ELEKTRON

ELECTRICAL EXPERIMENTS

INSTRUCTIONS
FOR
No. 2 OUTFIT

Price 1/-

MECCANO LIMITED, BINNS ROAD, LIVERPOOL 13.

ELEKTRON

ELECTRICAL EXPERIMENTS

The No. 2 Elektron Outfit contains apparatus and materials by means of which can be carried out a series of fascinating experiments in electrical science. These experiments have been specially chosen to explain in an interesting manner the principles on which the wonderful electrical mechanisms of to-day operate.

In the No. 1 Elektron Manual the mysteries of Magnetism and the marvels of the mariner's compass are described and explained, together with the production of Electricity by means of friction.

The No. 2 Elektron Manual completes the scheme by explaining the principles of the generation and application of electric currents. It deals also with the construction of the Bichromate Cell that produces the current required in a splendid series of experiments. The electrical apparatus that can be built from parts contained in the No. 2 Elektron Outfit includes a useful Reading Lamp; two different high speed working Electric Motors; a Shocking Coil, that will provide hours of fun and excitement; a real Electric Bell and a Buzzer that can be used in a simple telegraph system, and electro-magnets that can be put to many uses. Other attractive experiments described include electroplating, and materials are included by means of which an old spoon or other suitable article may actually be copper-plated.

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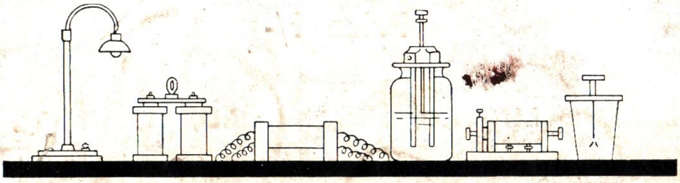


CURRENT ELECTRICITY

In the No. 1 Elektron Manual we deal with magnetism, and with charges of electricity produced by friction. We come now to electricity in motion, that is, continuous electric currents.

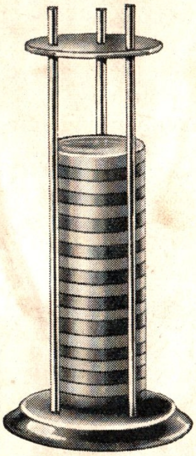


Fig. 1. Volta's Pile.

About 1786 Luigi Galvani, an Italian physician, while experimenting with frogs' legs found that these twitched when the nerves were touched by two different metals. He believed that this twitching was caused by electricity produced in some way from the tissues of the animal. Another Italian, Alessandro Volta, also attributed these twitchings to electricity, but he thought that this was produced by the contact of the two metals. To test his theory he placed a piece of flannel soaked in acid between discs of copper and zinc ; and on connecting the discs by a wire he obtained a weak current. Later he built a pile of metal discs separated by discs of flannel soaked in acid (Fig. 1). These were placed on top of each other in the succession copper, flannel, and zinc all through, and by connecting the first copper disc with the last zinc disc he obtained a more powerful current.

Electricity produced in this manner came to be known as Voltaic electricity, in order to distinguish it from the form produced by friction that had long been known. It retained this name for many years, but for reasons that will be made clear later in this Manual is now known as CURRENT ELECTRICITY.

Electric Current from Chemical Action

The Voltaic pile was soon replaced by the VOLTAIC CELL, which consisted of a glass vessel containing dilute acid, in which plates of copper and zinc were immersed.

A simple cell of this kind may be made from the Copper and Zinc Plates (Parts Nos. 1526 and 1527) included in the No. 2 Elektron Outfit. In addition about half a cupful of dilute sulphuric acid is required. Postal and railway regulations forbid the packing of this acid in the Outfits, and it should be purchased from a chemist or wireless dealer, or at a garage. Acid of accumulator strength should be asked for. The acid is placed in a cup or small tumbler and the Zinc and Copper Plates are dipped in it as shown in Fig. 2. Bubbles of hydrogen rise from the zinc, but not from the copper unless it is connected with the zinc by means of a wire.

This curious behaviour of the copper is brought about by the passage of an electric current through the wire from the Copper Plate to the Zinc Plate, the circuit being completed from the zinc through the acid and back to the copper. In order to show the existence of this current fix Terminals (Part No. 1563) on Bolts passed through the holes in the corners of the Copper and Zinc Plates, and secured in position by means of nuts. Bare the ends of two pieces, each 11 in. in length, of Connection Wire

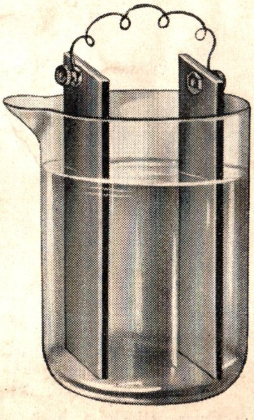


Fig. 2. A simple Voltaic cell.

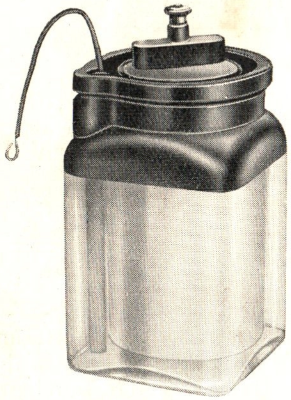


Fig. 3. The Leclanché cell.

(Part No. 1566) which has green glazed insulation, and attach one piece to the Terminal on the Copper Plate and the other to that on the Zinc Plate. Twist the loose end of one of these wires round the threaded terminal of the 2.5v. Flashlamp Bulb (Part No. 184a) and with the other touch the second terminal of the Bulb. The filament immediately glows, showing that a current is passing through it.

In a simple cell of this kind the Zinc and Copper Plates are said to be the poles. The current flows through the wire from the copper to the zinc, and the Copper Plate therefore is described as the positive pole and the Zinc Plate as the negative pole.

Preventing Polarisation

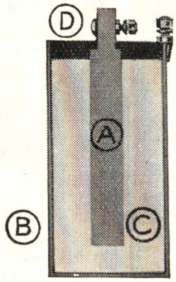


Fig. 4. Cross-section of a dry cell

In this experiment the filament of the Flashlamp Bulb glows only for a few seconds owing to the formation of bubbles of hydrogen on the Copper Plate that cover the metal and prevent the acid from reaching it. The chemical action that produces the current is thus brought to a standstill. The cell is then said to be POLARISED, and in order to depolarise it and restore it to activity the hydrogen must be removed from the Copper Plate. This is done by adding some chemical that will get rid of the hydrogen by combining with it.

There are many different forms of Voltaic cells in which different materials are used. One familiar cell is the LECLANCHÉ (Fig. 3), in which a zinc rod is the negative pole and a carbon plate the positive pole. This cell consists of a glass jar containing a zinc rod and a solution of sal-ammoniac, and an inner porous pot containing a carbon plate packed around with a mixture of crushed carbon and manganese dioxide, which seizes the hydrogen on its way to the carbon plate and combines with it.

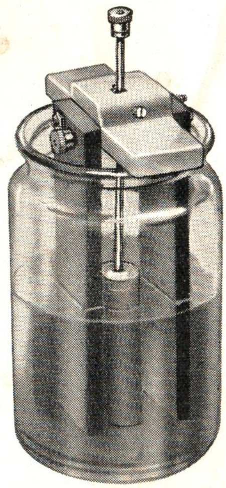


Fig. 5. The Elektron Bichromate cell.

The most familiar Voltaic cell to-day is the so-called dry cell. This is really a Leclanché cell, in which the containing vessel (Fig. 4, B) is made of zinc, and the liquid is taken up by an absorbent material to form a paste C. A is the carbon, surrounded by manganese dioxide, and D a pitch cover, the object of which is to prevent leakage.

Making a Bichromate Cell

A Voltaic cell specially designed for use in the experiments described in this Manual is illustrated in Fig. 5. In order to make it, a Carbon Plate (Part No. 1532) is fitted on each side of the Bichromate Cell Mounting (Part No. 1528) as shown in Fig. 6, by means of two Threaded Rods (Part No. 1533) and four Nuts. The Zinc Rod (Part No. 1531) is

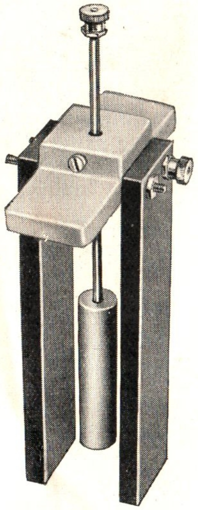


Fig. 6. The Cell Mounting of the Elektron Bichromate Cell, with the Zinc Rod and Carbon Plates in position.

screwed on one end of the Electroscope Rod (Part No. 1521), which is then passed through the hole in the Cell Mounting in such a manner that the Zinc Rod is between the Carbon Plates. The brass Rod slides freely through the hole in the Cell Mounting, but it may be held in any required position by means of the Bolt (Part No. 1530) provided, the purpose of this being to enable the Zinc Rod to be lifted clear of the liquid so that it is not consumed by the acid when current is not required from the cell. A Nut and a Terminal are screwed on the top of the brass Rod, and a second Terminal is screwed on the end of one of the Threaded Rods, where it is in electrical contact with the Carbon Plates.

A 1-lb glass jam jar forms a suitable container for the acid, to make which ½ oz. of Bichromate of Potash (Part No. 1577) is required. The quantity of this chemical supplied in the Outfit is 3 oz., and therefore one-sixth of this should be used. The red crystals are dissolved in 4 oz. of water—a tablespoonful is 1 oz.—and to the solution is added 1 oz. of dilute sulphuric acid, of the strength used in constructing the simple voltaic cell described on page 1. The mixture should be made in vessels standing in a sink or other place where no harm can be done if the liquid is accidentally spilled.

