power circuits

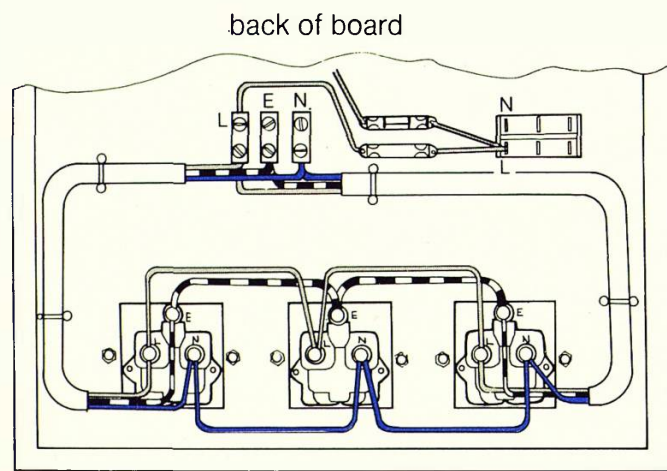
E Join the lengths of 3-core cable together near the fuseholder. Fix the 2 brown wires with one plastic junction, the blue wires with another and the green/yellow wires with a third plastic junction.



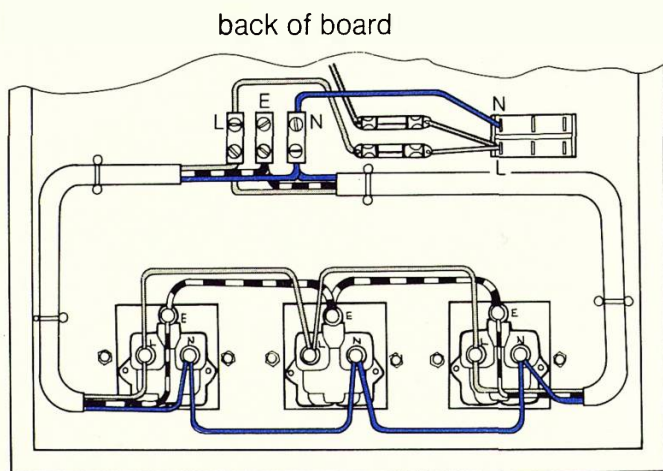
F Join the other ends of the 3-core cable to the first and third sockets. Make sure the wires go to the correct terminals.



G Join the brown wire from the plastic junction to the fuseholder with brown wire. Join the fuseholder to the Live terminal of the rocker switch with brown wire.



H Join the blue wire from the plastic junction to the Neutral terminal of the rocker switch with blue wire. Put the fuse in the fuseholder.



Keep the circuit board wired up to be tested in the next experiment.

Q1 Draw a circuit diagram for the circuit you have made.

Q2 What do the letters **L**, **N** and **E** on the back of a socket mean?

Q3 Why should you use a 3 amp fuse for the power circuit?

Q4 In a house what would the yellow/green Earth wire be fixed to?

Investigating the Live and Neutral circuits

Apparatus

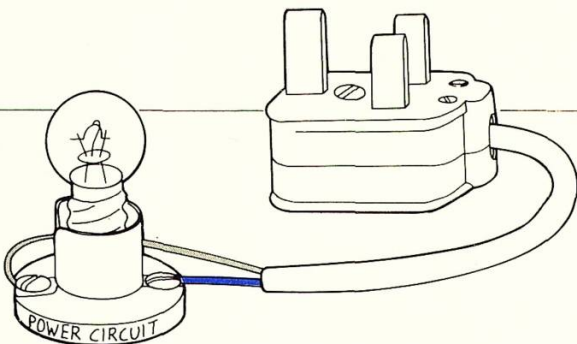
- ★ circuit board with lighting and power circuits wired up
- ★ three 24 W bulbs in holders
- ★ 2-core cable
- ★ wire strippers
- ★ three 3-pin plugs
- ★ ammeter
- ★ brown wire
- ★ blue wire
- ★ low voltage power supply
- ★ scissors
- ★ screwdriver
- ★ 3 labels

You are going to test the Live and Neutral parts of the socket ring main circuit.

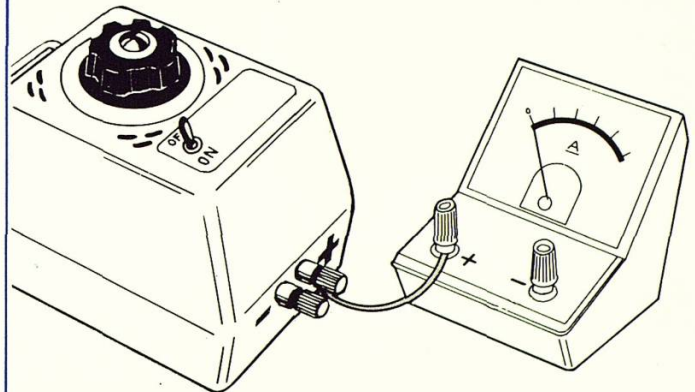
Q5 Copy this table.

Number of bulbs plugged in	Current passing (amps)
----------------------------	------------------------

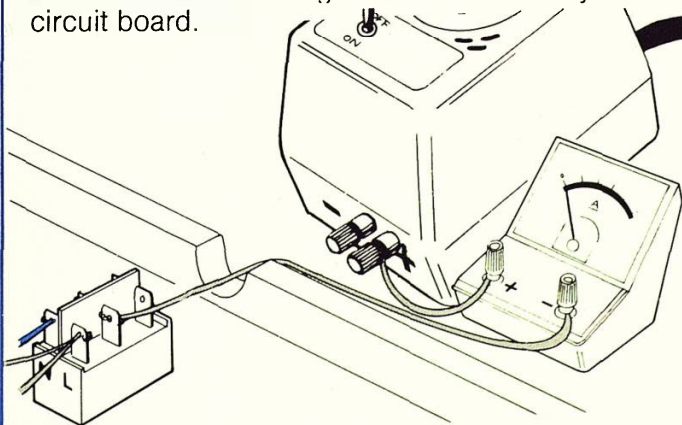
A Label each bulb holder **power circuit**. Connect each 24 W bulb to a 3-pin plug. Use 2-core cable. Only the Live and Neutral circuits are to be tested.



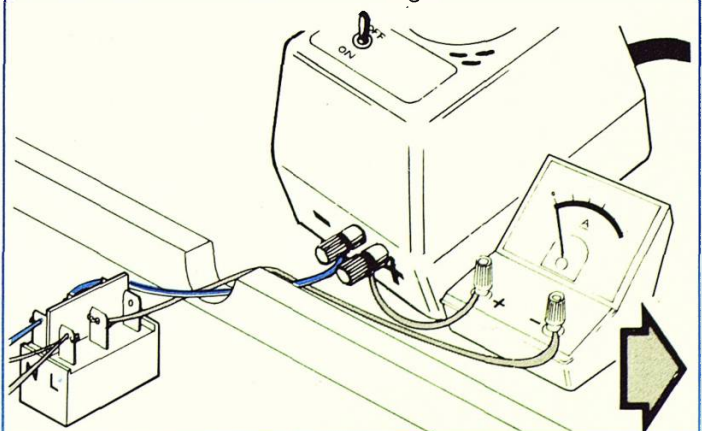
B Using brown wire, connect an ammeter to the positive (+) terminal of a low voltage power supply.



C Use a long piece of brown wire to connect the negative (-) terminal of the ammeter to the Live terminal of the large rocker switch on your circuit board.

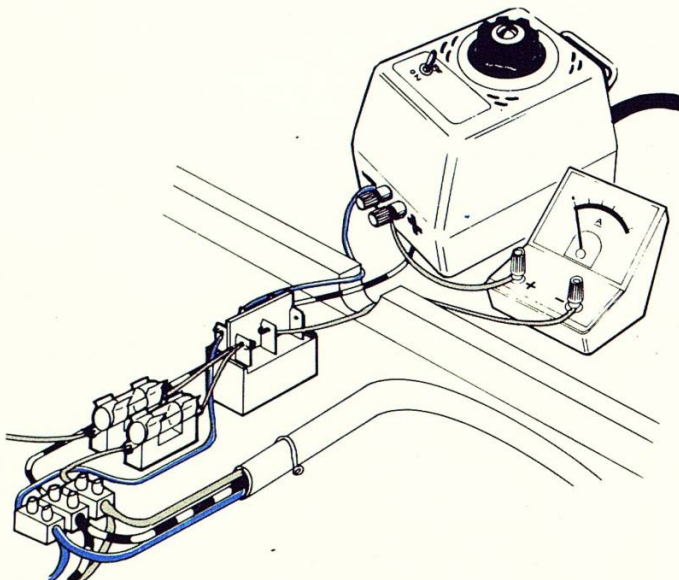


D Use blue wire to join the negative (-) terminal of the low voltage power supply to the Neutral terminal of the large rocker switch.

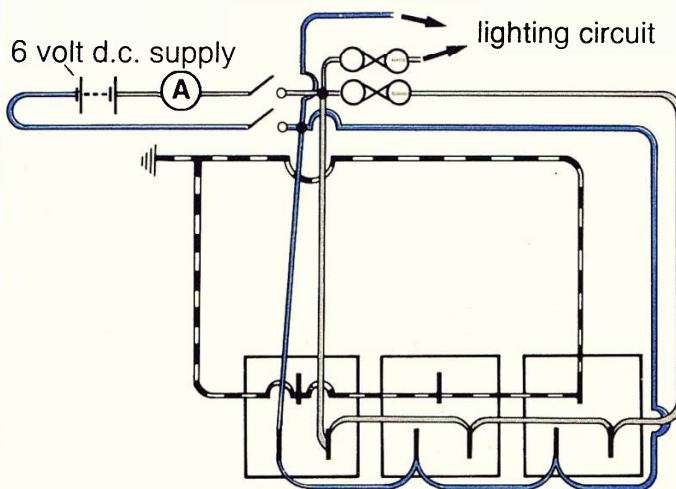


Household power circuits

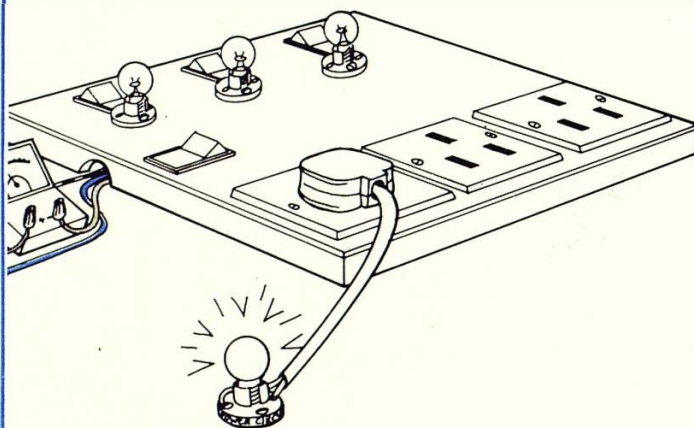
E Join the green/yellow wire from your power circuit on the circuit board to a suitable Earth point. The metal case of the power supply will do.



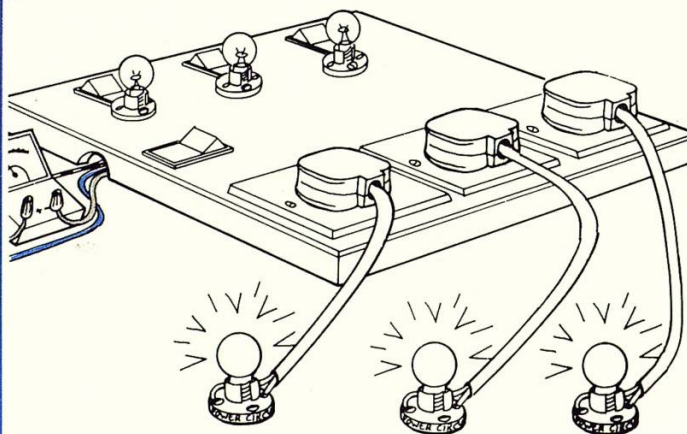
F Set the voltage on the low voltage power supply to 6 V. Check that the power circuit has a 3 A fuse. Check that the lighting circuit has a 1 A fuse. Use this diagram to check your wiring.



G Switch on the electricity. Plug a bulb into the first socket. Read the ammeter. Record the reading in your table.



