I SAY, FATHER!

HERE'S A REALLY FINE PLAY GUN

—a gun which looks and works like a real sporting gun. The FOX PLAY GUN has double steel barrels which "break" for loading at the breech just like a man's gun. You load it by putting two spring cartridges in the breech and pressing a small wooden ball into each cartridge. There are two triggers, of course, one for each barrel, and the balls travel with enough force to give you accurate target practice indoors or out-of-doors, but they can't hurt anybody or anything. Just tell Daddy that!

Looks like a real Gun, Works like a real Gun, but is Perfectly HARMLESS.

Show this advertisement to Father and tell him what hours of fine fun you could have (he also) with this splendid Play Gun. A strong bell target comes with each Gun together with two cartridges and a good supply of balls.

FOX PLAY GUN

DOUBLE BARREL BREECH LOADING

From all high-class Toy Dealers and Stores Price 17/6

—15 shots straight off!

This new Savage Repeating Rifle is just like a real one, too, and is perfectly safe even indoors. There's no explosive. The ⅜-inch lightweight fibre balls are fired by a coil spring which is compressed by a pump action lever. The magazine holds 15 balls and they give accurate target practice up to a 20-foot range. With a rifle like this you could have great fun getting up a regular Bisley among the family!

With every Savage Play Rifle you get a special target which holds each ball you shoot and so shows you exactly what each shot scored. It also prevents losing the balls.

Sold by all high class Stores and Toy Dealers.

Price 25/-

The New SAVAGE REPEATING PLAY RIFLE

If any difficulty in obtaining either of these wonderful guns, write:

BEDINGTON, LIDDIATT & CO. LTD., Dept. B, 4/7, Chiswell Street, London, E.C. 1.

MECCANO

Ships' Funnels

The realistic Ship's Funnel, Cunard type, introduced recently, has proved so extremely popular that we have decided to introduce 24 additional funnels representing those of nearly all the principal Shipping Companies. Four of the new funnels are described below and in subsequent issues of the *"M.M."* we propose to deal similarly with the others in the range.

The Meccano Ships' Funnels are raked and are provided with two perforated lugs by means of which they may be bolted to any Meccano Strip or Plate. They are all beautifully enamelled and finished.

Price 9d. each

138g
White Star Line.
Buff funnel. Broad black band at top.

Also representative of the following:

Anglo-Saxon Petroleum Co. Ltd.
Australind Steam Shipping Co. Ltd.
Bank Line
Barrie, Charles & Son.
Booker Line.
British Mexican Petroleum Co. Ltd.
Dunn, Chas. G. & Co. Ltd.
Elders & Fyffes Ltd.
Gillespie & Nicol.
Hogarth, H. & Son.
Hull & Netherlands S.S. Co. Ltd.
Jacobs, John I. & Co. Ltd.
King Line Ltd.
Shaw Savill & Albion Co. Ltd.

No. 138b
Isle of Man S.P. Co. Ltd.
Red funnel, broad black band at top. Two thin black bands round middle.

Also representative of the following:

Alkinson, E. P. & Sons.
Belfast S.S. Co. Ltd.
Chambers, J. & Co.
Commonwealth & Dominion Lines Ltd.
Glen & Co.
Houston, R. P. & Co.
Lang & Fulton.
London S.S. & Trading Corporation Ltd.

No. 138w
Moss Line
Black funnel with broad white band.

Also representative of the following:

American Line.
Aster Shipping Co. Ltd.
Bristol Steam Nav. Co. Ltd.
Brown, Atkinson & Co. Ltd.
Cleeves, W. V., Anthracite Collieries Ltd.
Currie, James & Co.
Donaldson Line.
Gardner, J. & A. & Co.
Japp Hatch & Co. Ltd.
Nisbet, Geo. & Co.
Sloan, Wm. & Co.
Stephenson Clark & Co. Ltd.
Yorkshire Coal & S.S. Co. Ltd.