In order to complete the cell the liquid is poured into the glass jar, and the Cell Mounting is placed in position. The Zinc Rod must only be lowered into the solution when current is actually required. The zinc slowly dissolves, but the substantial rod supplied will last for a considerable time. The red liquid changes in colour to deep green, and should be renewed when the cell shows signs of exhaustion. If at any time crystals form on the Carbon Plates, these should be removed from the jar and thoroughly washed.

Measuring Electric Currents

The movement of electricity through a conductor, such as a copper wire, may be compared to that of water flowing along a pipe from a storage reservoir to a house. The water flows along the pipe because it is forced to do so by pressure resulting from a difference of level, the reservoir being higher than the house.

In a similar manner a difference of electrical pressure exists between the positive and negative plates of a Voltaic cell. This difference produces an electricity-moving or

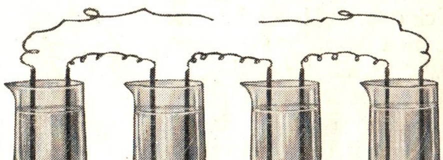


Fig. 7. (a) Voltaic cells arranged in series.

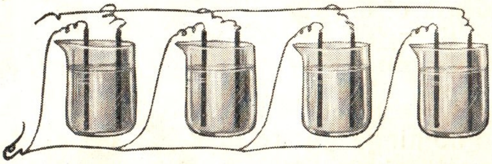


Fig. 7. (b) Voltaic cells arranged in parallel.

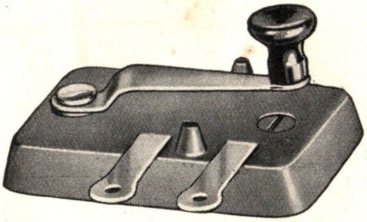


Fig. 8. The Elektron Switch.

ELECTRO-MOTIVE FORCE, which is measured in VOLTS. The rate of flow of water through a pipe is measured in gallons per second, and the rate of flow of electricity is measured in AMPERES. Volts thus represent the pressure at which a current is supplied, while the current itself is measured in amperes.

Water flowing through a pipe meets with resistance due to friction against the walls of the pipe. An electric current flowing through a wire also meets with resistance, although this is not due to friction. In a good conductor this electrical resistance is small, but in a bad conductor it may be very great. It is greater in a thin wire than in a thick one, and in a long wire than in a short one. Most metals, particularly copper, have low resistance, and for this reason copper wire is specially suitable for electrical connections. Resistance is measured in OHMS.

To sum up, we may describe a volt as the electromotive force that will cause a current of one ampere to flow through a conductor having a resistance of one ohm.

Combining Cells to make Batteries

We can produce electric currents more powerful than those from our Bichromate Cell by combining several cells to form what is known as a BATTERY. There are two ways of doing this. If two cells are arranged with the zinc of one connected to the carbon of the other, the effect is to add together their voltages. Higher voltages are obtained by adding more cells in a similar manner, connecting zinc to carbon all through (Fig. 7a). This is known as connecting in SERIES.

For some purposes we require more current, but not more pressure; that is, more amperes, but not more volts. For this purpose we connect together all the positive terminals and all the negative terminals of several cells, that is, zinc to zinc and carbon to carbon all through. A battery formed in this manner is said to have its cells connected in PARALLEL (Fig. 7b).

Switching Currents on and off

A very important part of all electrical circuits is the switch, by means of which the flow of current is started or stopped. The Switch (Part No. 1572) that is used in the experiments described in this Manual is shown in Fig. 8. In order to make use of it in an electrical circuit, Bolts are passed upward through the holes in the two brass strips and are fixed in position by means of Nuts. Terminals are then screwed on the Bolts in order to provide means of attaching the wires to and from the Bichromate Cell and other parts of the circuit.

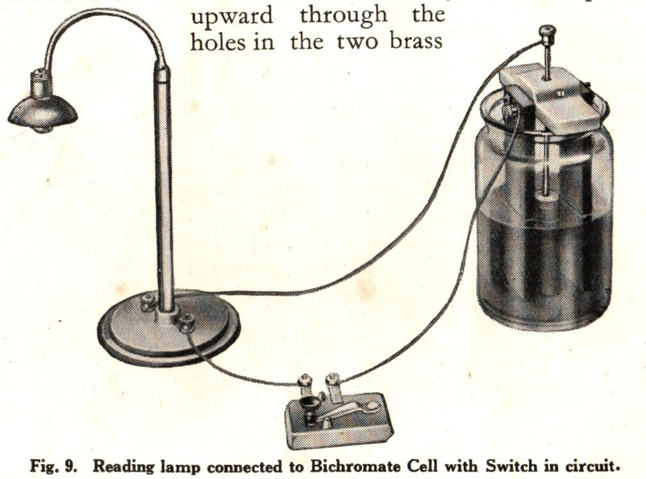


Fig. 9. Reading lamp connected to Bichromate Cell with Switch in circuit.

A Useful Reading Lamp

A useful reading lamp that can be made from Elektron parts is constructed as follows: The Erinoid Tube (Part No. 1509) is fixed in the central hole in the Circular Base (Part No. 1508) and the Stand Bracket (Part No. 1510) is fitted on its upper end. Two Terminals are mounted above the Circular Base on ½in. 6BA Bolts (Part No. 1575), pushed through the small holes from beneath, and fixed in position by means of 6 BA Hexagonal Nuts (Part No. 1562) above the Base. Two 13-in. lengths cut from the coil of Connection Wire (Part No. 1566) are pushed through the Erinoid Tube and over the Stand Bracket, their ends projecting about ¼in. below the slotted end, and the insulation of the projecting ends is then removed.

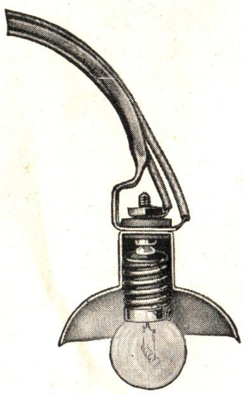


Fig. 10. Electrical connections of the reading lamp.

The Lampholder (Part No. 1534) is held upside down and the small Insulating Washer (Part No. 1561) is dropped into the narrow portion, followed by the Lampholder Screw (Part No. 1535), the shank of which is pushed through the Washer and the hole in the Lampholder. The blade of the Screwdriver is placed in the slot of the Screw to hold it in position, and the Lampholder is turned the right way up while the large Insulating Bush (Part No. 182) is placed on the shank of the Screw, followed by a 6BA Hexagonal Nut.

The slotted end of the Bracket is then inserted between the Lampholder and the Washer, and the end of one of the two wires is placed under it, care being taken that the wire does not make contact with the screw.

The end of the second wire is coiled between the Washer and the Hexagonal Nut, as shown in Fig. 10. The small screw is now tightened, and the Connection Wire pulled gently through the Erinoid Tube until it rests in the curve of the Bracket. The ends passing below the Circular Base are freed from insulation for a length of about ½in., and fixed under the heads of the bolts carrying the Terminals.

The Flashlamp Bulb (Part No. 184a) is screwed into the holder and the Terminals on the Circular Base are connected to those of the Bichromate Cell. The Switch (Part No. 1572) also should be included in the circuit, as shown in Fig. 9.

Magnetic Effects of an Electric Current

In the No. 1 Elektron Manual we point out certain similarities between the behaviour of electrified bodies and of magnets. We shall now see that magnetic effects can be produced by electricity, and to show this we make use of the Compass included in the Outfit, and the Bichromate Cell. If a wire connected to the terminals of the cell is held over the Compass Needle in the manner shown in Fig. 11, and the key of the Switch included in the circuit is pressed, the compass needle swings away from its usual north and south position. On reversing the wire so that the current flows in the opposite direction the Compass Needle moves when the Switch is closed, but to the other side of the wire.

The Compass Needle swings round also if the wire carrying the current is placed

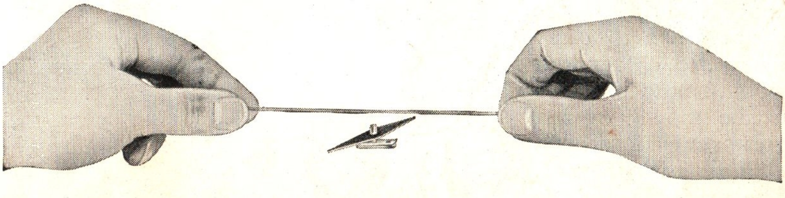


Fig. 11. A compass needle swings round when a wire through which an electric current is flowing is held above it.

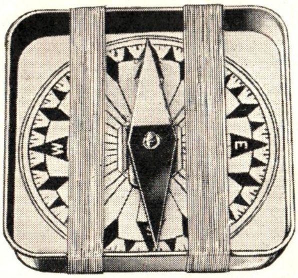


Fig. 12. The Elektron galvanoscope.

underneath it, and it moves in the same direction as that caused by a current flowing the opposite way through a wire held above it. A double effect therefore is produced by wrapping a complete turn of wire round the Compass Needle, and this is most easily done by leaving the Compass Needle and its supporting Pivot in the square Compass Box and coiling a length of the insulated Connection Wire (Part No. 1566) round it.

To Detect Electric Currents

Next try the effect of wrapping more turns of wire round the box, thus forming a coil enclosing the Compass Needle. It is best to make a double coil with a section on each side of the needle, as shown in Fig. 12, each section being parallel to the line joining N and S on the card. The Cotton-Covered Wire included in the Outfit (Part No. 1564) will enable 25 turns to be wound on each side, and the two windings must be continuous and in the same direction. The current in each length of wire above and below the needle helps to cause the deflection, and as would be expected, the needle moves over a greater angle than when a single turn is used. The magnetic effect is so greatly magnified in this manner that very small currents can be detected without difficulty.

