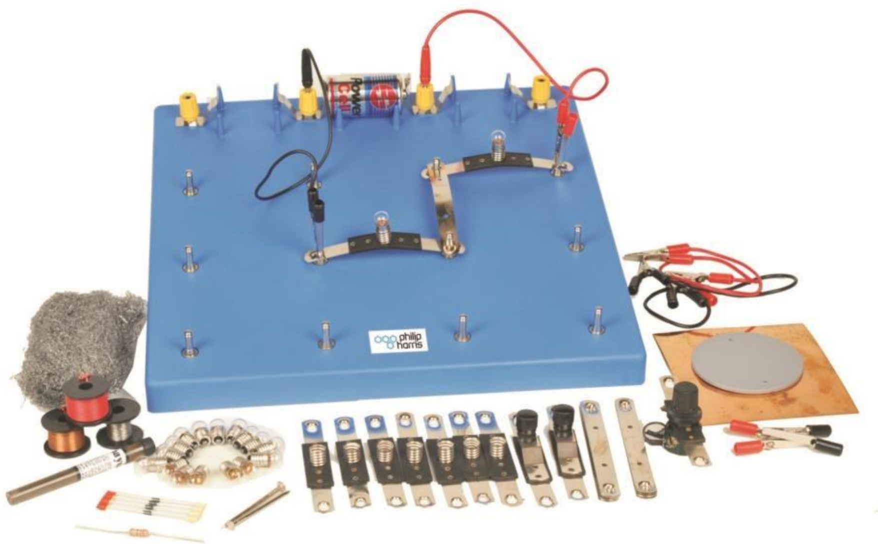
H26801 Harris Worcester Circuit Board Kit NFU 665



These notes are intended for the use of teachers: they are not instruction sheets for pupils. The teacher will doubtless give pupils whatever instructions, or questions to investigate, he thinks necessary.

The Worcester Circuit Board, which was devised for the Physics Section of the Nuffield Foundation Science Teaching Project, enables a pupil to explore for himself the phenomena associated with the flow of the electric current.

It is recommended that pupils should use the board individually or in pairs, but not in larger groups.

The boards provide an array of metal pegs placed 90mm from one another in a square pattern 270 x 270mm. In addition, clips are provided to take up to 3 D-cells. Spring strips join adjacent pillars, while components mounted on similar spring links provide an easy method of introducing such items as lamps, switches, and rheostats into circuits being investigated. The strips should be gently arched in the fingers (with the slots downwards) so that they may be slipped on to the pegs where their natural 'spring' will hold them in position and ensure a good contact.

The boards provide ample apparatus for a pupil to use in arranging and trying his own experiments, yet the basic framework gives him a starting point, and so helps to avoid aimless play. The individual items are cheap, fairly robust and well within the range of a pupil's experience. Even so, one must expect lamps to be 'blown', once, or perhaps twice; but subsequent 'blowings' might well be regarded as evidence that commonsense is not being used in the experimenting.

version H26801.15.06

Kit Components

QUANTITY	DESCRIPTION
1	Electric circuit board
9 Bulb holders 1 Bag 16 Bulbs	
2	Push-button switches
1	Variable resistor (potentiometer)
12	Connecting bars
1	Resistor
1	Coil of wire, 19 gauge copper
1	Coil of white wire, 24 gauge copper
1	Coil of steel wire, 28 gauge
2	Red connecting wires
2	Black connecting wires
2	Alligator clips
1 Container of graphite rods 1 Bag Steel wool	
1	Instructions (this booklet)

Spares and Accessories for Worcester Circuit Board

Flashlamp bulbs 2.5V 0.5A
Leakproof D-cells (may be SP2, HP2, R20 or LR20) Circuit board only
Connectors with lampholder (pack of 10) Mounted LED Plain connector Connector with rheostat Rectifier
Resistor
Flexible lead with 4mm plug and crocodile clip (pair)
Flexible leads with crocodile clips (pair)
Crocodile clips (pack of 10)
Mounted switches (pack of 10)
Soft iron nails 50mm square head (pack of 10)
Length of bare copper wire 0.90mm
Length of bare Eureka wire 0.25mm
Length of plastic covered copper wire 0.45mm
Hardboard discs drilled (pack of 10)
Pencil leads (box)
Pieces of copper foil 150 x 38mm (pack of 10)
Pieces of steel wool (pack of 10)
Instruction booklet
Component mounting strip (two limbed)

Pegs complete with two nuts and two washers (pack of 10) version H26801.15.06 Set of battery holder components