No. 138h
G.W.R. Steamers—Fishguard.
Red funnel with broad black band at top.

Also representative of the following:

Anglo American Oil Co. Ltd.
Atlantic Transport Co. Ltd.
Bristol Channel Steamers Ltd.
Bruce, J. & Co.
Cairns Noble & Co. Ltd.
Cockerline, W. H. & Co.
Denholm, J. & J. Ltd.
Dundee Perth & London Steamship Co. Ltd.
Ellermans' Wilson Line Ltd.
Glen Line Ltd.
Gow, Harrison & Co.
Guinness, A. Sons & Co. Ltd.
Hall Bros. S.S. Co. Ltd.
Holt, John & Co. (L'pool.) Ltd.
MacBrayne, D. Ltd.
Mackie, Richard & Co.
Power S.S. Co. Ltd.
Raeburn & Verel Ltd.
Royden, Thomas & Sons.
Watson Bros. Shipping Co. Ltd.

Obtainable from any Meccano dealer, price 9d., or direct from Meccano Ltd., Liverpool, price 10½d. post free.

MECCANO LTD., Old Swan, LIVERPOOL

JUST OUT—

JIG-SAW PUZZLES

of the famous

"GOLDEN ARROW LIMITED"

de luxe Pullman Express

LONDON—PARIS

drawn by "Nelson" Engine

"Sir Richard Grenville"

(No. 853.)

Price 5/- each.

These puzzles comprise 160 pieces and are obtainable at S.R. Enquiry Offices and at Messrs. W. H. Smith's Bookstalls and Shops.

Have you seen the Revised Edition of

"LOCOMOTIVES of the SOUTHERN" Booklet?

Price 1/-, at S.R. Bookstalls and from Locomotive Publishing Company, 3, Amen Corner, E.C. 4.

Coloured Plates of the **"Golden Arrow Limited," 1/- post free.**

Postcards of **"Lord Nelson"** and **"Atlantic Coast Express," 1d. each.**

Postcards of Express Engines, Goods Engines and Express Trains, **6d. per set.**

All obtainable from Advertising Department, Southern Railway, Waterloo Station, S.E. 1.

All Meccano Outfits and Hornby Trains are Stocked by Kendal Milne of Manchester

Order by post if you cannot call. We pay carriage and guarantee satisfaction.

Kendal Milne & Co.

MANCHESTER

MECCANO

Ships' Funnels

In the November "*M.M.*" we announced the introduction of 24 ships' funnels representing those of nearly all the principal Shipping Companies. Four of the new funnels were illustrated and described in page 888 of that issue.

Details of a further group, composed of seven funnels, are given below. In some cases the funnels represent more than one shipping line and we have indicated the names of these.

The Meccano Ships' Funnels are raked and are provided with two perforated lugs by means of which they may be bolted to any Meccano Strip or Plate. They are all beautifully enamelled and finished.

Price 9d. each

No. 138e
Pacific & Orient Steam Navigation Co. Ltd.

Black funnel

Also representative of the following:

Anchor Line Ltd.
Anglo Celtic Shipping Co. Ltd.
Ashdown, C. G. & Co.
Bolton, F. & Co.
Booth, S. S. Co. Ltd.
British & African Steam Nav. Co. Ltd.
British Dominions S.S. Co. Ltd.
Burdick & Cook.
Burrell & Son.
Capper, Alexander & Co.
Carron Company.
China Navigation Co. Ltd.
Clark & Service.
Claymore Shipping Co. Ltd.
Clyde Shipping Co. Ltd.
Cory's Trading Ltd.
Denaby Shipping Co.
Donald & Taylor.
Duncan, J. T. & Co.
Dundalk & Newry, S.P. Co. Ltd.
Dunlop, Thos. & Sons.
Eastern & Australian S.S. Co.
Essex Line Ltd.
General Steam Nav. Co. Ltd.
Gibson-Rankine Line.
Glover Bros.
Henderson, P. & Co.
Hudson, R. N. & Son Ltd.
Hutchison, J. & P. Ltd.
Joplin & Hull.
Kyle Transport Co. Ltd.
Miller, Wm. S. & Co.
Mogul Line.
Morgan & Cadogan Ltd.
Murphy, Michael Ltd.
North of Scotland & Orkney & Shetland S.N. Co. Ltd.
Pickard, A. W. & Co.
Rhondda Merthyr Shipping Co. Ltd.
Robertson, Wm.
Shamrock Shipping Co. Ltd.
Southern Railway Co. (South Eastern & Chatham Section).
Stott, W. H. & Co. Ltd.
Summerfield Steamship Co. Ltd.
Watts, Watts & Co.
Welsford, J. H. & Co. Ltd.
Woods, Tyler & Brown.