The instrument we have constructed is a "GALVANOSCOPE," that is, a detector of currents. We may use it, for instance, if we wish to find whether the wire of one of the coils used in a wireless set is continuous or has been broken. For this purpose one end of the coil is connected to the galvanoscope and the other to a terminal of the Bichromate Cell (Fig. 13). The other end of the galvanoscope coil is connected through the Switch to the second terminal of the cell. If the needle is deflected when the Switch is closed, then the coil under test is in order. On the other hand if the needle does not move, a break in the wire must be preventing current from flowing through the coil.

If a rod of soft iron is placed inside a coil of wire and a current is passed through the coil, the iron then becomes a magnet. To show this, wrap a length of Cotton-Covered Wire round a pencil so as to form a long narrow coil (Fig. 14). Connect the ends of this coil to the terminals of the Bichromate Cell with the Switch included in the circuit. Place a long nail inside the coil and switch on the current. The nail then becomes a magnet, with a pole at each end, for it attracts filings, needles or Meccano nuts (Fig. 15). As soon as the

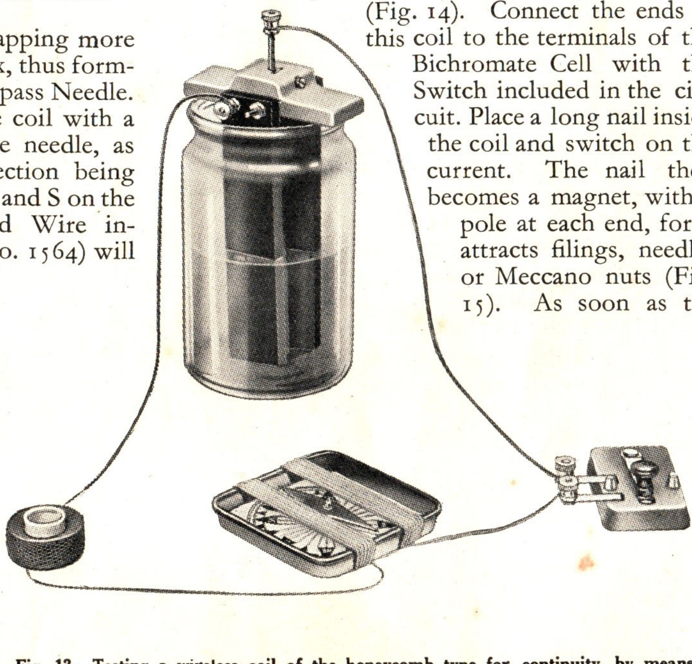


Fig. 13. Testing a wireless coil of the honeycomb type for continuity, by means of the Elektron galvanoscope and the Bichromate cell.

current is switched off, the filings drop off the nail, showing that its magnetism was entirely

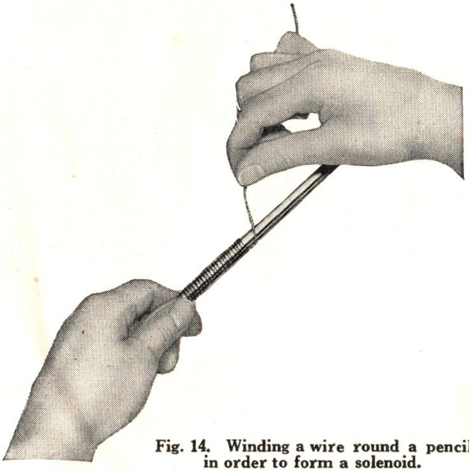


Fig. 14. Winding a wire round a pencil in order to form a solenoid.

due to the passage of the current. Temporary magnetism of this kind is known as electro-magnetism.

The coil of wire used in this experiment is called a SOLENOID. It is itself magnetic when current is passing through it, as may be proved by testing it with a magnetic needle. (Fig. 16). If the ends of the solenoid are dipped in iron filings while the current is flowing, these cling to it, but they drop off as soon as the current stops.

When a coil is to be used as an electro-magnet it is always provided with a core of soft iron.

Making Electro-Magnets

A powerful electro-magnet can be made by placing one of the Magnet Cores (Part No. 1539) inside a Magnet Coil (Part No. 1538), and passing a current through the windings, which are connected with the Bichromate Cell and the Switch in the usual manner. Practically all the experiments that were made with bar magnets may also be carried out with this electro-magnet. Its north and south poles can be found by bringing each end in turn near the north pole of a Compass Needle. It will then be noticed that the polarity is reversed by simply interchanging the wires in order to alter the direction of the current.

Making Magnetic Maps.

It is interesting to map out with filings the magnetic field of an electro-magnet. This is readily done by cutting a rectangular hole $1\frac{5}{16}$ in. by 1 in. in a sheet of cardboard, and placing the coil in this opening so that half of it is below the card and half above, as shown in Fig. 17. Iron Filings from the Glass Tube (Part No. 1513) are placed in the Sifter Box (Part No. 1512), after the small parts packed in it have been removed, and are shaken through the small holes in its base over the cardboard sheet covering the Magnet Coil. When current is passed through the Coil and the cardboard sheet is tapped gently the filings arrange themselves in curves, running from north pole to south pole, that show the direction of the lines of magnetic force. The magnetic fields of the Bar and Horseshoe Magnets can be mapped in a similar manner.

A powerful magnet of horseshoe shape (Fig. 18) may be constructed by using the two Magnet Coils, each provided with a Magnet Core. The Cores are inserted so that their threaded portions are at

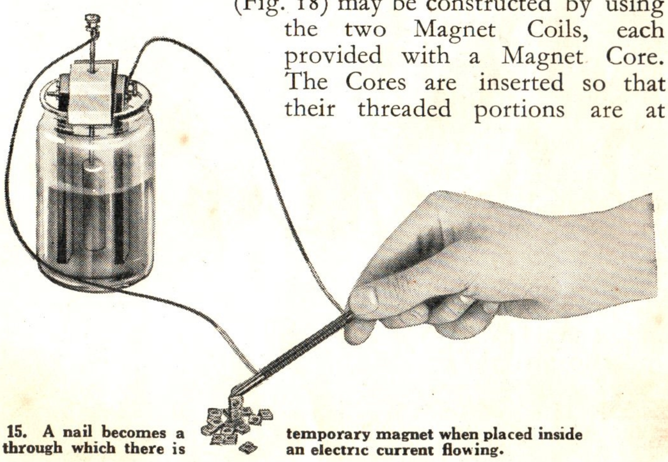


Fig. 15. A nail becomes a temporary magnet when placed inside a coil through which there is an electric current flowing.

the ends of the Coils where the two terminals are visible. Place the Coils side by side with the threaded ends of the Cores together and insert these in

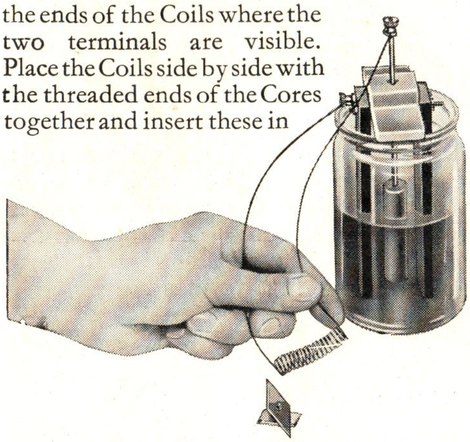


Fig. 16. Testing the magnetic powers of a solenoid.

the outer holes in the small Magnet Yoke (Part No. 1541), fixing them securely in this position by means of nuts.

This gives us a piece of soft iron having the shape of a horseshoe and with a Coil round each limb. The free ends are to be the poles of our electro-magnet and they must be of opposite kinds. For this reason current must flow in opposite directions through the windings of the Coils. This means that to anyone facing the poles of the electro-magnet, the current must appear to flow in a clockwise direction round one Coil and in a counter-clockwise direction round the other. In each Coil the winding begins at the core and ends on the outside. The inner terminals of the two windings are therefore joined by means of a short length of Connection Wire in order to give the desired arrangement.

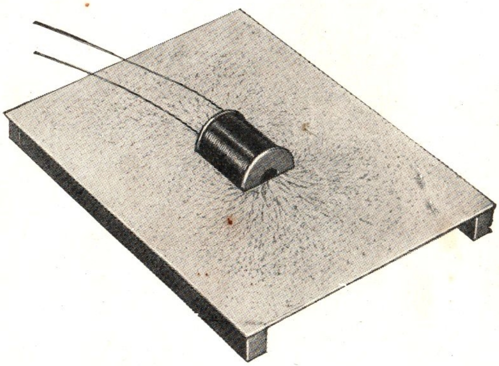


Fig. 17. Mapping the magnetic field of a coil through which current is passing

Each electro-magnet is now complete and only requires connection to the Bichromate Cell and the Switch. For this purpose the remaining terminals of the two Magnet Coils are connected to the Switch and one pole of the Bichromate Cell respectively, a further short length of wire completing the circuit by connecting the other pole of the Cell to the free terminal of the Switch.

The Magnet Hook (Part No. 1540) is screwed on the Yoke of our electro-magnet and enables us to suspend it from the cord of a Meccano model of a crane for use in lifting Strips and other Meccano parts representing castings or girders (Fig. 19). The electro-magnet is brought into contact with its load before the current is switched on, and the flow of this is stopped when the load has been lowered to the required position.

Steel cannot be used for the cores of electro-magnets, for it would retain much of the magnetism acquired, and would not release its load readily, as does soft iron.

Electro-magnetic cranes are used in steel mills, iron foundries, machine shops and shipyards. The powerful electro-magnets employed seize their loads in a tenacious and invisible grip without trouble or loss of time in fixing chains, ropes, or hooks, and deposit their loads exactly where they are wanted as soon as the current that flows through their windings is switched off. (Fig. 20).