H Plug in the second and third bulbs. Each time, record in your table the reading on the ammeter. Then switch on the lighting circuit as well. Read the ammeter.



Q6 What is the current if the power and lighting circuits are both switched on?

Q7 Does any current flow through the Earth wire?

Q8 Draw the circuit diagram for the power and lighting circuits.

Information: Power circuits

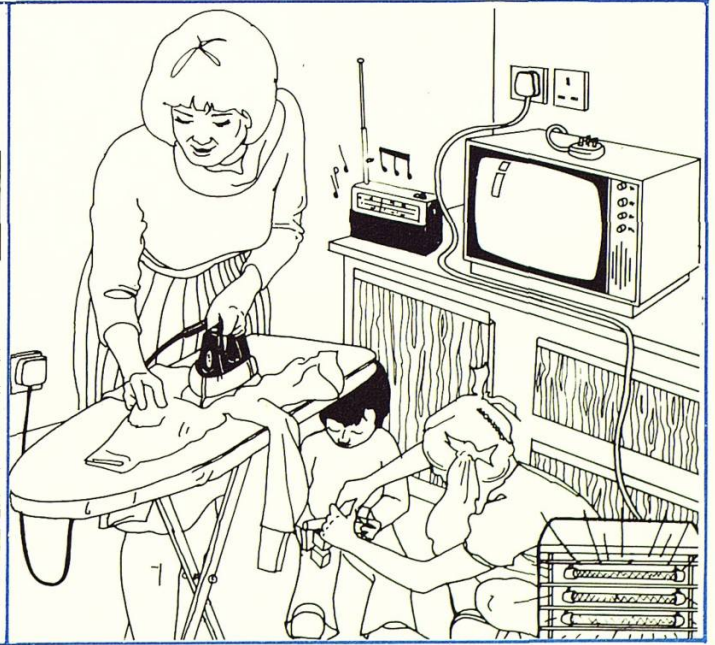
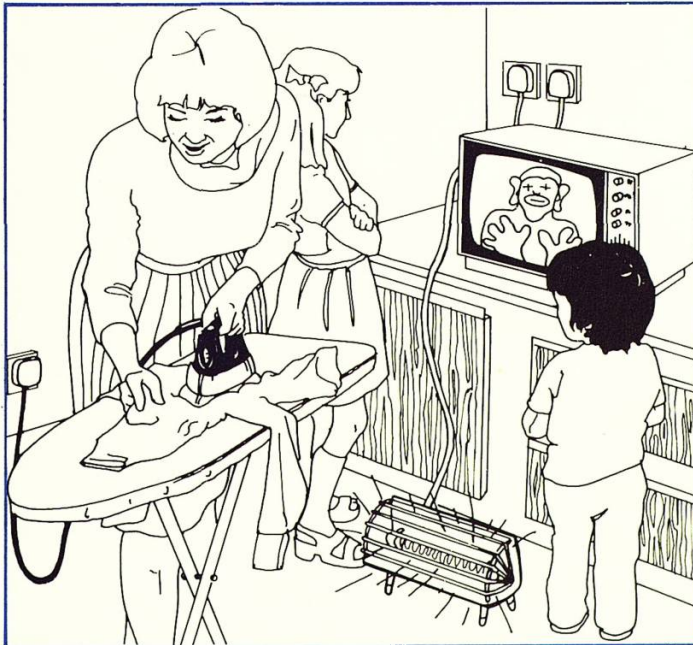
The sockets in a house are joined to power circuits. Each plug has a fuse. There must also be a fuse in the power circuit to protect the wiring behind the sockets. This is to stop the cable wires being overloaded by too many appliances, or from any other fault. If too much current passes through the circuit, the wires would get hot. Fires can be started by overloading circuits which have the wrong fuse protecting them.

If the power circuit cable can safely take 15 amps, it is protected by a 15 A fuse. The total power (watts) of the appliances used on the circuit must not be more than 3600 W (15×240).

This table is a guide to the power (in watts) of some common household appliances.

Appliance	Wattage
colour TV	105
iron	1200
1 bar electric fire	1000
hairdryer	350

Appliance	Wattage
record player	20
table lamp	60
3 bar electric fire	3000



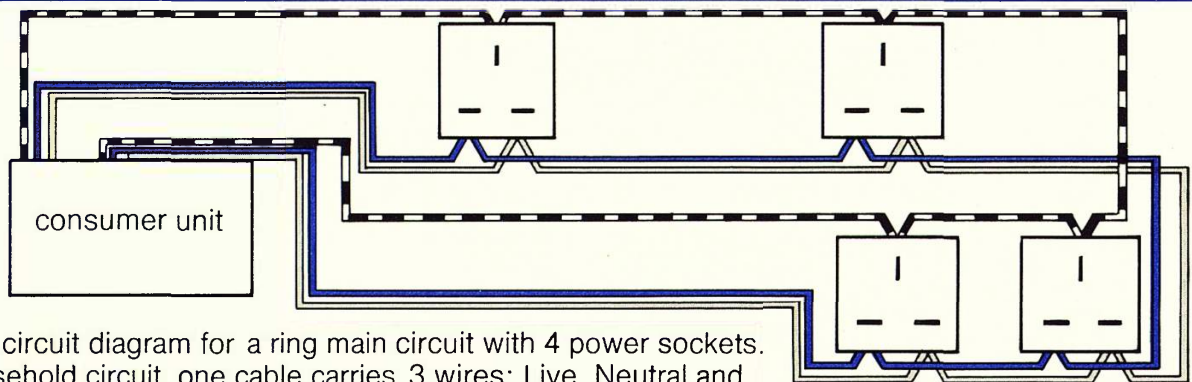
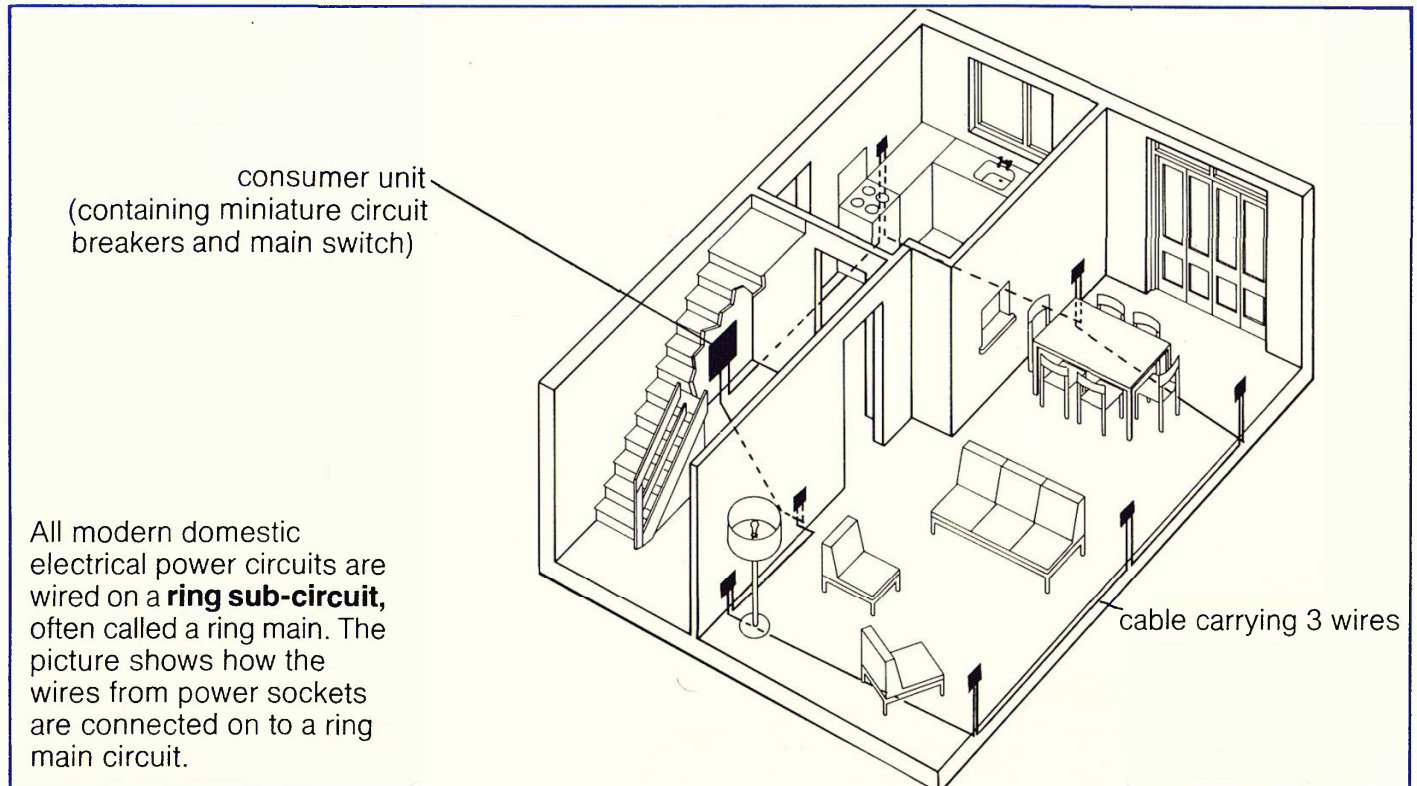
Look at these pictures. Then answer the questions

Q9 Would a 15 A power circuit fuse blow in either of the rooms shown above?

Q10 Explain your answer to Q9 by working out the total power (in watts) being used in each room. Use the table above to help you.