No. 138z
British & Irish S.P. Co. Ltd.
Green Funnel. Broad black band at top.

No. 138r
Brussels S.S. Co.
Yellow funnel. Black band at top with red and green bands round middle.

No. 138u
Yeoward Line.
Black funnel. Yellow band above middle flanked by two red bands.

No. 138k
Lamport & Holt Line.
Blue funnel. Broad black band at top with broad white band immediately beneath.

Also representative of Jas. Cormack & Co.

No. 138q
Clan Line.
Black funnel with two red bands above middle.

Also representative of W. R. Davies Steamers.

No. 138f
Alfred Holt & Co.
Blue funnel. Broad black band at top.

Also representative of G. T. Gillie & Co.

Meccano Funnels are obtainable from any Meccano dealer, price 9d., or direct from Meccano Ltd., Liverpool, price 10½d. post free.

MECCANO LTD., Old Swan, LIVERPOOL

MECCANO
Ships' Funnels

The new range of Meccano Ships' Funnels has become extremely popular with Meccano model-builders. There are 25 funnels in the series representing those of nearly all the principal Shipping Companies. Eleven of the funnels have already been illustrated and described, four in the November 1929 issue and seven in the January 1930 issue of the "*M.M.*"

Details of a further group, composed of seven funnels, are given below. In some cases they represent more than one shipping line and the names of these are indicated.

The Meccano Ships' Funnels are raked and are provided with two perforated lugs by means of which they may be bolted to any Meccano Strip or Plate. They are all beautifully enamelled and finished.

Price 9d. each

138T Canadian Pacific S.S. Co.

Buff funnel

Also representative of the following :—

Richard W. Jones & Co.
John Glynn & Son, Ltd.
J. Temperley & Co.
Royal Mail S.P. Co.
Hudson Bay Co.
John Hall, Junr. & Co. Ltd.
Joseph Constant.
Lyle Shipping Co.
MacAndrews' Line.
Orient Line (Anderson, Green & Co. Ltd.).
Pacific S.N. Co.
Garth Shipping Co. Ltd. (H. Clapham & Co. Ltd.).
Asiatic S.N. Co. Ltd.
Eastern Telegraph Co. Ltd.
Easton, Greig & Co.
New Zealand Shipping Co.

No. 138Y
Furness Line. Black funnel. Broad red band round middle with narrow black and red bands immediately above.

No. 138A
Cunard S.S. Co. Red funnel. Broad black band round top with three thin black bands round middle.

No. 138V
A. Coker & Co. Ltd. Blue funnel. Broad black band at top with narrower white band below.

No. 138C
T. & J. Harrison. Black funnel. Red band flanked by two white bands.

Also representative of the following :—
Alf. Rowland & Co.
John Harrison Ltd.

No. 138L
Manchester Liners Ltd. Orange funnel. Broad black band at top and narrower black band round middle.

Also representative of the following :—
Whimster & Co.
Joseph Constantine S.S. Ltd.

No. 138S
Union Castle Mail S.S. Co. Ltd. Red funnel. Broad black band round top with thin black band round middle.

Also representative of the following :—
David MacIver & Co Ltd.
R. Gilchrist & Co.