How Electric Bells Work

One of the best known and most useful applications of the electro-magnet is in the construction of the electric bell, illustrated in Fig. 21. A horseshoe electro-magnet MM is employed to attract a soft iron Armature A, held by the spring fixed to the Post P. At the end of the Armature is the Hammer H, and this strikes the Gong G when the Armature is attracted to the electro-magnet.

If the current merely flowed through the coils of the electro-magnet, the bell would only ring once when it was switched on. A special arrangement is necessary in order to give continuous ringing. The current passes from the coils to the Armature A by means of the Post P, and from there it flows to a Contact Screw CS and its Supporting Block B, from which it is conducted back to the cell. The Armature A loses contact with the Contact Screw CS as soon as it is attracted by the electro-magnet, and thus the flow of current is cut off. The Armature therefore is immediately released and the spring to which it is attached causes it to jump back to its original position. This again completes the circuit, and the Armature is once more attracted. The alternate attraction and return continue automatically as long as the switch is depressed, and the result is to produce a rapid succession of strokes on the gong. Bells of this type are known as trembler bells, because of the rapid movement of the armature and hammer.

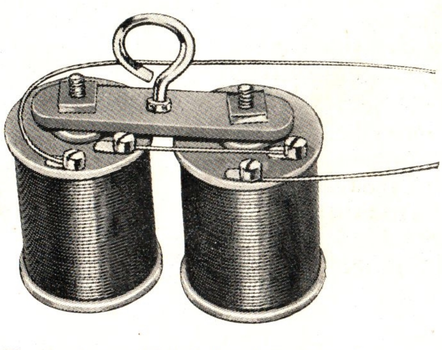


Fig. 18. A powerful horseshoe electro-magnet.

Constructing an Electric Bell

An excellent electric bell of this type (Fig. 23) may be made from the parts included in the Meccano No. 2 Electrical Outfit. The first step is to fix the electro-magnet already made on the Universal Base (Part No. 1500), shown in Fig. 22. In order to enable this to be done the small Yoke to which the Coils are attached is replaced by the Angle Yoke (Part No. 1547). This is fitted to the Universal Base by means of Bolts and Nuts passing through the holes numbered 4 and 5 (Fig 22), and also through the corresponding holes in the flange of the Angle Yoke. The inner terminals of the Coils are joined, under the Universal Base, by means of a short length of Connection Wire, and short pieces of wire connected to the remaining Coil terminals are pushed downward through adjacent holes in the Universal Base.

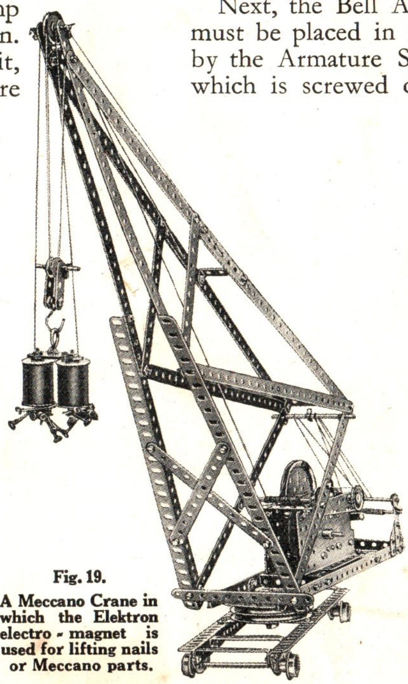


Fig. 19. A Meccano Crane in which the Elektron electro-magnet is used for lifting nails or Meccano parts.

Next, the Bell Armature (Part No. 1543) must be placed in position. This is carried by the Armature Support (Part No. 1550), which is screwed down on a ⅜ in. 6 B.A. Bolt (Part No. 1573) passed from underneath through the hole 2 (Fig. 22) and one hole of the Connecting Link (Part No. 1567). A screw passing through the small hole in the end of the Armature Spring presses it tightly against the flat on the Armature Support, which is turned round until the Armature is in front of the poles of the electro-magnet. The Bell Rod and Hammer (Part No. 1544) is fitted to the Armature by the Screw (Part No. 1588).

The Gong Pillar (Part No. 1546) is fixed in the hole marked 6 on the plan of the Universal Base, and is held there by means of its Nut. The Gong (Part No. 1545) itself is fitted on the Pillar, to which it is secured by means of a screw.

The Bell Contact Pillar (Part No. 1548) is used to support the Contact Screw. Its threaded end is fitted in the hole numbered 7 and it is turned round so that the hole drilled through its upper end points towards the Bell Armature before the Nut holding it in position is tightened. The Contact Screw is screwed into light contact with the Armature Spring.

It now only remains to complete the wiring. For this purpose 6 B.A. Bolts are pushed from below through the holes numbered 1 and 3 in the Universal Base and after securing them by means of Nuts, Terminals are screwed on them. The outer terminal of the Coil nearer Terminal 3 is connected to the lower end of this Terminal, and that of the other coil is connected to the Contact Pillar. Finally the Connecting Link (Part No. 1567) joins the Armature Support to the Terminal 1. This wiring is carried out under the Universal Base, and Fig. 24 shows its course.

Terminals 1 and 3 are connected with the poles of the Bichromate Cell, the Switch being included in one of the wires. When the key of the Switch is pressed on the brass stud, current flows through the coils of the electro-magnet, and the bell continues to ring as long as the key is pressed down. The Contact Screw is moved backward and forward until the position that gives the loudest ring is found, and is then fixed by tightening the locking screw.

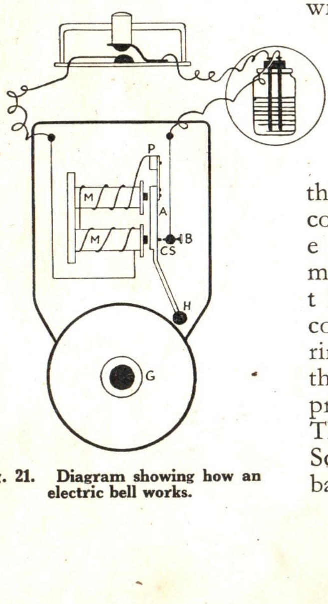


Fig. 21. Diagram showing how an electric bell works.

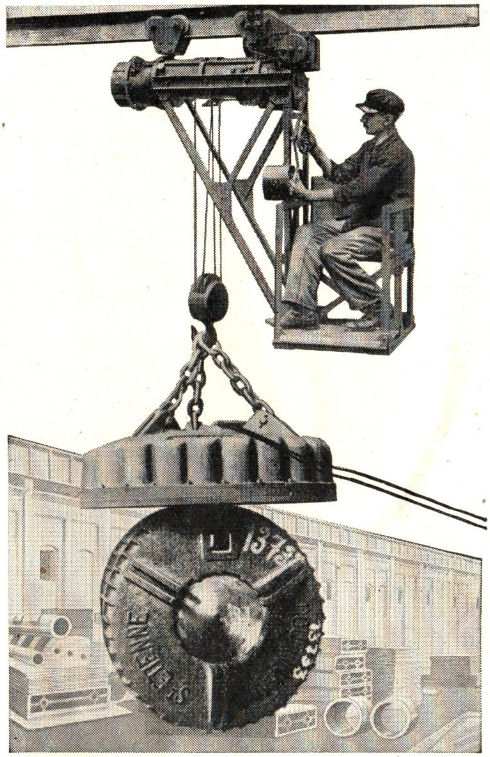


Fig. 20. An electro-magnetic crane at work.

Scaring Burglars and Detecting Fires

Electric bells and electro-magnets are used in constructing burglar and fire alarms. In one system of protection against burglars, the wires of bell circuits are so arranged that the opening of a door or window closes a simple switch, thus causing a bell to ring. This system has the drawback that it does not act if the wires are cut by a burglar who has been keen enough to detect their presence. It is better to connect the alarm wires with a small electro-magnet that holds the arm of a spring switch in the "open" position. Current flows continuously through the wires and is interrupted immediately a door or window is opened. The arm of the spring switch is then released, causing current to pass through a second circuit in the wiring of which an electric alarm bell is fitted.

The heat of a fire itself may give warning of the outbreak by closing switches that cause electric bells to ring. One device employed for this purpose consists of two thin strips of different metals, such as brass and steel, riveted together and suspended between two contact pieces. As the two metals used expand and contract at different rates when heated or cooled, a rise in temperature causes the strip to bend, and it is so adjusted that the heat of an outbreak of fire makes it bend sufficiently to touch the contact pieces, and thus to close a circuit that rings the alarm bell.

A Simple Telegraph System

The trembler bell may be used for signalling by means of short and long rings, but it is more usual to employ a buzzer for this purpose. This is constructed in exactly the same manner as the electric bell, but there is no Gong, and consequently no Bell Rod and Hammer. In order to turn our electric bell into a buzzer that may be used for telegraphy, therefore, all that is necessary is to remove these parts.

The other requirements for a simple telegraphic system are a switch and a source of electric current. Our Bichromate Cell may be used with the buzzer constructed in the manner just explained. The Switch included in the Outfit also is suitable. It is used in the same manner as when ringing an electric bell and forms a simple telegraph key (Fig. 25). Wires lead from the terminals of the Switch to the buzzer, which is placed at a little distance, the circuit also including the Bichromate Cell.

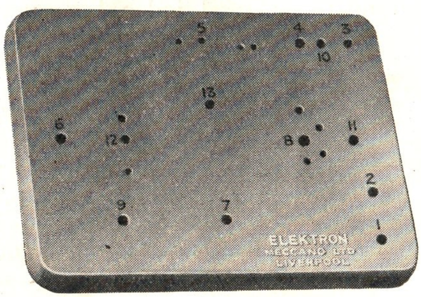


Fig. 22. The Elektron Universal Base. Terminals and other parts fit the large numbered holes, and connecting wires only are passed through the smaller openings.