Household power circuits

Information: Household circuits—new and old



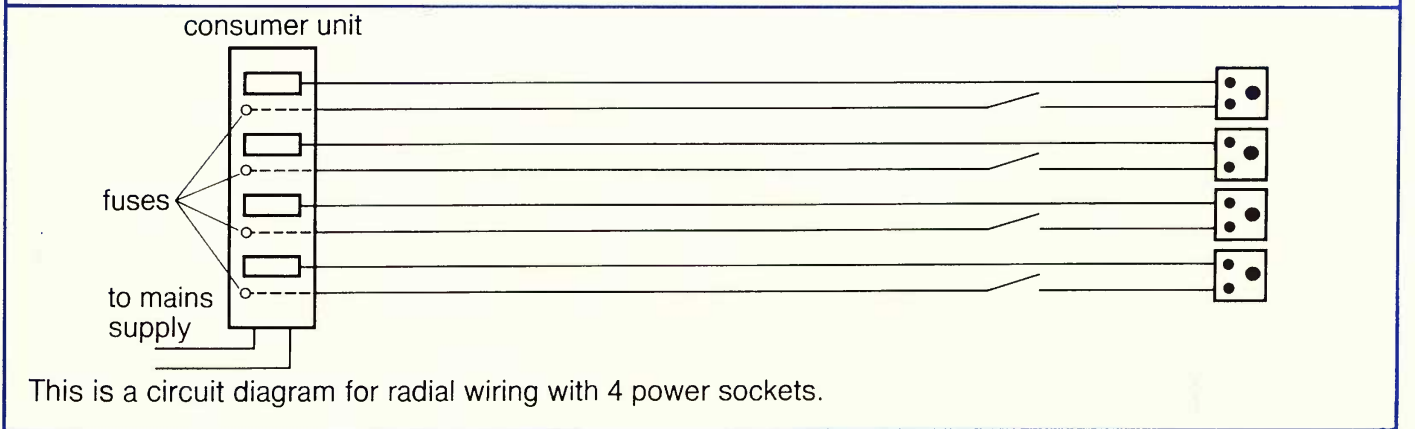
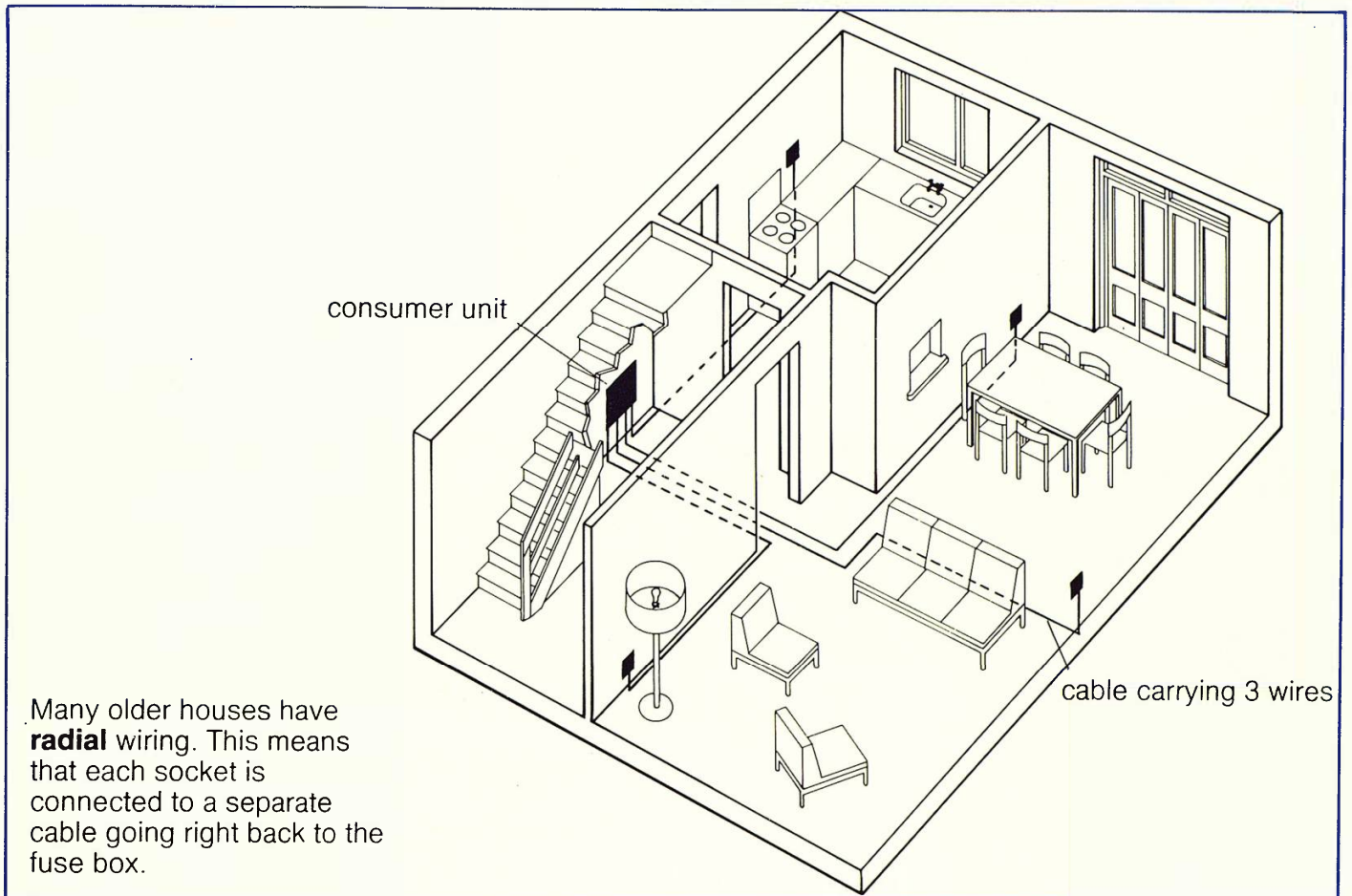
The main advantages of the ring sub-circuit are:

- 1 It generally uses less wire than older wiring systems.
- 2 It is easier to add extra sockets without major wiring.
- 3 Each plug has its own fuse.

Fuses and switches are always fitted in the Live wire of the circuit. This makes the circuit safe when switches are off or if a fuse blows.

A typical modern house would have 4 separate ring sub-circuits: one each for upstairs lights, downstairs lights, upstairs sockets and downstairs sockets. The cooker and immersion heater are wired separately on radial circuits because they draw very large currents.





Q11 Why should fuses and switches always be in the Live wire of the circuit?

Q12 Which type of circuit, radial or ring, uses more wire?

Q13 If a typical modern house has an electric cooker and an immersion heater, how many circuits would there be?

Q14 Why is it more difficult to add extra sockets on a radial wiring system than on a ring main?

5 Buzzers and bells

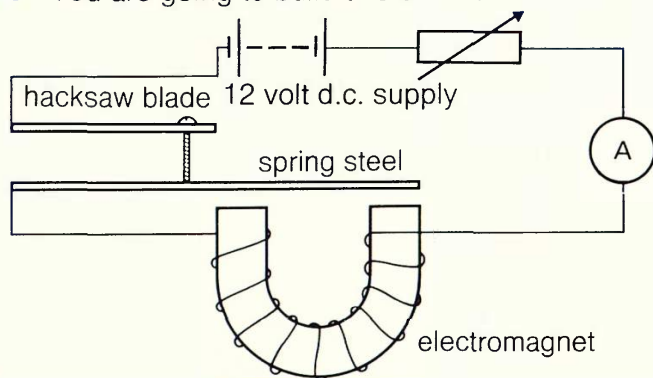
Making and investigating an electric buzzer

Apparatus

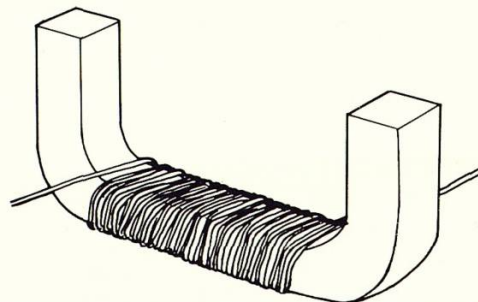
- ★ C-shaped piece of iron ★ rheostat ★ ammeter ★ crocodile clips
- ★ piece of hacksaw blade ★ 15 cm long piece of spring steel ★ G clamp
- ★ low voltage power supply ★ 50 cm × 25 cm (approx) piece of wood
- ★ clamp boss and stand ★ thin wire ★ thick wire ★ nut and bolt

You are going to make an electric buzzer and find out how it works.

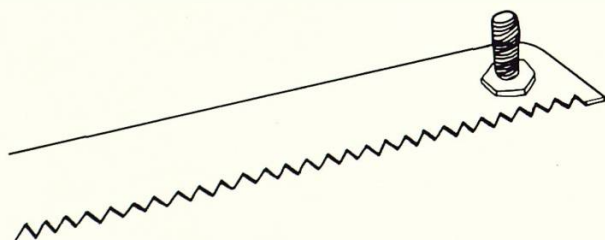
A You are going to build this circuit.



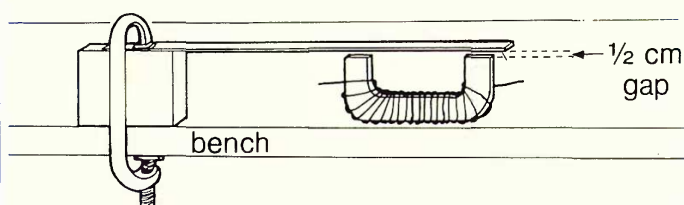
B Wind some thin wire 30 times around a C-shaped piece of iron. Leave a length of wire free at each end. This makes an **electromagnet**.



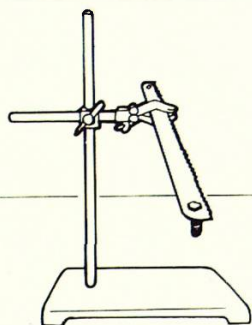
C Put a bolt through the hole in a piece of hacksaw blade. Fix it in place with a nut.



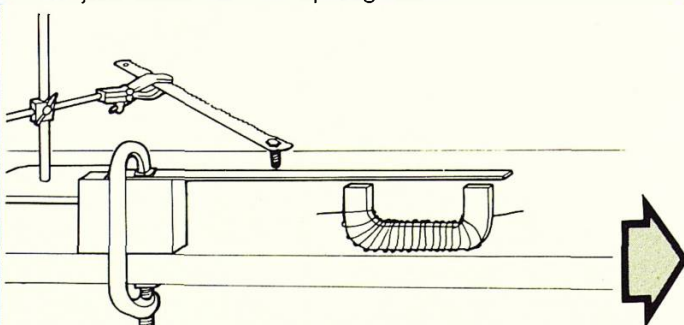
D Use a G-clamp to fix one end of the spring steel to a wooden block on the bench. Put the electromagnet under the other end of the steel.



E Put the hacksaw blade in a clamp. Attach the clamp to a boss and stand.

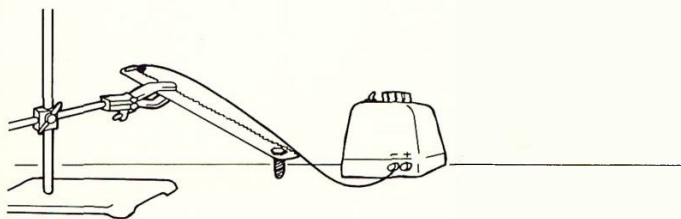


F Move the hacksaw blade up or down until the bolt just touches the spring steel.

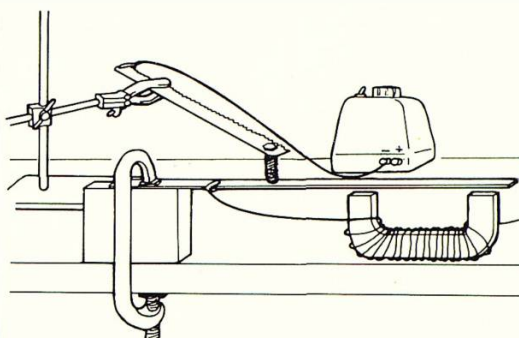


Buzzers and bells

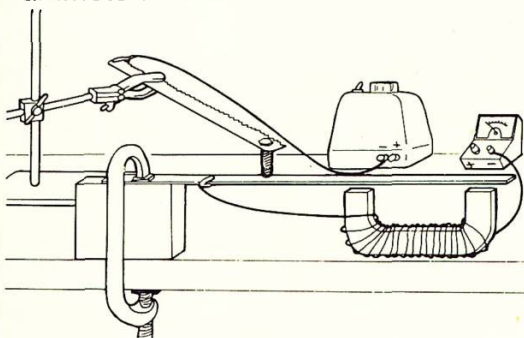
G Set a low voltage power supply to 12 V d.c. Do not switch it on yet. Using thick wire, join the negative (–) terminal of the power supply to the hacksaw blade.



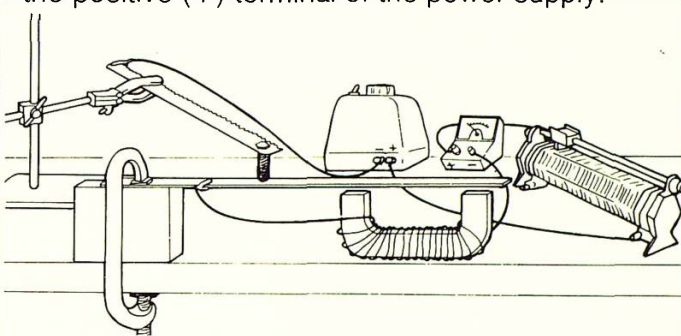
H Join the wire from the electromagnet to the spring steel. Fix it in place with a crocodile clip.



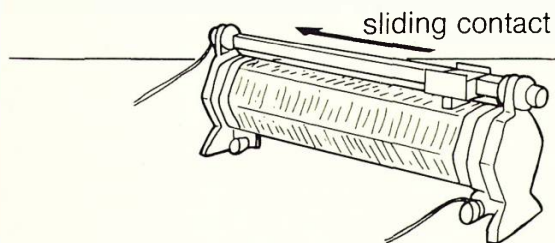
I Join the other end of the wire from the electromagnet to the negative (–) terminal of an ammeter.



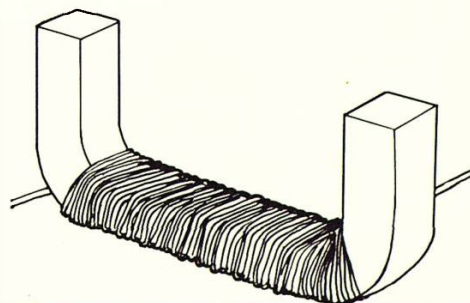
J Using thick wire, join the positive (+) terminal of the ammeter to a rheostat. Join the rheostat to the positive (+) terminal of the power supply.



K Set the rheostat to its **highest resistance**. Switch on the electricity. Slowly push the sliding contact on the rheostat until the buzzer buzzes.



L Switch off the electricity. Disconnect the electromagnet. Wind the wire around the electromagnet 20 more times. Repeat the experiment.



Q1 Draw the circuit diagram.