Experiments with the Worcester Circuit board

(a) Investigation of simple series circuits

(b) Investigation of simple parallel circuits

(c) Heating effect of currents

(d) Magnetic effect of currents

(e) Measuring current with a current balance

(f) Using an ammeter

(g) Investigation of current flow all round a series circuit

(h) Investigation of current in parallel circuits

(i) Switches

(j) Effect of resistance

(k) Effect of temperature on resistance

(l) Testing fuses

(m) Comparison of resistance wires

(n) Additional circuits including:- Series parallel circuits
Two-way switching Ring
main circuit
Detailed investigation into parallel lamp circuits

(o) Use of voltmeter as a cell counter

(p) Conduction in liquids

(q) Effect of rectifiers

THE WORCESTER CIRCUIT BOARD

GENERAL NOTES

It is well to make sure beforehand that the lamps to be used (2.5V 0.5A torch bulbs, MES fitting) are reasonably uniform; otherwise the sight of three lamps in series all with very different brightnesses will destroy all faith in using “a lamp’s worth of current” as a unit. Good quality bulbs are less likely to show this variation than cheap ones.

It is also important to have a stock of fresh cells (D type and preferably leakproof) at hand so that those which are exhausted can be replaced immediately.

Experience suggests that the boards are best stored with none of the accessories in place. This applies especially to the batteries.

To avoid confusion in the early stages, it is best to present only the components that are needed for the immediate task in hand. Extra cells, lamps and lampholders, links, etc, should be readily available for issue to pupils as they are called for. A useful way which assists laboratory organisation, is to provide a 'cafeteria' bench at the side of the laboratory from which such items can be drawn as required and to which they are later returned.

Pupils who move on very quickly, or who show by their facility that they are familiar with the basic ideas, can profitably investigate the more complex series – parallel type of circuit. However, we should not allow the child who has made a transistor set to say that this is beneath his dignity unless he can prove it.

Should pupils say that they can see no light in the lamps, ask them to shield the lamps and look carefully for a very faint red glow.

IMPORTANT NOTICE

Although the Nuffield specification for the Worcester Circuit Board called for the use of 1.25V flashlamp bulbs, some of the experiments in the manual require such a bulb to be run at twice its normal voltage (two cells in series supplying one bulb).

When the experimental manual was originally compiled (some forty years ago!) a 1.25V bulb was available which would tolerate being operated on 3V for a short period. This particular bulb is no longer manufactured.

2.5V 0.5A lamps are the best compromise for all experimental work.

EXPERIMENT NOTES

1. (a) Series Circuits

Simple Circuit Among the simple circuits pupils can investigate are those represented by the diagrams. It is suggested, however, that such diagrams should not be used with the pupils at this stage – experience with the equipment is required before the need for a diagrammatic shorthand becomes apparent. Clearly, pupils will start with a single cell (or battery) and one lamp and the geometry of the circuit should be changed. Subsequently a second cell is added – and pupils should be encouraged to connect this in opposition to the first as well as in the correct manner.

The normally bright lamp is clearly preferred by the maker and can serve as an elementary indicator of a standard current ('a fully-lit lamp's worth') and the picture develops of a standard requirement of one correctly connected cell for each fully lit lamp in a series circuit.

(b) Parallel Circuit

The board does not encourage the connection of cells in parallel for this is not normal practice. But lamps are connected in parallel and pupils should try these. How can 2 lamps be connected to one cell so that both are fully lit? What about 3 lamps? How can 4 lamps be fully lit? How can 6? Try 9 lamps with 3 cells.

2.Effects of the Current

(a) Heating

To emit light, the lamp filaments are obviously hot. A series circuit of 3 cells, one lamp and a 125mm length of 0.20 or 0.25mm bare eureka wire confirms the heating effect. The coil is readily supported in the circuit between 2 crocodile clips whose shanks are slipped over two adjacent pillars on the board, and will become hot to the touch.

(b) Magnetic effect

The same two clips will serve to include a tight coil (wound on a pencil) of insulated wire for experiments on the magnetic effect. The coil is wound from about a metre of wire and should be about 50mm long with leads 100 to 150mm long. These leads enable the pupil to connect it to the crocodile clip supporting pillars and to lay it on the bench (preferably so that its axis is East-West) near to a plotting compass.

The rest of the circuit comprises a cell (or 2 cells if necessary), a lamp and a pressswitch.

The small magnetic effect can be used to build up a marked swing of the needle if desired. It can also magnetise an iron nail. Two inch rectangular nails are particularly useful; they should be de-magnetised first if the effect is not to be spoiled. This is readily done by pulling the magnet smoothly from a coil which is carrying an alternating current.

At least 500 ampere-turns will be required; so a 500 turn coil capable of making 2 amperes at 12 volts will serve well.