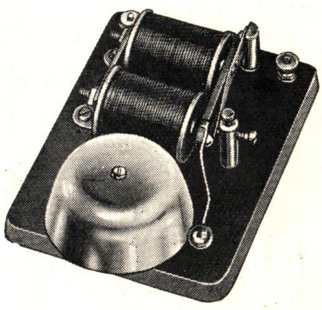


Fig. 23. The Elektron electric bell.

When the key in this circuit is pressed down the buzzer is sounded, and a listener at the receiving end may read the message conveyed by means of its short and long notes sent in accordance with the code employed. This is known as the MORSE CODE, and derives its name from Samuel F. B. Morse, the American inventor who worked out the first telegraph system. The code that Morse employed came into general use, and in its present form it is shown in Fig. 26. It is quickly learned, preferably by memorising the sounds representing each letter, instead of the number and order of the dots and dashes employed. Progress is most rapid when two friends take part in practice, for one may send messages for the other to read, and knowledge of the code and skill in telegraphy is then rapidly acquired.

Producing Higher Voltages

The current from the Bichromate Cell will pass through the human body without producing any effect, for it is of low voltage ; but it may be changed into one of sufficient voltage to give mild shocks by means of an induction or SHOCKING COIL. Parts with which to build such a coil are included in the Outfit, and when completed this will be a source of great fun, while the shocks obtained from it are stimulating and beneficial.

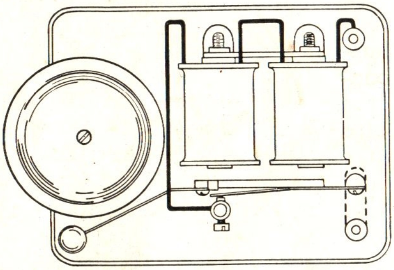


Fig. 24. The thick lines in this wiring diagram show how the connections required for the electric bell are made.

The principle on which the shocking coil works was discovered by Faraday, the great English scientist whose pioneer experiments laid the foundation of the modern electrical engineering industry. A simple experiment will make this principle clear. Connect the terminals of a Magnet Coil (Part No. 1538) to the galvanoscope used in previous experiments. Then place a Magnet Core (Part No. 1539) inside the Coil and bring one pole of the Bar Magnet near the end of the Core (Fig. 27). This movement must be made quickly, and it will then be noticed that the needle of the galvanoscope moves, showing that a current has been induced in the wire that constitutes the winding of the coil.

A current is induced also when the magnet is taken away quickly, but this time the needle moves in the opposite direction, showing that the second current is reversed. It is important to notice that the induced currents are temporary only, and are produced by the movements of the bar magnet.

In the shocking coil a current is induced in exactly the same manner as in this experiment, but the bar magnet is replaced by an inner coil with a soft iron core. This coil is given magnetic powers by passing an electric current through it, and as it magnetises the core, switching the current on and off has the same effect as that produced in the last experiment by the movements of the bar magnet. The inner or PRIMARY coil carries the current used to produce the magnetic changes; the outer coil, in which the current is induced, is known as the SECONDARY coil.

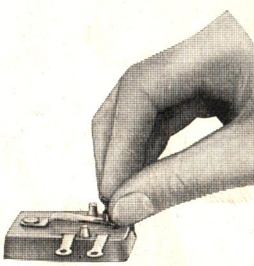


Fig. 25. Using the Elektron Switch as a telegraph key.

The Wound Bobbin for the Shocking Coil (Part No. 1552) has been constructed in this manner. The primary coil is wound with thick wire and forms two layers round the soft iron core. Over it is a wrapping of insulation, and then a large number of turns of finer wire forming the secondary coil, the layers of which are separated from each other by sheets of paper insulation. The complete Shocking Coil is shown in Fig. 28.

The voltage of the current induced depends on the relative number of turns in the two coils. For instance, if a primary coil has 100 turns and its secondary coil 2,500 turns, then the voltage of the induced current will be approximately 25 times that of the current in the primary circuit. In the Shocking Coil we are using the primary circuit consists of 180 turns and the secondary of 1,940 turns. This gives a voltage ratio of about 11. Our Bichromate Cell gives current at 2v. and therefore the normal induced current in the secondary of the Shocking Coil would be at about 22v. Actually the voltage is much higher, however. The effect of rapidly switching the current on and off is to set up in the primary coil extra currents of high voltage. These currents induce other currents of correspondingly higher voltage in the secondary coil, and so we get a voltage sufficient to produce tingling shocks.

Fig. 26 THE MORSE CODE

A	· —	N	— ·	1	· — — — —
B	— · · ·	O	— — —	2	· · — — —
C	— · — ·	P	· — — ·	3	· · · — —
D	— · ·	Q	— — · —	4	· · · · —
E	·	R	· — ·	5	· · · · ·
F	· · — ·	S	· · ·	6	— · · · ·
G	— — ·	T	—	7	— — · · ·
H	· · · ·	U	· · —	8	— — — · ·
I	· ·	V	· · · —	9	— — — — ·
J	· — — —	W	· — —	10	— — — — —
K	— · —	X	— · · —		
L	· — · ·	Y	— · — —		
M	— —	Z	— — · ·		

IN LENGTH OF SIGNAL A DASH IS EQUIVALENT TO THREE DOTS

Making a Shocking Coil

Two terminals are mounted on each of the flanges of the Wound Bobbin, and the terminals at one end are closer together than those at the other. The former terminals are the ends of the inner or primary coil, and those on the other flange are the ends of the outer or secondary coil. The Wound Bobbin is placed on the Universal Base with the secondary terminals near the hole No. 6 (Fig. 22) and the primary terminals near the hole No. 8, and is fitted in position by means of bolts passing through these holes and screwed into the corresponding flanges of the Wound Bobbin.

The ends of the secondary coil are connected directly to terminals fitted in the holes numbered 7 and 9 in the Universal Base, using short lengths of Connection Wire for this purpose. The current from the secondary coil is transmitted to its recipient through the Shocking Coil Handles (Part No. 1553). Two of these are required and they are connected to the Terminals by means of the flexible wires attached to them.

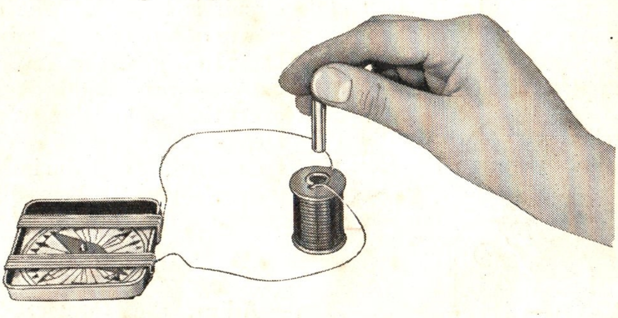


Fig. 27. Inducing a current in a coil by moving a magnet towards it.

It is impossible to " make and break " the current in the primary coil with sufficient rapidity by means of an ordinary switch, and instead we employ an interrupter built from the parts already used for a similar purpose in making the electric bell. The Armature Support is screwed down on a $\frac{3}{8}$ in. 6B.A Bolt inserted from below in the hole numbered 10, and the Bell Armature is then fitted on it in such a manner that the end of the Armature is opposite the end of the Core of the Coil. The Contact Pillar is fitted in the hole numbered 11, with the Contact Screw just touching the Spring of the Armature. Additional terminals are then placed in position in holes numbered 2 and 3 (Fig. 22).

The primary circuit may now be wired. Wires from the ends of the primary coil are pushed through the small holes near the end of the Wound Bobbin, and one of them is taken to the Terminal 3 while the other is connected to the bottom of the Armature Support. The Brass Connecting Link (Part No. 1567) is employed to join the foot of the Contact

Pillar with Terminal 2, this wiring being placed underneath the Universal Base (Fig. 29). Finally, Terminal 3 is connected with one pole of the Bichromate Cell, and the Switch is included in the circuit by connecting its Terminals to Terminal 2 and the second pole of the Bichromate Cell respectively.

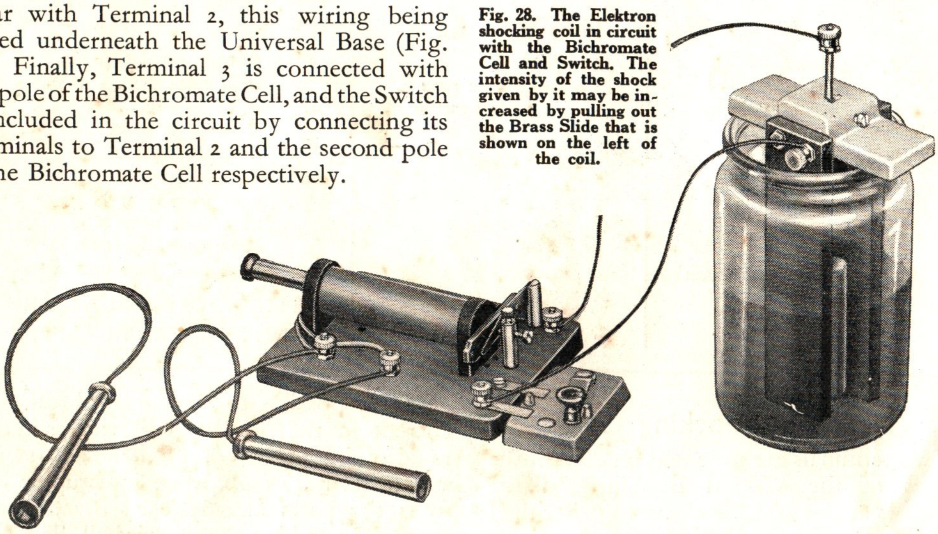


Fig. 28. The Elektron shocking coil in circuit with the Bichromate Cell and Switch. The intensity of the shock given by it may be increased by pulling out the Brass Slide that is shown on the left of the coil.