Q2 What happened when the electricity was switched on?

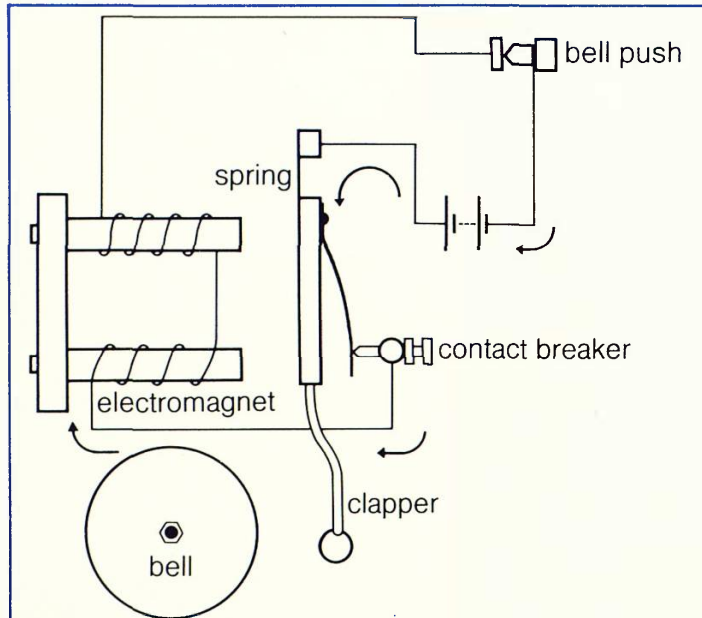
Q3 What happened when the current was increased (when you pushed the sliding contact along the rheostat)?

Q4 What happened to the buzzer when you wound more wire around the electromagnet?

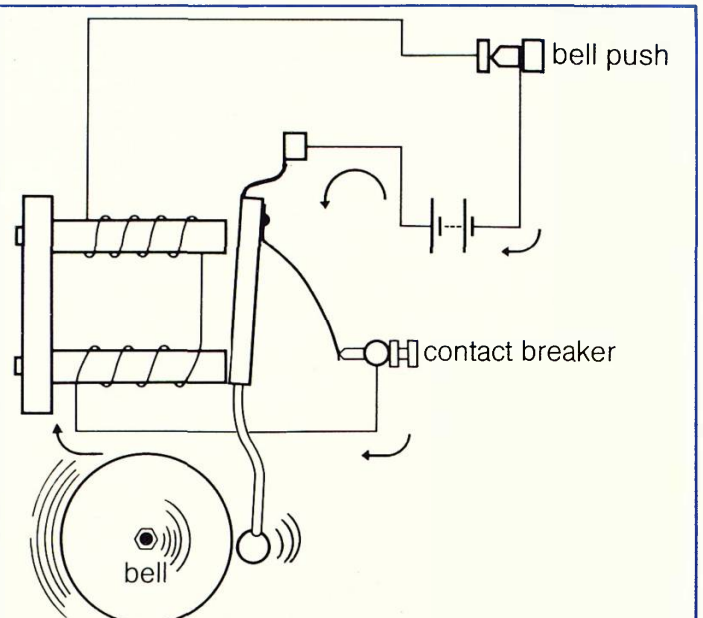
Buzzers and bells

Information: How buzzers and bells work

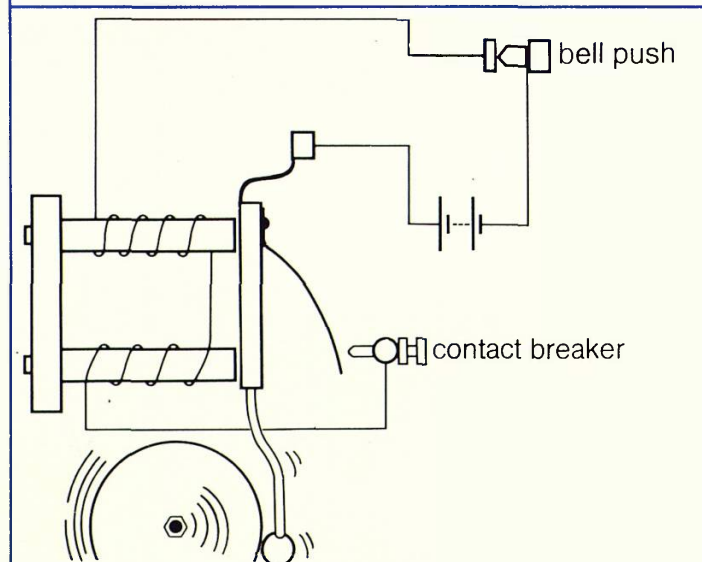
Bells and buzzers work in a similar way.
They both need an electromagnet and a **contact breaker**.



The diagrams show how an electric bell works. When someone presses the bell push, the circuit is completed. Electricity flows through the contact breaker and into the wire around the electromagnet.



The electromagnet starts to work. It draws the piece of steel towards it. This steel is attached to the clapper. The clapper hits the bell and makes a sound.



As the piece of steel reaches the electromagnet, it breaks the circuit at the contact breaker. The electromagnet then stops working. The piece of steel flies back. As soon as the steel spring reaches the contact breaker, the process starts again. The clapper hits the bell many times in one second.

Q5 Does an electromagnet attract steel if there is no electricity flowing through it?

Q6 What would happen to the bell if the battery was nearly worn out?

Q7 In your last experiment, which piece of apparatus acted as a contact breaker?

6 Water heaters

Making a low voltage immersion heater

Apparatus

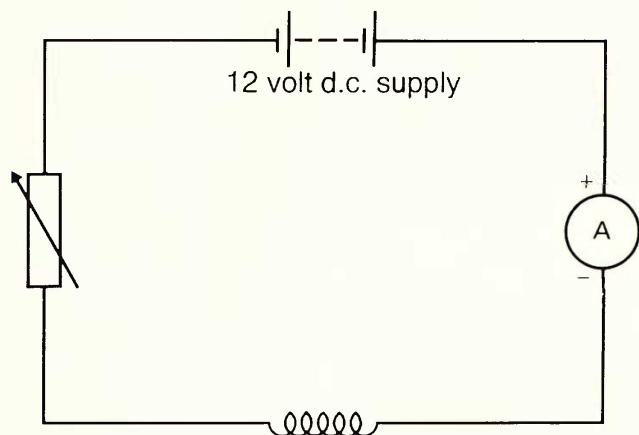
- ★ ammeter ★ rheostat ★ low voltage power supply ★ thermometer
- ★ glass rod ★ newspaper ★ 2 elastic bands ★ 100 cm³ beaker
- ★ thin, medium and thick enamelled eureka wire ★ 10 cm long (approx) piece of wood
- ★ 2 drawing pins ★ clamp with boss and stand ★ measuring cylinder
- ★ stop clock ★ ruler

You are going to make a low voltage **immersion heater**. This experiment can only be done safely at a **low** voltage.

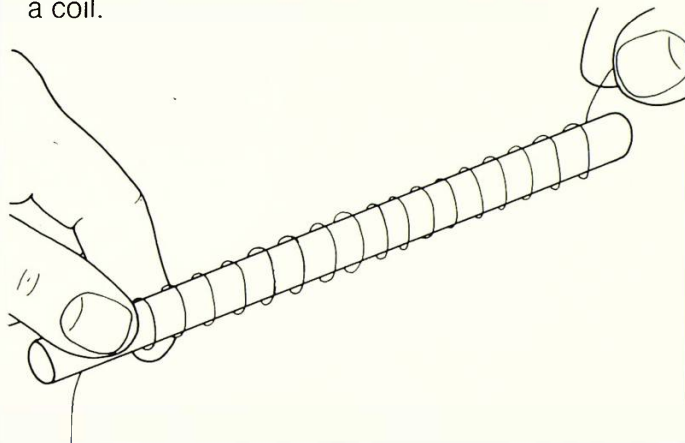
Q1 Copy this table.

Thickness of wire	Starting temperature (°C)	Temperature (°C) after 10 minutes
-------------------	---------------------------	-----------------------------------

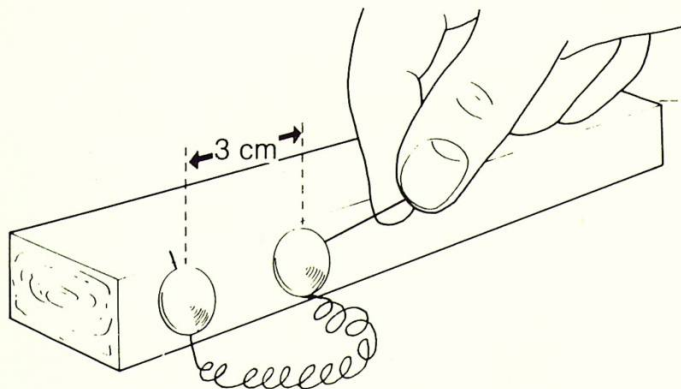
A You are going to build this circuit.



B Wind some thick enamelled eureka wire around a glass rod. Remove the rod. This makes a coil.



C Put 2 drawing pins 3 cm away from each other at one end of a piece of wood. Wind the ends of the coil around the drawing pins.

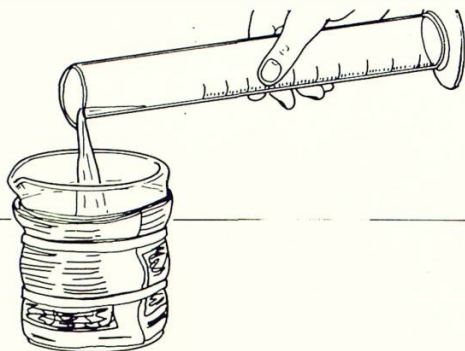


D Wrap several pieces of newspaper around an empty 100 cm³ beaker to **insulate** it. Use elastic bands to hold the newspaper in place.

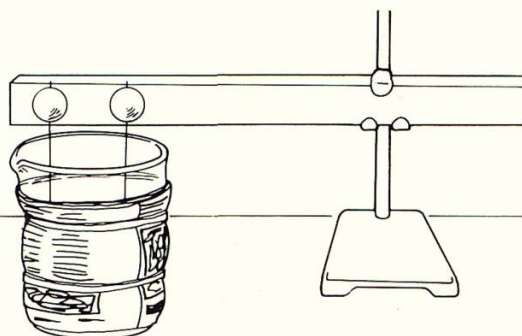


Water heaters

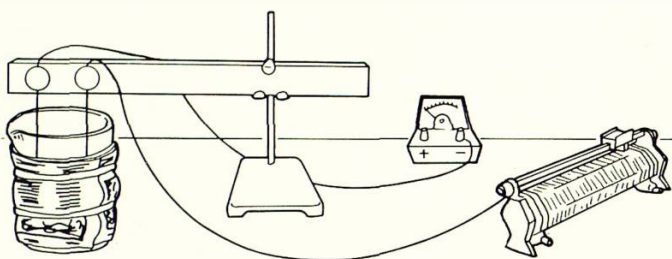
E Carefully, fill the beaker with cold water to within 5 mm of the top. Do not spill any on the newspaper.



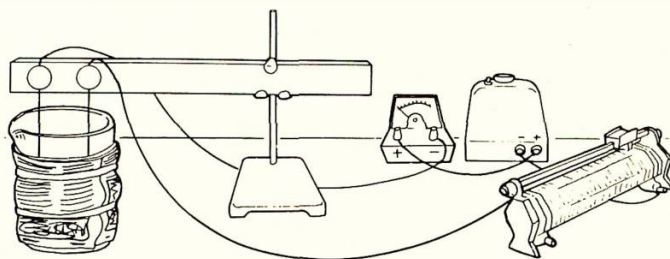
F Put the piece of wood into a clamp. Adjust the height of the wood so that as much of the coil as possible is in the water.



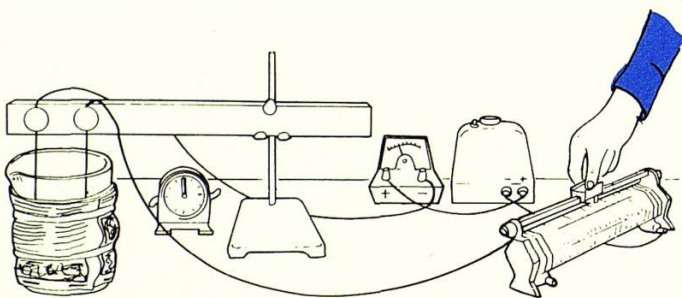
G Use wire to join one end of the coil to the negative (–) terminal of an ammeter. Join the other end of the coil to a rheostat.