3. Measuring the current with the Current Balance

Little progress can be made with the 'fully-lit lamp's worth' of current as a unit. But the magnetic effect does offer a way for a pupil to make a current measuring device which will serve as an introduction to the commercial ammeter.

The current balance is assembled by the pupils as shown in the diagram. The first step is the assembly of the lever arm from a drinking straw and a small Alcomax III magnet. This is secured to the end of the straw with sellotape. The straw should then be balanced on the needle and then, when the centre of gravity has been located, the needle is pushed through the straw just about 1 millimetre from that point, on the side remote from the magnet. Care should be taken to see that the needle is at right angles both to the straw and the longer axis of the magnet.

The whole assembly is then placed so that the needle rests on the metal channel with the magnet near to the centre of the coil.

To balance the straw a rider is needed. This is made from about 25mm of copper wire (0.45mm or thinner) and slipped in position so that the straw is horizontal. Ideally it should achieve balance at a position about 40 to 50mm from the needle, and this position should be marked on the straw.

The position of the end of the balanced straw is itself marked on the wooden strip, which, attached by an elastic band to the small wooden block, stands upright at the end of the balance, which is now ready for use.

The balance is essentially a null deflection instrument and the position of the magnet relative to the coil should not change from reading to reading.

The balance should be used in a simple series circuit of 1 cell and 1 lamp arranged so that the current flows in such a direction as to draw the magnet into the coil. This necessity to observe correct polarity is good experience for the pupils. Then the rider can be moved gently along the straw (a 50mm length of wire makes a useful tool for this operation, the straw being steadied carefully with the other hand whilst the adjustment is made) until balance is restored. This new position of the rider provides a measure of 1 'fully-lit lamp's worth' of current and should be compared with that obtained with under-and over-run lamps.

The pupils should then try the balance in circuits where 2 lamps in parallel are lit by 1 cell, (and the total current is two 'fully-lit lamp's worth') and where three lamps in parallel are lit.

These balances can also be used to explore the conducting properties of such materials as wood, paper, nylon thread, aluminium leaf, a soft pencil lead. Such specimens are readily connected in to the circuit by using two crocodile clips as described above. Perhaps the simplest technique is to set the rider for one 'fully-lit lamp's worth' and to note whether the current passing through the specimen is more or less than this.

4. Using an ammeter

Such a balance as the one made up by the pupil is, of course, fragile. Nevertheless, it is well worth the trouble of construction as an introduction to the commercial ammeter. A moving coil, low resistance instrument with a range of 0 to 1 or 1.5A is needed, and the scale markings should be clear and unambiguous. (Moving-iron instruments are likely to have a relatively high resistance and are not advised). Such a bench meter is issued to the pupils who substitute it for their current balance in the simple series and parallel circuits already described. Where pupils use both instruments in the same circuit, it is wise to separate them by the width of the circuit board, for the external field of some ammeters can disturb the balance.

A new unit (the ampere) replaces the ‘fully-lit lamp’s worth’ as a unit of current. At this elementary stage, the unit is best regarded as an arbitrary one – related to an internationally maintained standard (cf, the yard, the pound, the metre and the kilogram). It is worth noting, perhaps, that the legal definition of the ampere is almost as arbitrary as the unit adopted here.

The definition is as follows:- “Electrical Current; a standard of electrical current denominated one ampere agreeing in value within one tenth of one per cent with the fundamental unit and being the current which is passing in and through the coils of wire forming part of the instrument marked ‘Board of Trade Ampere Standard Verified 1894 and 1909’ when on reversing the current in the fixed coils the change in the forces acting on the suspended coil in its sighted position is exactly balanced by the force exerted by gravity in Teddington upon the iridioplatinum weight marked ‘A’ and forming part of the said instrument”.

5. Current all round a series circuit

This is an extremely important experiment and its result is far from obvious to young pupils; indeed to many it appears to be contrary to commonsense.

Pupils should set up a series circuit of two cells and two lamps and then explore the effect of connecting their ammeter (either the commercial model or their own current balance) into a number of different places in that circuit; between the lamps, between the cells and the lamps, between the cells. Each time they should note the current and so discover the surprising result that this is the same at all the points measured. In fact, the ‘electricity’ is not being used up in its passage around the circuit.

Both the work with the current balance and the ammeter will have shown the need for correct polarity connections.

6. Current in parallel circuits

If desired, pupils can now explore the currents flowing in the branches of parallel circuits. A suitable circuit uses two cells to light six lamps in 3 parallel groups.