It is convenient to attach the Switch to the Universal Base, for this plan reduces the amount of loose wire between the Shocking Coil and the Bichromate Cell. It is readily fitted by fixing the Brass Terminal Strips under the Nuts on Terminal 2, and under an additional Terminal fitted in the hole numbered 1. If this plan is adopted, the wires from the poles of the Bichromate Cell are connected to Terminals 1 and 3, as shown in Fig. 28, and moving the key of the Switch to the left then completes the circuit.

When the Switch is moved to the "on" position, current flows through the Coil to the Armature Support, and then by way of the Armature and Spring to the Contact Screw and Pillar, finally returning through the Switch to the Bichromate Cell. As the current in the windings of the primary coil makes the soft iron core into a temporary magnet, however, the Armature is immediately pulled away from the Contact Screw and the circuit is broken. The core then loses its power of attraction and the Armature springs back, to begin its movement again. Thus the current is made and broken at high speed, and every time one of these changes occurs, a momentary current of high voltage is induced in the secondary coil, the intensity depending on the position of the Brass Slide (Part No. 1554).

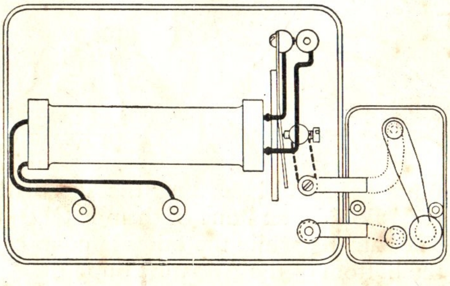


Fig. 29. Wiring diagram of the shocking coil. The wires indicated by the heavy lines on the left are above the Universal Base, but other wires, and the Connecting Link, are below it.

"Shock" Your Friends!

Adjust the Contact Screw to give a regular movement, which is accompanied by a steady buzzing noise. In order to give one of your friends a mild electric shock, ask him to hold one of the Brass Handles in each hand (Fig. 30). Starting with the Brass Slide (Part No. 1554) pushed right into the coil, switch on the primary current and gradually withdraw the Slide in order to increase the power of the shock. He will then feel a tingling sensation that causes involuntary convulsive movements. The effect varies greatly with different people, some being extremely sensitive to the electric shock, while others scarcely feel any shock at all. Great fun may be had with the Shocking Coil, particularly if it is used to give an electric shock to a ring of people holding each other's hands, only those at the ends of the ring making contact with the Brass Handles.

Fig. 30. Stimulating friends with an Elektron shocking coil is great fun !

Sparks 42 in. in Length

Very high voltages can be obtained by using coils with a large number of turns in the secondary (Fig. 31). A coil has been made having no less than 280 miles of wire in 340,000 turns for the secondary. A shock from a large induction coil is extremely dangerous, and such coils are employed only for scientific or medical purposes. The Shocking Coil we have constructed gives practically no spark, but the large one to which we have just referred was capable of sparking readily across a gap with a length of 42 in. or even more.

Induction coils are used to pass sparks between two terminals in a glass tube, from which most of the air has been removed. If the pressure is low enough the spark spreads out into a violet glow that fills the tube, and similar discharges in tubes containing various gases under very low pressure produce brilliant luminous effects. These tubes are known as VACUUM TUBES.

How X-Rays were Discovered

A German scientist named Professor Röntgen was experimenting with tubes of this kind in 1895, and was astonished to find that photographic plates wrapped in black paper became fogged when left near his apparatus. Eventually he discovered that they were affected by strange rays, produced in his vacuum tubes (Fig. 32), that penetrated the black paper almost as easily as light passes through glass. They are now known as Röntgen Rays or X-rays, and are used regularly by doctors in taking photographs of the interior of the human body (Fig. 33).

The principle on which the shocking coil depends plays an extremely important part in the electrical industry, particularly in TRANSFORMERS, which are devices for changing the voltage of alternating current, to which we shall refer later. These transformers consist of primary and secondary coils, and the change of voltage depends upon the relative numbers of turns in them. For instance, if a current of 200 v. is to be transformed into a current of 600 v. the number of turns in the secondary coil must be three times the number in the primary coil. Voltages may be decreased also in a similar manner, and a current at 600 v. would be transformed or "stepped down" to 200 v. by passing it through a transformer with a primary having three times as many turns of wire in it as the secondary winding.

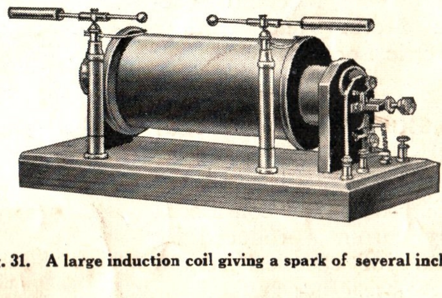


Fig. 31. A large induction coil giving a spark of several inches.

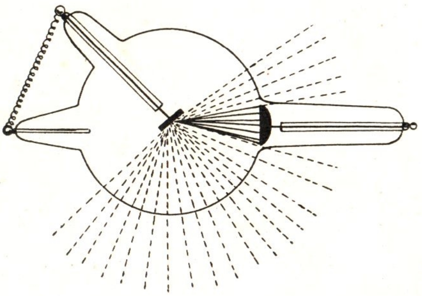


Fig. 32. The paths of X-rays produced when an induction coil is discharged through a vacuum tube.

At power stations large transformers with more turns in the secondary than in the primary are installed, in order to increase the voltage when necessary, particularly for transmission of current to long distances, as this is carried out most economically at high voltages. In order to make this current available for use, transformers with fewer turns in the secondary than in the primary are installed at sub-stations, from which current is supplied to consumers in the surrounding district.

Small transformers are largely used for reducing the voltage of mains current in order to make it available for many purposes. The Meccano Transformers are excellent examples of these, and are designed to supply current at voltages suitable for driving Meccano Electric Motors and Hornby Electric Locomotives.

Measuring the Heat of the Stars

So far we have considered only currents produced by means of chemical action. There are other methods of producing current, however, and one of these, in which current is produced direct from heat energy, may be demonstrated in an attractive experiment. The current produced is small, and in order to detect it our galvanoscope is necessary.

Fig. 33. An X-ray photograph showing the bones of the hand.

Cut the short length of bare Copper Wire (Part No. 1584), into two equal pieces and attach one of these to each of the ends of the galvanoscope winding. Join the free ends of the Copper Wires to the short length of Resistance Wire (Part No. 1581) included in the Outfit, each joint being given three twists in order to make good contacts. This gives a closed circuit, including the galvanoscope coil, in which there are two junctions of copper and the alloy of the Resistance Wire, which consists chiefly of nickel.

Now heat one junction in the flame of a match (Fig. 34) and the needle of the galvanoscope immediately swings to one side, showing that a current is flowing through the windings. After allowing the heated junction to cool, heat the second one in a similar manner. Again the needle of the galvanometer is deflected, but in the opposite direction to that in the first experiment, showing that the direction of the current through the circuit is reversed. The current at the heated junction always flows from the copper to the Resistance Wire.

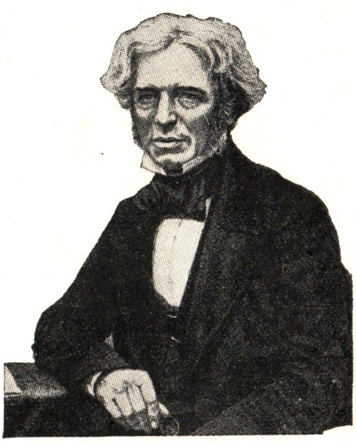
Current generated by heating the junction of different metals is known as thermo-electric current, and it is exactly similar to the current given by Voltaic cells and accumulators. Metallic junctions of this kind are known as THERMO-COUPLES.

Thermo-couples can be made to respond to extremely minute changes of temperature. One in use at the Mount

Wilson Observatory in California can detect the heat of a candle at a distance of 100 miles, and measure the heat radiated from stars too faint to be seen without the aid of a telescope!

Generating the World's Current

Electric current required for lighting and heating, and for driving electric trams and trains, is generated by means of dynamos installed in large power stations. The principle of the dynamo is based on Faraday's discovery that a current is induced in a coil of wire by moving a magnet towards or away from the coil, as already mentioned in our description of the shocking coil. Faraday found also that a current was induced in the coil by moving this towards or away from a magnet. As we have seen, a magnet is surrounded by a field of magnetic force, and the current is induced in the coil when the lines of force of the magnet are cut across.



Michael Faraday (1791-1867).

In order to understand the working of the great generators used in power stations we will consider the working of a DYNAMO in its very simplest form, as shown diagrammatically in Fig. 35. Between the poles of the magnet, N and S, revolves a coil of wire A^1, A^2, which is mounted on a spindle SS. This revolving coil is called the "ARMATURE." Two insulated rings R R are each connected to one end of the coil, and the brushes BB made of copper or carbon each press on one ring. The current is conducted away from these brushes into the main circuit, where we will suppose it to be used to light a lamp.

Let us assume the armature to be revolving in a clockwise direction. Then A^1 is descending and cutting the lines of force in front of the north pole of the magnet, and so a current is induced in the coil and, of course, also in the main circuit. Passing on its way, A^1 reaches the lowest point of its circle and begins to rise in front of the south pole, inducing another current, but this time in the opposite direction. The general result is to produce a current that reverses its direction every half-revolution, and such a current is called an "ALTERNATING" CURRENT, as distinguished from "DIRECT" CURRENT, derived from a Voltaic cell or an accumulator, the name of which is an indication that it always flows in the same direction.

In a dynamo such as our diagram represents there are only two magnetic poles, and the current flows backward and forward once every revolution.