Obtainable from any Meccano dealer, price 9d., or direct from Meccano Ltd., Liverpool, price 10½d. post free.

MECCANO LTD., Old Swan, LIVERPOOL

Electricity Applied to Meccano

I.—The Primary Cell and the Accumulator

In the January issue of the "*M.M.*" we hope to commence a series of articles dealing with the construction of electrical Meccano models. These will not be merely ordinary Meccano models to which electricity is applied only as a source of power to drive them, but they will be models of actual electrical apparatus, including the Morse key, tapper and buzzer for telegraphy, an induction or shocking coil, a useful switch, a coil winder, motors, etc.

Although electrical knowledge is not required in the actual building of most of these models, it is impossible to obtain the greatest fun and interest from their working without knowing something of the nature and operation of the force that we call electricity. We commence this month, therefore, a brief outline of the principles of electricity, dealing with the subject in simple and non-technical language.

THE first electrical discovery was made over 2,000 years ago by the Greeks, who found that amber when rubbed gained the power of attracting light substances. It is from "*electron*," the Greek name for amber, that our word electricity is derived. Other materials such as glass, ebonite or sealing-wax behave similarly to amber. For instance, if we hold a stick of sealing-wax in the hand and rub it briskly with a dry cloth it becomes electrified and will then attract small pieces of paper.

If we try the same experiment with a rod of metal, however, we get no result at all. This is not because the rod does not become electrified, but because the electricity leaks away as fast as it is produced. The explanation is that such substances as glass, sealing-wax and amber are non-conductors of electricity—in other words they do not allow electricity to pass along them. When therefore we produce electricity by rubbing, the electricity must stay there, being unable to travel along and disappear. Metals, on the other hand, allow electricity to pass easily and therefore are known as good conductors. Electricity is produced when a metal rod is rubbed, but instantly it spreads over the whole rod and escapes by way of the hand.

If we wish our metal rod to retain its charge we must cut off this means of escape, and this may be done quite easily by providing the rod with a handle of glass or some other non-conducting material. When a conducting substance is guarded in this manner by a non-conducting substance so that its electricity cannot escape it is said to be "insulated" from the Latin word "*insula*," meaning an island, and non-conductors are also called "insulators."

Substances such as dry air, resin, silk, glass, sealing-wax and gutta-percha are non-conductors; cotton, linen and paper are partial conductors; and among good conductors are metals, acids, water and the human body. Silver is the best conductor of all the metals, but on account of its expense it cannot be used for cables and wires and its place is taken by copper, which is only slightly inferior in its conducting qualities.

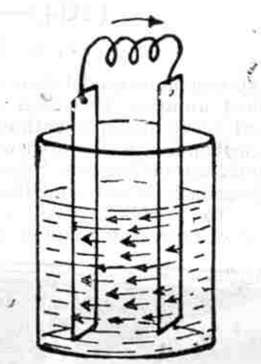


Fig. 1. Voltaic Cell

We have just seen that when a metal rod is held in the hand and rubbed, electricity is produced but escapes immediately. If we could arrange matters so that the electricity was renewed as fast as it flowed away we should obtain a continuous flow or current. An electric current may be produced in various ways, one of the simplest being by means of chemical action. Towards the end of the eighteenth century an Italian scientist, Alessandro Volta, constructed what has since been given the name of the voltaic cell. This consisted of a glass vessel containing dilute sulphuric acid in which were immersed a plate of zinc and a plate of copper, not in contact with one another. If these plates were connected by means of wire outside the cell an electric current immediately began to flow. The direction of the current was from the copper plate to the zinc plate outside the glass vessel and from zinc to copper through the liquid inside it.

This simple cell had the great defect of choking itself, as it were, after being in action for a short time. What actually happened was that bubbles of hydrogen were formed and collected on the copper plate, forming a layer sufficient to hinder and ultimately stop the flow of current. When in this condition the cell was said to be "polarized."