The simple additive law which emerges for the various junctions is important information for the pupils and, with the fact that this current is the same all round a series circuit, provides a justification for the use of the word 'current' in the electrical case. The electrical behaviour is, in this respect at least, analogous to the behaviour of water in pipes, of traffic at a roundabout and so on. It could be due to a continuous 'juice' flowing one way or the other, or to two such streams flowing in opposite directions, or to 'bits' of electricity travelling one way to the other; or to two such streams flowing in opposite directions. There is no evidence to settle this question from these experiments.

7.Switches

Pupils will have discovered how a gap in a circuit prevents the flow. They will find that switches can be improvised simply by swinging a link on its peg, or by unscrewing a lamp in its holder.

8.Resistance

Some conductors (e.g. the length of bare eureka wire 0.25mm used in experiment 2(a)), dim the lamp in series with them. This should be investigated. The simplest method is to set up a circuit of 2 cells, a lamp, an ammeter and about 450mm of the same resistance wire to which connection is made through crocodile clip leads. First, use the whole length of wire and then slowly shorten it – noting the effect on the lamp.

The wire can then be replaced by a fixed resistor (3.9 ohm, 1 watt, wire wound) and by the dimmer (rheostat). As the latter is adjusted, so the effect on the current should be observed.

It would be of assistance to pupils' understanding if the back of one of these dimmers can be removed, so that the construction can be seen and related to the simple wire and clip arrangement tried earlier.

9. Temperature effect

When a strand of steel wool 50 to 75mm long (from an ordinary steel wool cleaning pad, or better, of grade 2) is clipped with crocodile clips on pillars and put in series with 3 cells, an ammeter and a lamp, the latter will show very clearly that the resistance of the steel wire is dependent upon temperature. Indeed, blowing on the wire will cool it sufficiently to increase the current quite considerably.

Should mounting the wool between the clips cause difficulty, paper clips can be used to grip the wire, and these can then be held in the crocodile clips.

The same wire can be used to show fusing; but now remove the lamp or it may fuse first! Then shorten the length of steel wire in circuit by sliding the clip of a crocodile clip lead along it until the wire fuses (and burns).

10. Voltmeter as cell counter

This experiment requires either a voltmeter with a full scale deflection for 5 or 6 volts or a moving coil meter with a full scale deflection of, say, 10mA. In this latter case connect a radio-type resistor of about 1000 ohms in series with the meter. It is an advantage if the scale markings are obscured. This is readily achieved by 'sellotaping' a piece of frosted plastic sheet over the appropriate part of the instrument.

The instrument is then connected across one, two and three cells and can be calibrated directly in cells.

11. Conduction in liquids

The circuit board provides a useful background for simple work on the conduction of electricity through liquids. The simplest cell is a beaker with a hardboard lid, with holes through which 2 pencil leads can be slipped. These make excellent carbon electrodes to which connection can be made through flying leads terminating in crocodile clips.

With such an arrangement pupils can try the passage of electricity through distilled or deionised water. They should then add a few common salt or copper sulphate crystals and try again. Then, starting again with a clean beaker and distilled water, try adding a few drops of dilute sulphuric acid. And perhaps, fresh distilled water with some sugar; or an oil. Tap water too should be tried. In each case, the beaker should be rinsed thoroughly and a fresh supply of distilled water used.

To experiment with copper plating, the same beaker can be provided with electrodes of copper foil cut into strips about 75mm by 12mm and clipped to the sides of the beaker with the crocodile clips on the flying leads.

Pupils will be tempted to plate other materials; but objects of zinc or iron should be avoided, because they are likely to displace copper anyway and so confuse the story.

13. Rectifiers

A silicon rectifier with a forward resistance of about 4 ohms and a maximum current capacity of about 500mA offers an interesting contrast to the 3.9 ohm wire wound resistor used in Experiment 8.

The pupil sets up a simple series circuit of 1 lamp, 1 or 2 cells and 1 ammeter, with 2 crocodile clips arranged to receive specimens. First the resistor is inserted and then reversed. Then the rectifier is inserted and reversed.

Warnings

For your safety, this product should be used in accordance with these instructions, otherwise the protection provided may be impaired.

Warranty

The axial and lateral search coil is guaranteed for a period of one year from the date of delivery to the customer. This warranty does not apply to defects resulting from the action of a user such as misuse, improper wiring, any operations outside of its specification, improper maintenance or repair, or unauthorized modification.

Our liability is limited to repair or replacement of the product. Any failure during the warranty period should be referred to Customer Services.

In the event of a fault, apart from replacing the instrument fuse in the IEC socket, the power supply should be referred to the Philip Harris recommended repair agent.

Please contact Customer Services or techsupport@philipharris.co.uk for advice.

Supplier details

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Orders and Information Tel: 0845 120 4521
Fax: 0800 138 8881
Repairs Tel: 0845 120 3211

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