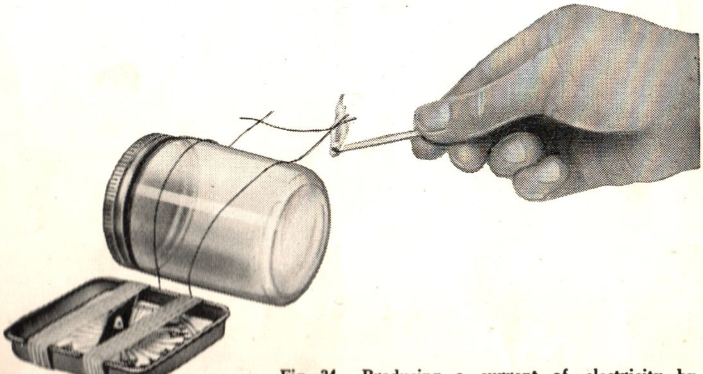


Fig. 34. Producing a current of electricity by heating the junction of two wires of different metals by means of a burning match.

By using a number of magnets, however, arranged so that the coil passes in turn the poles of each, the current may be made to flow

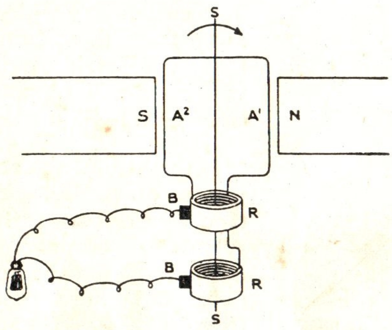


Fig. 35. Diagram of Dynamo generating alternating current.

backward and forward several times. One complete flow backward and forward is called a " period," and the number of periods per second gives the periodicity or "FREQUENCY" of the current. A dynamo with only one coil or set of coils generates what is known as " single-phase " current, that is, current that keeps on flowing backward and forward in one wave. If there are two distinct sets of coils we obtain a current in which there are two distinct waves, one rising as the other falls, and this is called a " two-phase " current. By using three sets of coils we obtain " three-phase" current, which is largely used in actual practice.

Alternating current is unsuitable for certain purposes, and by making a small change in the dynamo this current may be converted into " direct " current, which does not reverse direction.

The difference between a direct and an alternating current dynamo lies in the rings, and the new arrangement is shown in Fig. 36. In place of the two rings in Fig. 35 there is a single ring divided into two parts, each half being connected to one end of the revolving coil. Each brush thus remains on one half of the ring for half a revolution and then passes over to the other half. Thus during one half revolution the current is flowing from brush B^1 in the direction of the lamp. During the next half revolution the current will reverse its direction, but as brush B^1 has now passed over to the other half of the ring, the current is still leaving by it. A moment's thought, therefore, will show that the current must always flow in the same direction in the main circuit, leaving by brush B^1 and returning by brush B^2.

This arrangement for converting an alternating current into a direct current is called a " commutator," from the Latin *commuto*, meaning " I exchange."

Dynamo Becomes a Motor

A dynamo supplied with mechanical power to rotate its armature provides us with electric current. If we reverse matters and supply the dynamo with electric current, its armature rotates and provides us with mechanical power. In other words, a dynamo in these conditions becomes an ELECTRIC MOTOR.

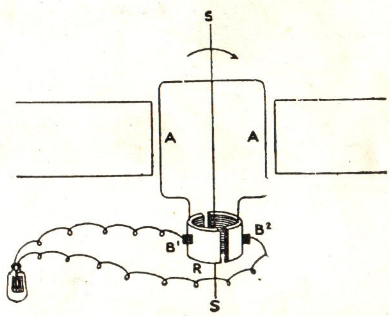


Fig. 36. Diagram of Dynamo generating direct current.

Bearing in mind what we have learned about the principle on which the dynamo works, it is easy to understand the principle of the electric motor. Suppose, for instance, we wish to use as a motor the dynamo illustrated in Fig. 36. First of all we take away the lamp and substitute for it a second direct current dynamo. We know already that when a current is sent through a coil of wire the coil becomes a magnet, having a north pole and a south pole. In the present case the coil in our dynamo becomes a magnet immediately the current from the second dynamo is switched on, and the attraction between its poles and the opposite poles of the magnet causes it to make half a revolution. At this state the commutator

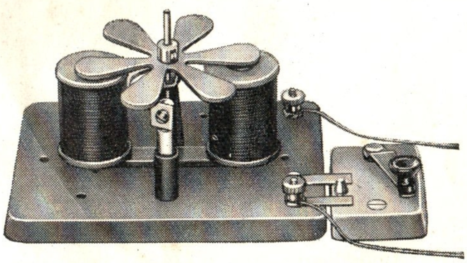


Fig. 37. The Elektron direct current motor.

reverses the current, and consequently also the polarity of the coil. There is now repulsion where before there was attraction, and the coil makes another half revolution. This process continues until the armature attains a very high speed.

Building an Electric Motor

A motor designed to run on the direct current supplied by our Bichromate Cell may be constructed from parts included in the Outfit. This motor is shown in Fig. 37, and is constructed as follows. Pass the screwed ends of the Magnet Cores (Part No. 1539) through the holes in the ends of the Large Magnet Yoke (Part No. 1555) and then downward through the holes numbered 8 and 12 in the Universal Base (Fig. 22). Fix the Magnet Cores in position by means of Nuts underneath the Universal Base and place the Magnet Coils over them, passing wires connected to the outer terminals of these Coils downward through the small holes conveniently placed near them.

Now fix the Bearing Bracket (Part No. 1558) upright by means of a bolt, passing through the hole numbered 13, and a nut. Attach the Armature and Commutator (Part No. 1556) on the Armature Shaft (Part No. 1557) near its squared-off end and pass the point of the Shaft through the hole in the Bearing Bracket to rest in the depression in the middle of the Large Magnet Yoke in which it pivots. The Armature, which has six poles, is now above the Bracket and must be fixed to its shaft, by means of the set screw provided, in such a position that its poles just clear the Magnet Cores as the Armature Shaft is spun round.

Pass the long 6 BA Bolt from below the Universal Base through the hole 7. Over it place the $\frac{11}{16}$ in. Erinoid Sleeve (Part No. 1560), and then screw on to it the Armature Support (Part No. 1550). The Commutator Contact Brush (Part No. 1559) is fixed to the flat on top of the Armature Support, which is swung round into such a position that the free end of the Brush rests against the contacts of the Commutator.

Nuts and Bolts are placed in position in holes 1, 2 and 3 and Terminals are screwed on the shanks of the Bolts, the Switch being attached to the Universal Base, as in Fig. 37.

Fig. 38 shows the directions taken by the connections, all of which are made beneath the Universal Base. The wire from the outer terminal of the Magnet Coil fitted in hole No. 8 is connected to Terminal 3, and the inner terminals of the two Magnet Coils are joined by a connecting wire, the ends of which are passed upward through holes in the Universal Base. Connect the outer terminal of the second Magnet Coil to the

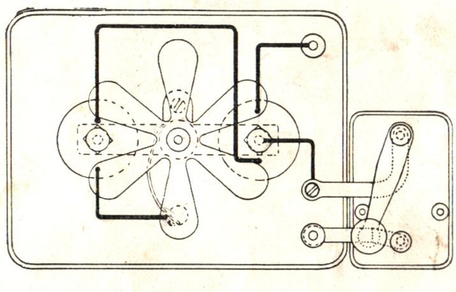


Fig. 38. Wiring diagram of the Elektron direct current motor

base of the Contact Pillar and similarly connect one Magnet Core with Terminal 2.

When all is ready connect Terminals 1 and 3 with your Bichromate Cell, lower the Zinc Rod into the solution and switch on. Give the Armature a twirl and it then may be made to run at high speed by slight adjustment of the Commutator Contact Brush.

How the Elektron Motor Works

The working of the motor may be explained as follows. Current flowing through the windings of the left hand coil magnetises the core, and this attracts one of the poles of the Armature towards it. As the Armature swings round it carries with it the Commutator, and when the Commutator Brush loses contact with the section of the Commutator against which it is pressed the circuit is broken. The momentum of the Armature carries it round until the Magnet Core is halfway between two of its poles, however. Contact is then made between the Brush and the next segment of the Commutator, with the result that the Magnet Core is again magnetised, and the next pole of the Armature is attracted towards it. The whole process is then again repeated, each pole of the Armature in turn being attracted by the Magnet Core, and the momentum carrying it onward when the attraction ceases owing to the action of the Commutator. A similar process takes place at the second Magnet Core and thus the rotation of the Armature is maintained.

Experiments should be made with the Commutator Brush pressing against different points of the Commutator in order to find the position that gives the best results. The highest speed is attained when contact is made a little before reaching the neutral position, with the Magnet Cores half-way between adjacent poles of the Armature. A speed of 500 r.p.m. may be obtained by careful adjustment of this kind, and as the Armature has six poles, this means that 3,000 magnetic impulses are given every minute.

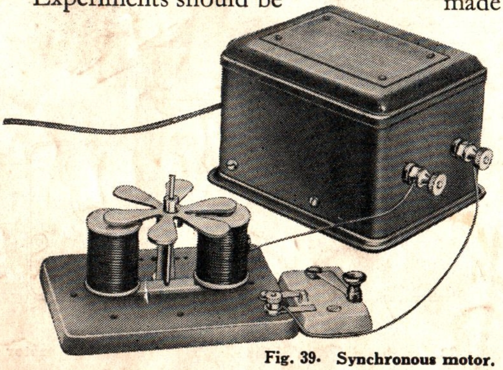


Fig. 39. Synchronous motor.

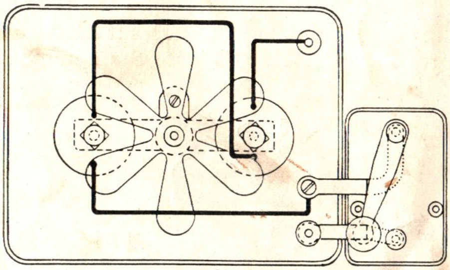


Fig. 40. Wiring diagram of the Elektron synchronous motor

Four coloured rings (Part No. 1571) are included in the Outfit. Brilliant kaleidoscopic effects may be obtained by placing two or more of these on the Armature while it is rotating.