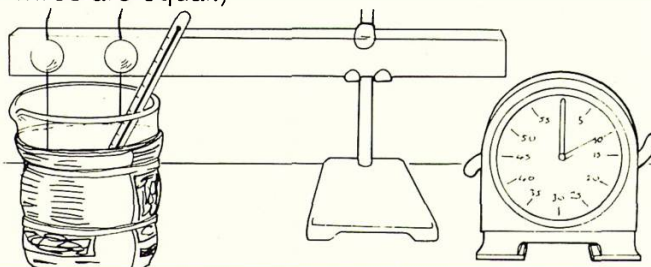
H Set a low voltage power supply to 12 V. Do not switch it on yet. Use wire to join the positive (+) terminals of the ammeter and the power supply. Join the negative (–) terminal of the power supply to the rheostat.



I Take the temperature of the water. Record it in your table. Switch on the electricity. **Quickly**, move the slider on the rheostat until the ammeter reads 2 amps exactly.



J After 10 minutes, switch off the electricity. Stir the water and record its temperature in your table. Empty the beaker. Repeat steps B to J with medium enamelled wire. Then repeat steps B to J with thin enamelled wire. (The lengths of the wires are equal.)



Q2 Draw the circuit diagram.

Q3 Which thickness of wire heated the water to the highest temperature?

Q4 Why did you refill the beaker each time with cold water?

Q5 Why is it very dangerous to try and build an immersion heater like this and connect it to a voltage higher than 12 V?

Investigating immersion heaters using different currents

Apparatus

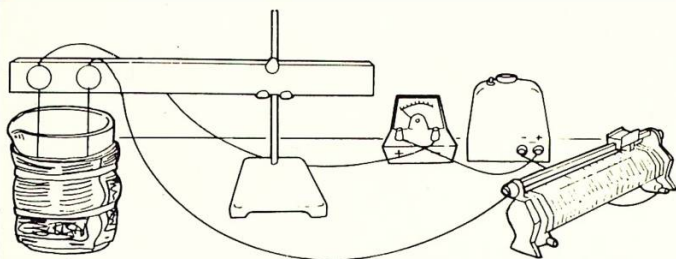
- ★ ammeter ★ rheostat ★ low voltage power supply ★ thermometer
- ★ glass rod ★ newspaper ★ elastic bands ★ thin enamelled eureka wire
- ★ 100 cm³ beaker ★ piece of wood (approx) 10 cm long ★ 2 drawing pins
- ★ clamp with boss and stand ★ measuring cylinder ★ stop clock ★ ruler

You are going to make an immersion heater and find out the effect of passing different currents through it. Never do this experiment with a mains voltage supply.

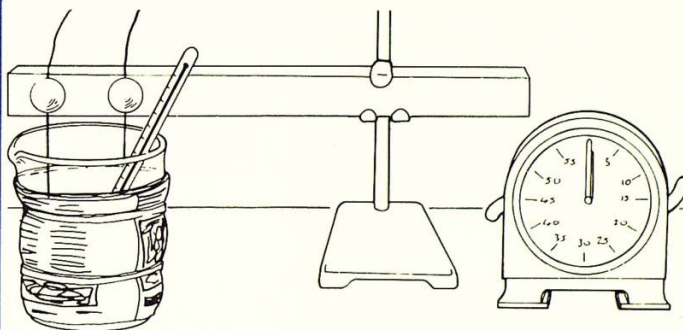
Q6 Copy this table.

Current used (amps)	Starting temperature (°C)	Temperature (°C) after 10 minutes
---------------------	---------------------------	-----------------------------------

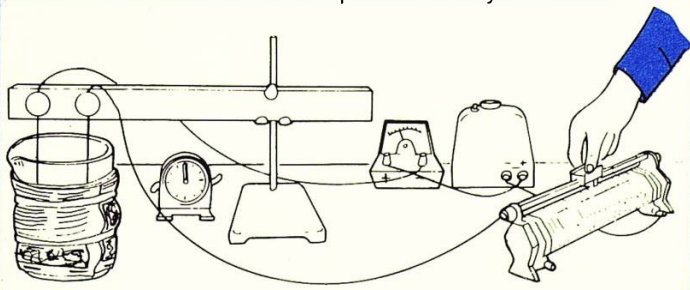
A Use thin enamelled eureka wire to make a coil. Follow steps B to H of the last experiment to set up the apparatus.



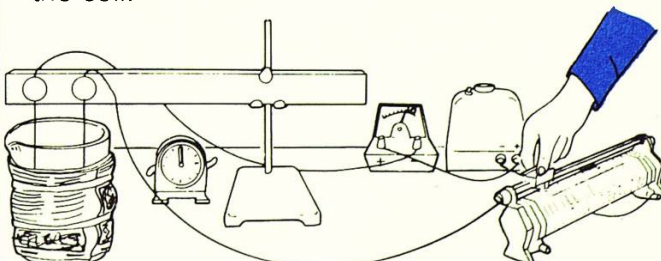
B Record in your table the temperature of the water.



C Switch on the electricity. Quickly, move the slider on the rheostat so the reading on the ammeter is 2 amps. After 10 minutes, stir the water and record its temperature in your table.



D Switch off the electricity. Empty the beaker. Refill it with fresh water. Repeat steps B and C, adjusting the rheostat so that 1.5 amps go through the coil. Then repeat so that 1 amp goes through the coil.



Q7 Which current heated the water to the highest temperature?

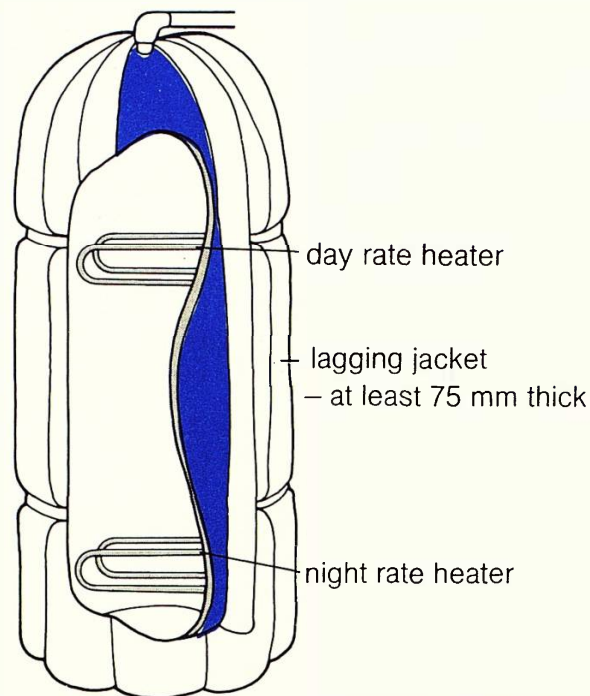
Q8 Would it matter if the amount of water in the beaker were different each time? Explain your answer.

Water heaters

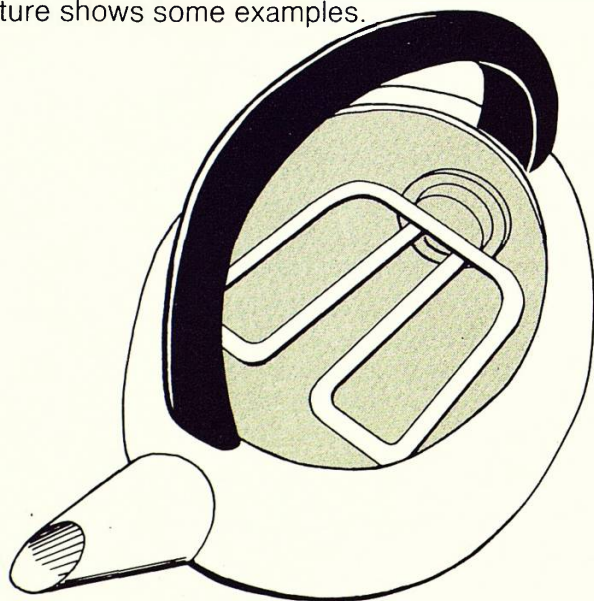
Information: Immersion heaters

Immersion heaters are used to heat water in storage **cylinders** or tanks. The heater is made of a coil of resistance wire insulated in a protective metal sheath. An electric current passes through the coil and makes it hot. The heat is passed from the coil to the water via the metal sheath.

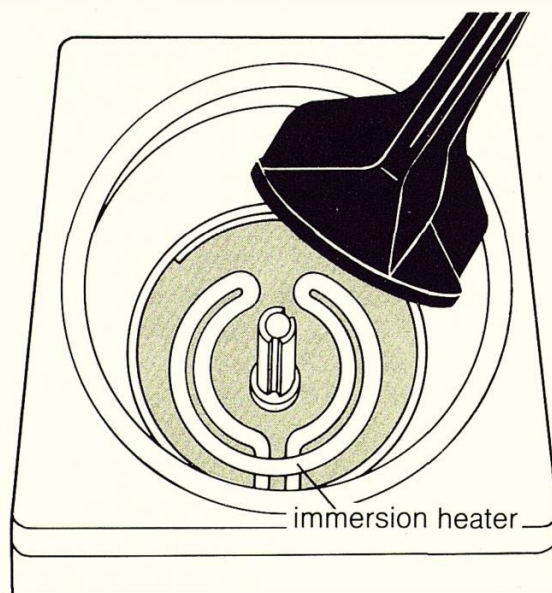
The immersion heater is controlled by a **thermostat**. The thermostat switches off the electricity when the water has reached the required (needed) temperature. The water cylinder should be **lagged** against heat loss. It should be surrounded by a jacket to keep the heat in. Some hot water cylinders have two heaters so that water heated during the night can be charged at a cheaper rate than during the day.



Other appliances in common use in the home use immersion heaters. The picture shows some examples.



electric kettle



washing machine

Q9 Why is it necessary to have a thermostat controlling an immersion heater?

Q10 Would you expect to get an electric shock from touching the metal cylinder?

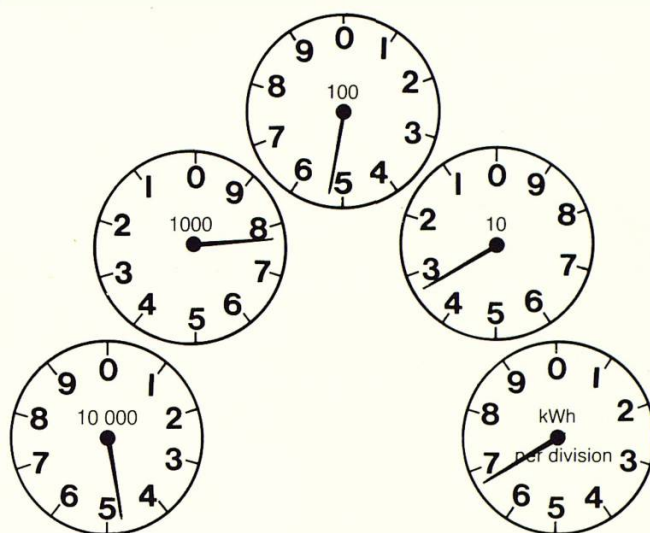
Q11 Why is it necessary to lag the tank of an immersion heater?

Information: Reading an electricity meter

An electricity meter tells you how much electricity you have used. It measures the electricity in **kilowatt hours**. One kilowatt hour is the amount of electricity used to run a 1000 watt appliance for 1 hour without being switched off.

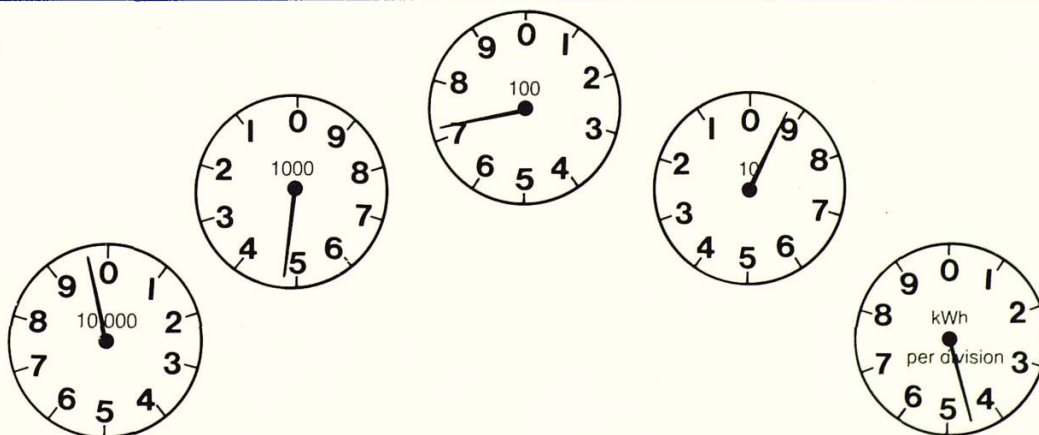


There are two kinds of electricity meter: the **digital meter** and the **dial meter**. The row of figures on a digital meter shows the number of units of electricity used. The white meter shown in the photo has a reading for daytime use and a second reading for the lower-priced night rate.



It is a little more difficult to take a reading from a dial meter. You should only read dials marked 10 000, 1000, 100, 10 and kWh per division. If the pointer on any dial is between two numbers, read the smaller number. The reading on this meter is 47 536 units.

The difference between the last reading and the present one on your meter gives the number of units used in that period.



Q12 Work out the reading on this meter.

Water heaters

Information: The cost of electricity

Early in 1979, electricity cost 2.83p per unit.

Q13 What does electricity cost now, per unit?

Q14 Copy this table.

Work out the electricity cost per week for each appliance.

Appliance	Units used per week	Cost per unit	Cost per week
Immersion heater	85 (if tank well lagged)		
Electric blanket	1 (underblanket) 3 (overblanket)		
Electric cooker	20 (3 meals per day)		
Freezer	9 (6 cubic feet)		
Hair dryer	1 (3 hours' use)		
Electric fire	20 (2 bar fire for 10 hours' use)		
Electric lights	6 (six 100 W bulbs for 10 hours each)		
Colour TV	2 (12 hours' viewing)		
Automatic washing machine	9 (weekly wash for 4 people)		
Tumble dryer	2 (1 hours' drying)		
Vacuum cleaner	1 (2 hours' cleaning)		

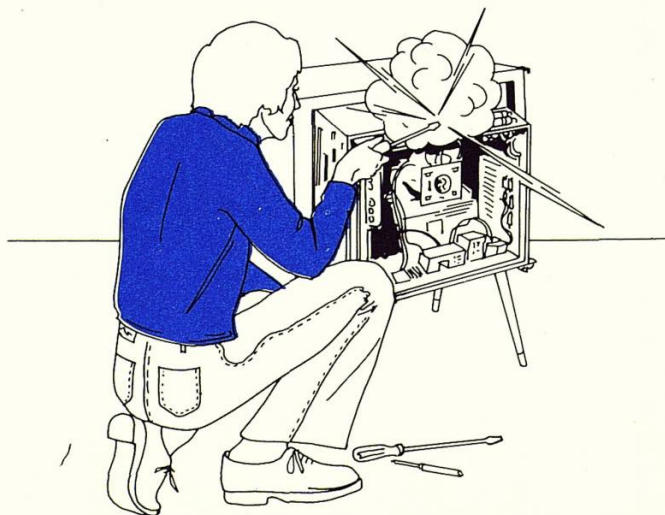
Q15 What is the total electricity bill for one week?

Information: The dangers of electricity.

As you have now worked through this book, you may feel able to carry out electrical repairs. Be warned!

Working with mains electricity is totally different from your experiments. People have died from shocks of only 100 volts. Mains electricity is at 240 volts.

The golden rule is to unplug or disconnect the appliance and switch off at the mains fuseboard before trying any inspection or minor repair. Some appliances, such as TV sets, have electricity stored in them after they have been switched off. If you are not absolutely sure of what you are doing — don't start. Get a qualified electrician to do it for you.



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Teachers' Guide to Domestic Electricity



Introduction

The units

Science at Work is a series of 18 science units for 14-16 year old, less able pupils. Each unit consists of a pupils' book and a teachers' guide. Each provides a complete half-term's course of study. The units are self-contained, and can be taken in any order.

The pupils' books

The pupils' books provide information, practical investigations and questions. Pupils are thus able to work from the books at their own pace; generally, the work becomes more difficult towards the end of each book and the weakest pupils are not expected to finish every unit. The material has been checked by a language specialist, who has ensured that the reading level is as low as possible.

INVESTIGATIONS

Each investigation begins with a list of the apparatus required. The purpose is then stated, and instructions for the investigation given (in words and pictures). Finally, the pupils are asked questions which help them record their results and draw conclusions. (Throughout the books a pupil is expected to make a written response each time a 'Q' appears.)

INFORMATION

Appropriate information from the real world follows most investigations, in most cases from the world of work. Questions are also asked about these information sections.

The teachers' guides

Each unit has a teachers' guide. This contains record sheets and information for the teacher.

RECORD SHEETS

Record sheets in the form of masters are provided in each guide. These sheets will save pupils copying tables, and will help them write answers to questions as complete sentences. One record sheet is provided for each chapter of the pupils' book. Teachers may decide to give record sheets only to those pupils who have difficulty with writing; alternatively, they may be given to all pupils.

OTHER RESOURCES FOR THE TEACHER

Each teachers' guide contains:

- course and unit objectives
 - hints on introducing and teaching the unit
 - an apparatus list (for technicians)
 - safety procedures
 - new scientific words (which pupils may have difficulty reading)
 - answers to questions in the pupils' book
 - a resource list.
- Specimen questions for a post-unit test are also included.

Examining the course

Science at Work is derived from a successful and well-proven modular scheme developed by teachers in Manchester LEA. Most of the pupils following the course in Manchester gain a CSE Mode III certificate in science. A paper giving information on CSE Mode III construction for this course is available from J. C. Taylor, Senior District Inspector, Education Office, Crown Square, Manchester M60 3BB.

Aims of the course

1. To provide a flexible science course based on non-sequential study units. Though developed predominantly for less able pupils, the course can cater for pupils capable of CSE grade I by the addition of suitable extension work.
2. To develop pupils' thinking in scientific methodology and the approach to problem solving.
3. To give knowledge and understanding of science relevant to pupils' interests, environment, and future work and leisure needs.
4. To develop pupils' interest in science and enjoyment of science.
5. To provide a wide range of practical experiences and develop practical skills.
6. To develop the ability to work both independently and as a member of a team.

General objectives of the course

1. To develop the ability to carry out experimental procedures and written work according to instructions.
2. To develop manipulative skill in handling equipment and an awareness of safe practice.
3. To develop powers of accurate observation.
4. To develop the ability to check statements and assertions against tests of observation and experiment.
5. To develop skill in handling the interpretation of data.

6. To develop the ability to look for and make generalisations (this objective is likely to be achieved by only the ablest pupils).

7. To be able to understand and recall the factual content of the material.

8. To develop communication skills—verbal, written, and mathematical.

9. To develop the ability to apply knowledge gained.

10. To encourage pride in neatly and accurately produced work.

11. To develop awareness of the responsible use of science and technology.

Objectives of the Domestic Electricity unit

When they have completed the unit, pupils will have practised the following skills:

the use and manipulation of screw-drivers, wire cutters and strippers

the handling of simple circuit components

the interpretation of circuit diagrams and component symbols

the setting up and testing of electrical circuits

the reading of scales on ammeters and thermometers

that fuses melt or blow if too much current passes through them

of the current rating of fuses

that resettable circuit breakers are more convenient to use in domestic wiring

that rheostats can be adjusted to change the amount of current flowing through a circuit

that switches break a circuit

that power can be expressed in watts and kilowatts

that the amount of current used by appliances can be calculated ($\frac{W}{V} = A$)

of the power rating of appliances

of circuits and sub-circuits in domestic wiring

of the differences between ring main and radial wiring

of how to make an electromagnet

of the application of an electromagnet in a buzzer

of the use of contact breakers in a buzzer

of how water heaters work

of how the use of electricity is monitored and a meter is read

of how an electricity bill is calculated.

In their work on *Domestic Electricity*, pupils will become aware:

that live and neutral wires are required to supply electric current to an appliance

that the earth wire is a safety device

that wires are colour coded

that an ammeter measures the flow of electric current

that fuses are safety devices, they are used to prevent damage to appliances

Teaching the Domestic Electricity unit

Introducing the unit

The reliance we place on electrical appliances can be demonstrated by having a display of photographs and items such as hair drier, spin drier, washing machine, soldering iron, light bulbs (different wattages), fridge, freezer, cooker hair rollers, power drill, lawn mower, iron, radio, television, record players etc, etc.

Posters could be on display: many visual aids are available either free or for a small charge from

The Electricity Council, 30, Millbank, London SW1P 4RD

Some titles are detailed in the lesson notes.

Before experimental work starts teachers should check that children can read scales by using a display ammeter or similar device. Some teachers may prefer to teach the slightly easier investigations (buzzer and water heater) before the ones that demand delicate manipulative skills (construction of model household circuits).

Teaching the unit

The pupils' book contains 6 chapters.

Each chapter has practical and information sections. There are sequential questions within each chapter: these indicate when a student has to write in a notebook. For slow readers and writers, there are record sheets to each chapter. The record sheets are copyright free and are contained within this teacher's guide (pages 8-15).

Samples of the type of questions that may be used for assessment when pupils have completed the unit are on page 16.

In the pages which follow, each chapter is discussed with reference to: apparatus per working group; new scientific words; safety and teaching hints; answers to practical and information page questions; resources.

Detailed teaching notes

It is essential that the plugs and sockets used in the experiments are incompatible with the mains plugs and sockets in the laboratory. (Any incompatible 3-pin plug is suitable.) Otherwise, there is a danger of electrocution. Alternatively, batteries may be used in series as a power source and the mains supply to the laboratory cut off.

Throughout the pupils' book all the drawings of plugs and sockets on practical pages are drawn 'incorrectly' for this reason. Pupils should be made aware of the potential danger from the outset of the unit.

Strictly, the brown/blue/yellow-green coding applies only to flexible cables. The wiring "behind the socket" is coded red/black/green.

1 PLUGS AND SOCKETS

CONNECTING A FLEX TO A PLUG AND SOCKET

(pupils' book page 2)

Apparatus: 3 core flexible cable; 3 pin plug; socket; screwdriver; scissors; wire strippers

New Words: cable, fuse, terminals, insulation, wire, earth, neutral, live

In the first exercise it will be necessary to check that the pupils can use screwdrivers and wire strippers. Also that they understand the need for 2 wires, the live and neutral, to supply electric current to an appliance, and a 3rd wire, the earth wire, used as a safety device should an appliance become faulty.

Q1 240 volts.

Q2 The live and neutral wire.

Q3 It is connected to the earth.

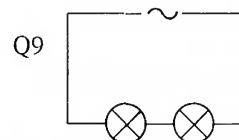
Q4 It is to stop the possibility of an electric shock if the metal case of an appliance becomes live.

Q5 Neutral

Q6 Brown

Q7 Green/Yellow

Q8 Ammeter



The Electricity Council have a film "Living with Electricity" which outlines the importance of correct plug wiring. It is available on free loan.

2 FUSES

CHECKING A FUSE

(pupils' book page 5)

Apparatus: fuseholder; 1A fuse; 12V 0.1A lamp in holder; connecting wire

Pupils will need help in interpreting circuit diagrams.

Fuses in which the wire can be seen are most suitable. Some 'blown' fuses could be made available for comparison.

12V 0.1A bulbs (M.E.S. cap), bulbholders, fuses and chassis-mounted fuseholders are available from R. S. Components Ltd., Fitzroy House, Epworth Street, London E.C.2.

Q2 The lamp would not light.

Q3 Any electric appliance such as an electric bell or a heater, etc.

The Electricity Council have information sheets called "Plugs and Fuses" and a 35 mm film strip—"From Socket to Appliance".

FINDING THE CURRENT AT WHICH A FUSE BLOWS

(pupils' book page 6)

Apparatus: fuseholder; 1A fuse; ammeter (0–5A); rheostat (0–15ohm); wire; low voltage power supply

New Words: rheostat, variable resistor, ammeter, resistance, overloaded, voltage

It will be necessary to check that the ammeter is connected round the right way before pupils switch on the power supply. Many rheostats have 3 terminals so the teacher will have to check that the connections to this are correct. Also pupils may experience difficulty in knowing which way to move the slider of the rheostat to decrease resistance. It may be necessary to teach pupils how to read the ammeter scale, using a display ammeter.