The Elektron Synchronous Motor

The motor we have just made runs on direct current, that is, current flowing continuously in one direction. There are also motors that use alternating current.

A special kind of alternating current motor that has been developed in recent years is the SYNCHRONOUS MOTOR. In one form this consists of a disc carrying a number of iron teeth, and an electro-magnet, one pole of which projects towards the rim of the disc in such a manner that its face is close to the teeth as the disc revolves. The alternating current passes through the windings of the electro-magnet, and thus this pole is alternately north and south.

Suppose that at a certain moment the electro-magnet pole is north and that the disc is rotating. South polarity is induced in the iron tooth nearest the magnet pole, and mutual attraction causes the tooth to move towards the pole. If this continued to be north, the attracted tooth would tend to stop directly opposite to it. The momentum of the disc carries it onward, however. In addition, when the pole becomes a south pole owing to the change in the direction of the current through its windings, the original induced south polarity of the tooth does not change immediately, but lags behind a little. The result is that the tooth is repelled by what is now the south pole of the magnet, and the disc is thus helped to continue its rotation. Each tooth in turn is first attracted and then repelled by the electro-magnet, and the speed of rotation of the disc depends on the rate at which the electro-magnet changes its polarity. This, in turn, depends on the frequency of the alternating current.

The direct current motor that we have already made from the parts of the Outfit may be converted into an interesting synchronous motor (Fig. 39). For this purpose the Armature Support and Commutator Brush are not required and should be removed. The wiring also must be arranged more simply and this is shown in Fig. 40.

It will be seen that this motor consists simply of two electro-magnets and an armature with six poles, each of which corresponds with one of the teeth in the simple motor by means of which the action of a synchronous motor has been explained. Current for it may be supplied by the Meccano Transformers T6, T6A, T6M or T26M, the output terminals of which are connected to Terminals 1 and 3. The only other connections required are from Terminal 3 to the outer end of the nearer Magnet Coil and from the outer end of the second Magnet Coil to terminal 2, the inner ends of the Magnet Coils remaining connected as in the continuous current Motor. When the Switch is closed the poles of the Magnet Cores alternately become north and south, and thus attract and repel the poles of the Armature owing to the lag of magnetic induction.

When current is switched on the Armature is given a twirl in order to commence rotation.

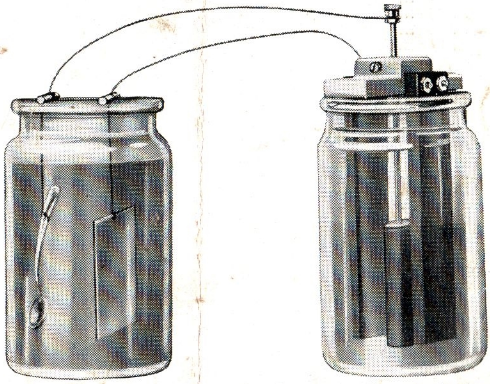
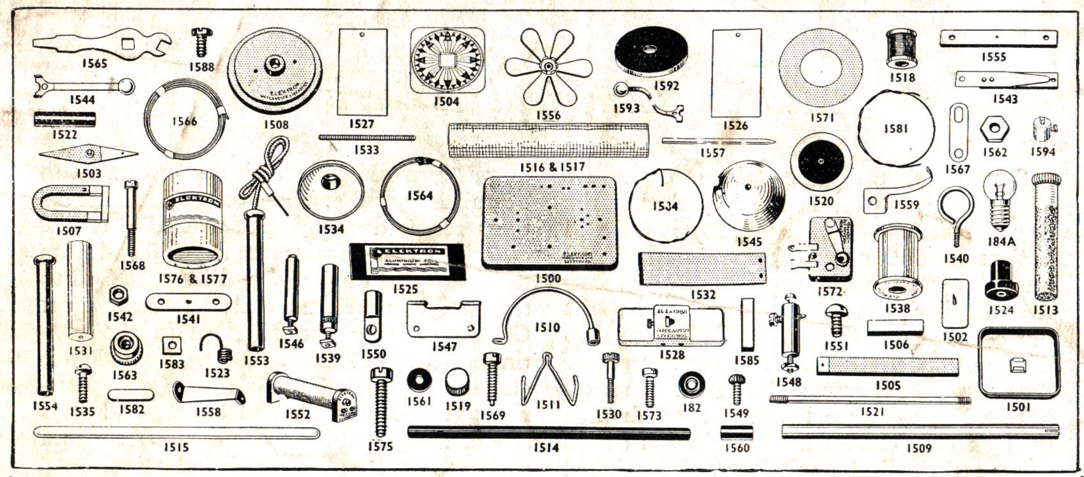


Fig. 41. Plating a spoon with copper by means of current from the Elektron Bichromate Cell.

Electroplating

One of the most interesting applications of electric current is in electroplating, that is, coating objects with a thin layer of metal.

The No. 2 Outfit provides the necessary materials for carrying out copper plating (Fig. 41). The object to be plated — which may be an old spoon that has reached the end of its domestic service—is suspended by means of copper wire in a glass jar containing a solution made by dissolving one-eighth of the quantity of the blue Copper Sulphate crystals (Part No. 1576) in 12 oz. or 12 tablespoonfuls of water. Then the Copper Plate (Part No. 1526) is similarly suspended in the solution, but quite clear of the spoon. The wire by means of which the Copper Foil is suspended is connected to the positive terminal of the Bichromate Cell, and that supporting the spoon to the negative terminal. Current passing through the solution then carries with it copper that covers the spoon with a reddish brown deposit.



Elektron Parts List

No.		Qty. in Outfit No.1	Qty. in Outfit No.2
1500	Universal Base	–	1
1501	Compass Box	1	1
1502	Compass Mount and Pivot ...	1	1
1503	Compass Needle and Cup ...	1	1
1504	Compass Chart	1	1
1505	Bar Magnet	2	1
1506	Bar Magnet Keeper	2	–
1507	Horseshoe Magnet and Keeper ...	1	1
1508	Circular Base	1	1
1509	Erinoid Tube for Stand Bracket	1	1
1510	Stand Bracket	1	1
1511	Stirrup	1	–
1512	Sifter Box and Lid	1	1
1513	Tube of Iron Filings	1	1
1514	Ebonite Rod	2	–
1515	Glass ,, ...	1	–
1516	Square of Flannel	1	–
1517	,, ,, Silk	1	–
1518	Reel of Silk Thread	1	–
1519	Cork	2	–
1520	Electroscope Plate	1	–
1521	,, Rod	1	1
1522	Erinoid Sleeve 1¼" long ...	1	–
1523	Electroscope Hook	1	–
1524	Ebonite Bush	1	–
1525	Sheet of Aluminium Foil ...	1	–
1526	Copper Plate, 2"×1"	–	1
1527	Zinc ,, 2"×1"	–	1
1528	Cell Mounting	–	1
1530	Cell Mounting Bolt	–	1
1531	Zinc Rod	–	1
1532	Carbon Plate	–	2
1533	Threaded Rod	–	2
1534	Lampholder	–	1
1535	,, Screw	–	1
1538	Magnet Coil	–	2
1539	,, Core (complete)... ...	–	2
1540	,, Hook	–	1
1541	,, Yoke, Small	–	1
1542	,, Hook Nut	–	1
1543	Bell Armature (complete) ...	–	1
1544	,, Rod and Hammer	–	1
1545	Gong	–	1
1546	Gong Pillar (with Nut and Screw)	–	1
1547	Angle Yoke	–	1
1548	Bell Contact Pillar (complete) ...	–	1
1549	Bell Contact Pillar Locking Screw	–	–
1550	Armature Support		1
1551	,, Screw	-	1
1552	Wound Bobbin for Shocking Coil	–	1
1553	Shocking Coil Handle	–	2
1554	,, ,, Slide	–	1
1555	Magnet Yoke, Large	–	1
1556	Armature and Commutator ...	–	1
1557	,, Shaft	–	1
1558	Bearing Bracket	–	1
1559	Commutator Contact Brush ...	–	1
1560	Erinoid Sleeve, $\frac{11}{16}$" long ...	–	1
1561	Insulating Washer, Small ...	–	1
1562	6 B.A. Hex. Nut	–	12
1563	Terminal	–	6
1564	10 yd. Coil No. 35G. E.S.C.C. Copper Wire	–	1
1565	Spanner, Screwdriver	1	1
1566	Connection Wire	–	1
1567	Connecting Link	–	1
1568	6 B.A. 1" Special Bolt	–	1
1569	6 B.A. Contact Screw	–	–
1571	Coloured Ring	–	4
1572	Switch	–	1
1573	6 B.A. Bolt, ⅜"	–	3
1575	6 B.A. Bolt, ½"	–	5
1576	Copper Sulphate in Container	–	1
1577	Bichromate of Potash in Container	–	1
1581	Length of Resistance Wire 6" ...	–	1
1582	Steel Piece...	4	–
1583	6 B.A. Square Nut	–	1
1584	26G Copper Wire, 6" length ...	–	1
1585	Horseshoe Magnet Keeper ...	–	–
1586	26 G.S.C.C. Copper Wire ...	–	–
1587	23 ,, ,, ,, ...	–	–
1588	Screw for Bell Hammer and Bell Armature	–	1
1589	Manual of Instructions for Outfit No. 1	1	–
1590	Manual of Instructions for Outfit No. 2	–	1
1591	Terminal Screw for Coils ...	–	–
1592	Ebonite Disc in Holder ...	1	–
1593	Sparking Rod	1	–
1594	Brass Holder for Ebonite Rod...	1	–
182	Insulating Bush 6B.A. ...	–	1
184a	Flashlamp Bulb 2½-volt ...	–	1

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