Q4 It returned to zero.

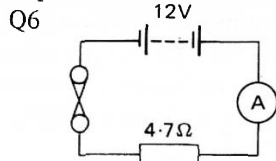
Q5 1 amp.

USING A FUSE WITH TOO HIGH A CURRENT RATING

(pupils' book page 7)

Apparatus: fuseholder; 5A fuse; ammeter (0–5A); 4.7 ohm resistor; connecting wire; low voltage power supply; 2 crocodile clips; heatproof mat
New Words: ohm, current rating

Pupils must be warned not to touch the resistor as it will get very hot.



Q7 2.5A (approx.)

Q8 It smoked and melted.

Q9 No.

Q10 A fuse prevents too much current flowing to an appliance.

Q11 The fuse would blow and current would not flow to the appliance.

Q12. The current rating.

Q13 Circuit breakers can be reset but fuses have to be replaced when the circuit has been overloaded.

Q14 The fuse would blow.

Q15 The current required for a record player is very much lower than 13A, so if a fault occurred in the circuit the record player would be damaged before the fuse blew.

Q16 Power (watts)

Voltage (volts)

$$\therefore \frac{2400}{240} = \text{Current in amps.}$$

$$\therefore \text{Current} = 10\text{A.}$$

$$\text{So fuse required} = 13\text{A.}$$

The Electricity Council (free loan) 16 mm film "Circuits and Connection" plus their 35 mm film strip "Behind the Socket", may be useful.

3 HOUSEHOLD LIGHTING CIRCUITS

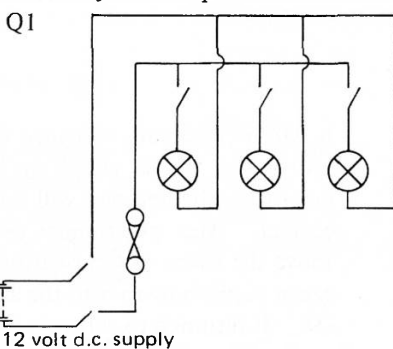
BUILDING A MODEL OF A HOUSEHOLD LIGHTING CIRCUIT (pupils' book page 11)

Apparatus: large circuit board; 3 12V 0.1A bulbs in holders; 1A fuse; fuseholder; scissors; 3 small rocker switches; large 2-way rocker switch; brown plastic-coated connecting wire; blue plastic-coated connecting wire; 6 plastic junctions; low voltage power supply; wire strippers; screwdriver; nuts and bolts

New Words: rocker switch

Pupils will probably have difficulty in constructing this circuit so will require help. The circuit board can be built from pegboard, 60 cms square, supported about 4.5 cms off the ground by a wooden frame. Suitable pegboard is hard-board drilled with 5 mm diameter holes, 2 cms apart. The frame can be made from wood approximately 4.5 cm by 1.5 cm, in lengths that should be securely nailed to the edge of the pegboard. Rectangular gaps to hold the rocker switches can be cut out beforehand using a sharp modelling knife and a narrow saw-blade. Bulbs in holders, fuses and fuseholders are as the experiment "Checking a fuse", pupils' book page 5.

R. S. Components Ltd. supply the large rocker switch (a double pole, double throw switch.) The small rocker switches are single pole, single throw and can be obtained from Bi Pak Semiconductors, PO Box 6, Ware, Herts. (Large rocker switches can be used throughout but the pupils may have more difficulty understanding how to connect them). The plastic junctions are made from one plastic-coated terminal block which is a set of 12 junctions. These can easily be cut apart to form 12 separate screw-connectors.



Q2 The lamps do not light.

Q3 Too much current is flowing.

Q4 1A.

Q5 So each bulb can be switched on and off independently.

Q6 Yes.

Q7 The circuit can be overloaded without blowing the fuse. (Only 0.1A is required for each lamp, giving a total of 0.3A.)

INVESTIGATING THE LIGHTING CIRCUIT (1) (pupils' book page 14)

Apparatus: circuit board from last experiment; connecting wire; ammeter (0–1 A); scissors; low voltage power supply; wire strippers; screwdriver

INVESTIGATING THE LIGHTING CIRCUIT (2) (pupils' book page 15)

Apparatus: circuit board from the last experiment; wire; ammeter (0–1 A); low voltage power supply; scissors; wire strippers; screwdriver

4 HOUSEHOLD POWER CIRCUITS

BUILDING A SOCKET RING MAIN (pupils' book page 17)

Apparatus: circuit board with completed lighting circuit; fuseholder; 3 A fuse; 3 plastic junctions; 3-core flexible cable; 3 mains sockets; blue wire; brown wire; yellow/green wire; wire strippers; screwdriver; nuts and bolts; scissors

New Words: ring main

Q9 They are equal.

Q10 The bulbs are less bright on 6V than 12V.

Q12 It stayed the same.

Q13 It stayed the same.

Q14 10 light bulbs.

Q15 Fluorescent tubes last longer than ordinary lamps. They also give out more light.

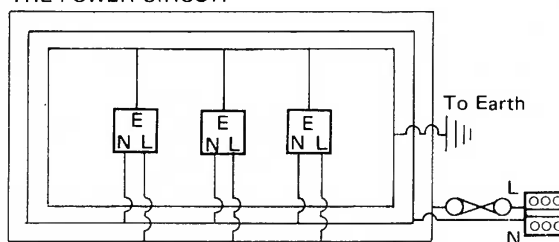
(Strictly, the correct name is a ring sub-circuit.)

In earlier editions of the pupils' book, there is no connection from the neutral terminal or the fuseholder. This has been corrected in later editions.

Pupils may need considerable help and encouragement to finish this. A board should be already wired up for reference.

To answer Question 1 students may need a lot of help—a duplicated incomplete diagram may help.

Q1 THE POWER CIRCUIT



Q2 Live, Neutral, Earth.

Q3 So that no more than 3 A can flow.

Q4 It is connected to Earth.

The Electricity Council 16 mm film "Switches and Controls" and 35 mm film strip "Switches and Controls" may be useful.

INVESTIGATING THE LIVE AND NEUTRAL CIRCUITS (pupils' book page 19)

Apparatus: circuit board with lighting and power circuits wired up; three 3-pin plugs; three 24W bulbs in holders; ammeter (0–10 A); low voltage power supply; 2-core cable; brown plastic-coated connecting wire; blue plastic-coated connecting wire; scissors; wire strippers; screwdriver; 3 labels

24W 2A bulbs and holders are available from Griffin and George Ltd.

Pupils will need help with Question 8. A duplicated incomplete sheet would help.

Please notice that the latest colour TVs use 175 W (information page 21).

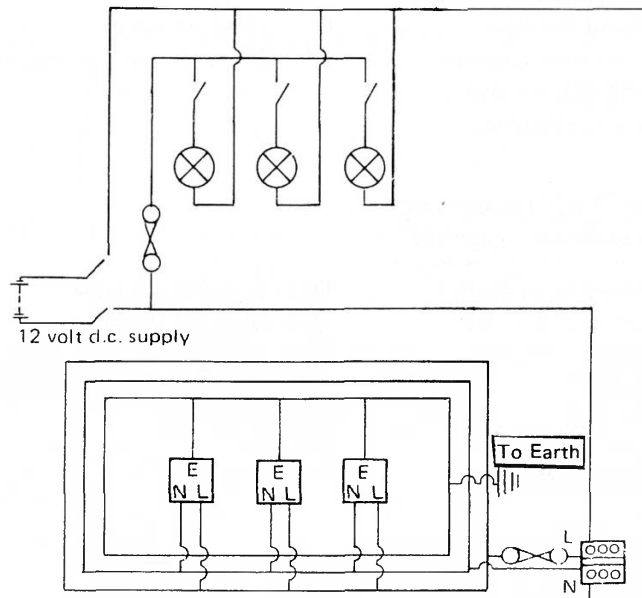
Q6 6.3A

Q7 No.

Q8

Q9 2nd room fuse would blow.

THE POWER AND LIGHTING CIRCUIT



Q10 1st room	Watts	2nd room	Watts
Colour T.V.	105	Iron	1200
Iron	1200	3-bar electric fire	3000
1-bar electric fire	1000		
		TOTAL	4200
TOTAL	2305		

$$\text{Watts} = \text{Amps} \times \text{Volts}$$

$$2305 = \text{Amps} \times 240$$

$$\therefore \text{Current} = \frac{2305}{240} \text{ A}$$

$$= 9.6 \text{ A}$$

$$\text{Watts} = \text{amps} \times \text{volts}$$

$$4200 = \text{amps} \times 240$$

$$\text{Current} = \frac{4200}{240} \text{ A}$$

$$= 17.5 \text{ A}$$

$$\therefore 15 \text{ A fuse would blow.}$$

Q11 This makes the circuit safe when a fuse blows.

Q12 Radial.

Q13 Six. One each for cooker, immersion heater, upstairs lights, downstairs lights, upstairs sockets and downstairs sockets.

Q14 The radial system requires more major re-wiring than the ring method.

5 BUZZERS AND BELLS

MAKING AND INVESTIGATING AN ELECTRIC BUZZER

(pupils' book page 24)

Apparatus: C-shaped piece of soft iron; rheostat (0–15 ohms); ammeter (0–5A); crocodile clips; piece of hacksaw blade; 15 cm long piece of spring steel; G clamp; low voltage power supply; 50 cm x 25 cm (approx.) piece of wood; clamp, boss and stand; connecting wire; nut and bolt; 26 s.w.g. insulated copper wire (for electromagnet)

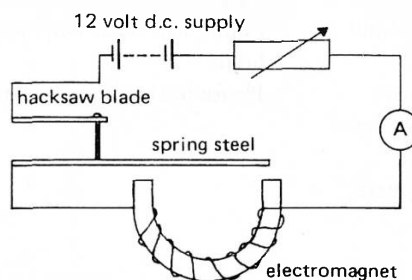
New Words: electromagnet, contact breaker

Pupils will need some help in adjusting the position of the components to get a suitable buzzing effect. Contact can be improved by first cleaning the hacksaw blade and spring steel with wire wool.

Pupils should be warned that sparking may occur at the contact screw.

Pupils will need help if a detailed answer to question 2 is required.

Q1



- Q2 The apparatus started buzzing. (The spring steel was attracted to the electromagnet breaking the circuit. No current is then flowing so the electromagnet stops attracting the spring steel. This makes the steel spring back up forming a circuit once more. This series of events repeats quickly so a buzzing noise is heard.)
- Q3 The buzzing noise gets louder.
- Q4 The buzzing noise was louder with more wire on the electromagnet.
- Q5 No.
- Q6 It would ring faintly or not at all.
- Q7 The bolt.

6 WATER HEATERS

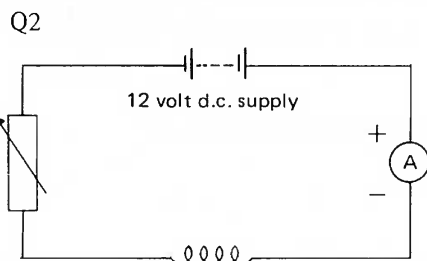
MAKING A LOW VOLTAGE IMMERSION HEATER

(pupils' book page 27)

Apparatus: ammeter (0–5 A); rheostat (0–15 ohms); low voltage power supply; thermometer (0–110°C); glass rod; newspaper; 2 elastic bands; 100 cm³ beaker; approx. 30 cm lengths of 22, 26, 34 s.w.g. eureka wire (enamelled); 10 cm long (approx.) piece of wood; 2 drawing pins; clamp with boss and stand; measuring cylinder (0–150 cm³); stop clock; ruler

The voltage for this experiment must not be greater than 12 V.

The pupils should be warned that the coil can get hot quickly when left out of the water. They may need help reading the thermometer. 20 cm lengths of wire of the three gauges stated give a temperature range between 2°C and 10°C in about 10 minutes each. The coils must not touch or shorting will occur. To avoid this the wire should be enamelled by dipping it into shellac varnish; the ends must be left bare or cleaned before use with sandpaper.



- Q3 Thin wire.
- Q4 So that the water had the same starting temperature.
- Q5 Because the current would be too high and there would be a danger of overheating or possibly an electric shock.

INVESTIGATING IMMERSION HEATERS USING DIFFERENT CURRENTS

(pupils book page 29)

Apparatus: as previous experiment but only thin enamelled eureka wire is required.

- Q7 2 A.
- Q8 Yes. In 10 minutes more water would not heat up so much.
- Q9 So that the water is only heated to the required temperature.
- Q10 No.
- Q11 So that as little heat as possible is lost from the tank.
- Q12 94794.

The Electricity Council 35 mm film strip "Basic Electrical Effect" and their 24-page booklet "Electric Water Heating" may be of use.

Other helpful visual aids from the Electricity Council include:

16 mm film—"Measuring the Usage" (free loan)

35 mm film strip—"Living with Electricity"

Information Sheets—"Guide to Running Costs", "How to Read Your Meter", "Safety in the Home".

Wallchart—"Electricity Distribution".

1 Plugs and sockets

INFORMATION: PLUGS AND SOCKETS (page 1)

- Q1 The voltage of mains electricity in this country is
- Q2 The two wires that supply the electric current to an appliance are
.....
- Q3 The Earth wire is connected to
- Q4 The Earth wire is for
.....

CONNECTING A FLEX TO A PLUG AND SOCKET (page 2)

- Q5 The letter N on the inside of a socket means
- Q6 The colour of the wire that carries a high voltage when the electricity is switched on is
- Q7 The colour of the wire that usually does not carry electricity is

INFORMATION: CIRCUITS AND SYMBOLS (page 4)

- Q8 The symbol (A) stands for
- Q9 In the space below draw a circuit diagram showing two bulbs and an a.c. power supply.

2 Fuses

CHECKING A FUSE (page 5)

- Q1 On the back of this sheet of paper draw the final circuit diagram. It should show a 6 volt d.c. power supply (battery), a lamp and a fuse.
- Q2 If the fuse was blown the lamp *would/would not* light, when the electricity was turned on.
- Q3 To check a fuse a person could use a instead of a lamp.

FINDING THE CURRENT AT WHICH A FUSE BLOWS (page 6)

- Q4 When the fuse blows, the reading on the ammeter
.....
- Q5 A one amp fuse will let through before it blows.

USING A FUSE WITH TOO HIGH A CURRENT RATING (page 7)

- Q6 On the back of this sheet of paper draw the circuit diagram. It should show a d.c. power supply (battery), an ammeter, a 4.7 ohm resistor and a fuse.
- Q7 The current flowing round the circuit measured amps.
- Q8 During the experiment the resistor
- Q9 The fuse *did/did not* protect the resistor.

INFORMATION: FUSES (page 8)

- Q10 The job of a fuse is to
.....
- Q11 If a 5 amp fuse was used to protect an appliance that took 7 amps
.....

INFORMATION: FUSES AND CIRCUIT BREAKERS (page 9)

- Q12 The numbers on the circuit breakers show
- Q13 Circuit breakers are easier to use than fuses because

INFORMATION: WHICH FUSE SHOULD I USE? (page 10)

- Q14 If a 3A fuse was used in the plug attached to an electric fire, it would
- Q15 For a record player, I would change the 13A fuse in a plug because
.....
- Q16 A 2.4kW storage radiator takes a current of amps. So the fuse required will be a fuse.

3 Household lighting circuits

BUILDING A MODEL OF A HOUSEHOLD LIGHTING CIRCUIT (page 11)

- Q1 On the back of this sheet of paper draw the circuit diagram of the completed circuit. It should show a 12 volt d.c. power supply (battery), a rocker switch, a fuse and three lamps in the correct arrangement.
- Q2 With the rocker switch turned off, the lamps
- Q3 If the fuse blows it means that
- Q4 The largest current the circuit can take is
- Q5 Switches should always be connected between the bulb and the power supply so that
- Q6 With a 5 amp fuse in place of the 1 amp fuse, the circuit *would/would not* still work.
- Q7 A 5 amp fuse is unsuitable for this circuit because

INVESTIGATING THE LIGHTING CIRCUIT (1) (page 14)

Q8

Bulb number	Current passing (amps)

- Q9 All three readings from the ammeter are
- Q10 The brightness of the bulbs at 6V is *less/more* than the brightness at 12V.

INVESTIGATING THE LIGHTING CIRCUIT (2) (page 15)

Q11

Number of bulbs connected in the circuit	Current passing (amps)

- Q12 After removing bulb 1, the reading on the ammeter
- Q13 As more bulbs were taken out, the current *got bigger/stayed the same/got smaller*.
- Q14 It would take 100W light bulbs to use as much electricity as a 1kW fire.
- Q15 The advantages of fluorescent lighting are
-
-

4 Household power circuits

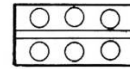
BUILDING A SOCKET RING MAIN CIRCUIT (page 17)

Q1 On the back of this sheet of paper draw the circuit diagram. It should show three sockets, the Earth wiring, the Live wiring, the Neutral wiring, a fuse and the plastic junction. The sockets and plastic junction can be drawn as shown below.

socket



plastic junction



Q2 The letters on the back of a socket mean the following: L =

N = E =

Q3 A 3 amp fuse must be used for the power circuit because

Q4 In a house the yellow/green Earth wire is connected to Earth by fixing it to

INVESTIGATING THE LIVE AND NEUTRAL CIRCUITS (page 19)

Q5

Number of bulbs plugged in	Current passing (amps)

Q6 If both the power and lighting circuits are switched on, the current is amps.

Q7 Current *does/does not* flow through the Earth wire.

Q8 On the back of this sheet of paper draw the circuit diagram for the power and lighting circuits. It will be a combination of two circuit diagrams you have already drawn.

INFORMATION: POWER CIRCUITS (page 21)

Q9 A 15 amp fuse *would/would not* blow in the first room. A 15 amp fuse *would/would not* blow in the second room.

Q10 The total power (in watts) being used in the first room is watts. The total power being used in the second room is watts.

Q11 Fuses and switches should always be in the Live wire of the circuit because

Q12 The type of circuit which uses more wire is the

4 Household power circuits (continued)

Q13 In a typical modern house there would be circuits.

Q14 It is more difficult to add extra sockets on a radial wiring system because

.....

.....

5 Buzzers and bells

MAKING AND INVESTIGATING AN ELECTRIC BUZZER (page 24)

Q1 In the space below draw the circuit diagram of the electric buzzer.

Q2 When the electricity was turned on

.....

Q3 When the current was increased

.....

Q4 When more wire was wound round the electromagnet

.....

INFORMATION: HOW BUZZERS AND BELLS WORK (page 26)

Q5 An electromagnet with electricity flowing through it *does/does not* attract steel.

Q6 If the battery was nearly worn out the bell

.....

Q7 In the experiment where a buzzer was made the acted as the contact breaker.

Domestic Electricity

The colour coding for the wiring in this book does not apply to flexible cords and house-wiring cables and is intended only for school use.

Only low voltages (12 V or less) should be used for practical wiring circuits.

Page 5 of the Teachers' Guide states that the earth wire in a house should be connected to a water pipe. This is dangerous. Earth connections should only be made to special earth terminals.

6 Water heaters

MAKING A LOW VOLTAGE IMMERSION HEATER (page 27)

Q1

Thickness of wire	Starting temperature ($^{\circ}\text{C}$)	Temperature ($^{\circ}\text{C}$) after 10 minutes)

Q2 In the space below draw the circuit diagram. It should show the 12 volt d.c. power supply (battery), an ammeter, a rheostat, and a coil.

Q3 The wire that heated the water to the highest temperature was the *thick/medium/thin wire*.

Q4 The beaker was refilled with cold water each time because

.....

.....

Q5 It is very dangerous to build an immersion heater like this using a voltage higher than 12 volts. This is because

.....

INVESTIGATING IMMERSION HEATERS USING DIFFERENT CURRENTS (page 29)

Q6

Current used (amps)	Starting temperature ($^{\circ}\text{C}$)	Temperature ($^{\circ}\text{C}$) after 10 minutes

Q7 The current that heated the water most was amps.

6 Water heaters (continued)

Q8 It *would/would not* matter if the amount of water in the beaker was different each time. This is because

INFORMATION: IMMERSION HEATERS (page 30)

Q9 It is necessary to have a thermostat controlling an immersion heater because

Q10 I *would/would not* expect to get an electric shock from touching the metal cylinder.

Q11 It is necessary to lag the tank of an immersion heater so that

INFORMATION: READING AN ELECTRICITY METER (page 31)

Q12 The reading on this meter is

INFORMATION: THE COST OF ELECTRICITY (page 32)

Q13 Electricity now costs

Q14

Appliance	Units used per week	Cost per unit	Cost per week
Immersion heater	85 (if tank well lagged)		
Electric blanket	1 (underblanket) 3 (overblanket)		
Electric cooker	20 (3 meals per day)		
Freezer	9 (6 cubic feet)		
Hair dryer	1 (3 hours' use)		
Electric fire	20 (2 bar fire for 10 hours' use)		
Electric lights	6 (six 100W bulbs for 10 hours each)		
Colour TV	2 (12 hours' viewing)		
Automatic washing machine	9 (weekly wash for 4 people)		
Tumble dryer	2 (1 hour's drying)		
Vacuum cleaner	1 (2 hours' cleaning)		

Q15 The total electricity bill for one week is

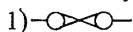
Specimen post-unit questions

1) The colours of the wires in modern flexible cables are green/yellow, blue or brown. Put the correct colour by the names of the wires below.

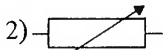
- a) Live
- b) Earth
- c) Neutral

2) Match each name below with its correct circuit symbol.

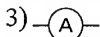
a) lamp



b) ammeter



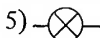
c) battery or power supply



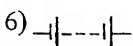
d) variable resistor (rheostat)



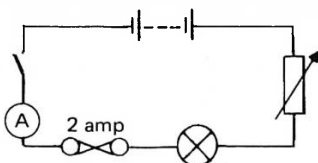
e) switch



f) fuse



3) The circuit was set up as shown in the diagram.



When the switch was closed the lamp did not light. Which of the following would you not have to do when you checked the circuit? (Tick (✓) the answer.)

- a) Check all the wiring connections.
- b) Alter the rheostat.
- c) Remove the fuse.
- d) Clean the contacts in the switch.
- e) Screw the bulb tightly in the holder.

4) Which units are used to show the power of an appliance? (Tick (✓) the answer.)

- a) ohm
- b) watt
- c) volt
- d) amp

5) A house had a lighting circuit of 3 bulbs. If one blew, what would happen to the other 2 bulbs? (Tick (✓) the answer.)

- a) They would get brighter.
- b) Both would go out.
- c) They would get dimmer.
- d) They would stay the same brightness.

6) Which would use the least electricity in 5 minutes? (Tick (✓) the answer.)

- a) An ordinary 100W lamp.
- b) An ordinary 150W lamp.
- c) A fluorescent 60W lamp.
- d) A fluorescent 100W lamp.
- e) An ordinary 40W lamp.

7) Which of the following can be used to vary the amount of electricity flowing through a circuit? (Tick (✓) the answer.)

- a) lamp
- b) ammeter
- c) fuse
- d) rheostat
- e) battery

8) The power used by an electrical appliance can be worked out. Which of the following would you use for the calculation? (Tick (✓) the answer.)

- a) watts = volts – amps
- b) watts = volts x amps
- c) watts = volts + amps
- d) watts = $\frac{\text{volts}}{\text{amps}}$

9) Which of the following appliances contains an electromagnet? (Tick (✓) the answer.)

- a) an electric fire
- b) an electric kettle
- c) a table lamp
- d) an electric bell

10) Which of the following contains an immersion heater? (Tick (✓) the answer.)

- a) an electric kettle
- b) an electric bell
- c) a fan heater
- d) an electric fire
- e) a table lamp

11) Which of the following is an advantage of a ring main? (Tick (✓) the answer.)

- a) It is easy to add extra sockets to the circuit.
- b) It uses more cable than radial wiring.
- c) It uses cheaper 2-core cable instead of 3-core cable.
- d) It does not need fuses at every socket.

12) Which of the sentences below explains the job of the Earth wire? (Tick (✓) the answer.)

- a) It stops the current flowing if the plug is overloaded.
- b) It controls the voltage of the mains.
- c) It makes any bare metal parts of an appliance safe.
- d) It brings more current to the appliance when needed.

SCIENCE AT WORK

Project Director

John Taylor

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