Since Volta's time many cells have been devised to overcome this difficulty and thus to produce a constant current over a long period. One of the most successful of these is known as the Daniell cell, which consists of an outer vessel of copper, which takes the place of a copper plate, and an inner porous pot containing a zinc rod. Dilute sulphuric acid is placed in the porous pot and a strong solution of copper sulphate in the outer jar. When this cell is in action hydrogen is liberated by the action of the zinc on the acid, just as in Volta's cell, but in this case the hydrogen passes through the porous pot and splits up the copper sulphate into copper and sulphuric acid. Thus, instead of hydrogen, pure copper is deposited on the inside of the copper vessel and the action of the cell is not interrupted.

An even more familiar source of current is the "Leclanché" cell used for ringing domestic electric bells. This consists of an inner porous pot containing a carbon plate packed round tightly with a mixture of crushed carbon and manganese dioxide, placed in a glass jar containing a zinc rod and a solution of salammoniac. In this case polarization is prevented by the oxygen in the manganese dioxide, which seizes the hydrogen as it collects on the carbon plate and renders it harmless by combining with it. If this cell is used continuously for more than a very minute current, hydrogen is produced faster than the oxygen can deal with it. The cell then becomes polarized, but it soon recovers after a short rest.

The so-called "dry" cells so much used for wireless purposes and flashlamps are merely Leclanché cells in which the liquid is replaced by a moist paste so that there is nothing to spill. As soon as one of these cells really becomes dry it ceases to give any current.

We must now learn something about the manner in which an electric current is measured. We know that water flows from the reservoir to our house on account of a difference of level that produces a water-moving or water-motive force. In a similar manner a difference of electric pressure, such as exists between the plates of a voltaic cell, produces an electricity-moving or electro-motive force, which is measured in "volts." The rate of flow of water in a pipe is stated in gallons per second and the rate of flow of an electric current is stated in "amperes." In other words, the electric pressure at which a current is produced is measured in volts, while the current itself is measured in amperes.

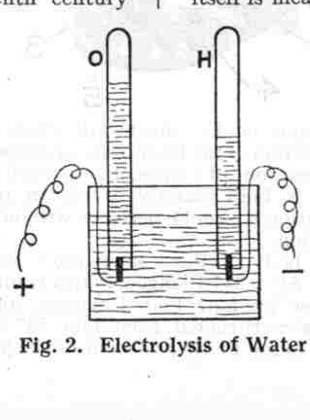


Fig. 2. Electrolysis of Water

Water flowing through a pipe is resisted by friction against the walls of the pipe. In a similar manner an electric current meets with resistance, although this is of a different nature. This resistance is small in a good conductor but great in a bad one; it is also greater in a thin wire than in a thick one and in a long wire than in a short one. Resistance is measured in "ohms." The resistance of a circuit must be overcome by the electro-motive force before a current can flow, and the definition of a volt is *that electro-motive force which will cause a current of one ampere to flow through a conductor having a resistance of one ohm.*

These three units of measurement are named respectively after the three famous scientists, Alessandro Volta, André Marie Ampère, and Georg Simon Ohm.

A single voltaic cell gives us an electro-motive force of from one to two volts, according to its type. A Daniell cell, for instance, gives about one volt, and a Leclanché or dry cell about one-and-a-half volts. People often speak of a single voltaic cell as a "battery," but this is wrong, for a battery consists of several cells coupled together. Different methods of coupling produce different results.

If we connect together all the positive poles and all the negative poles of several Daniell cells—that is copper to copper and zinc to zinc—we get much more current but no more electro-motive force than from one cell. In other words we get more amperes but no more volts. This method is called connecting in "parallel." On the other hand, if we connect the positive pole of one cell to the negative pole of the next—or copper to zinc throughout—we add together the electro-motive forces of all the cells, but the amount of current is no greater than that of one cell. In this case, therefore, we get more volts but no more amperes. This is known as connecting in "series."

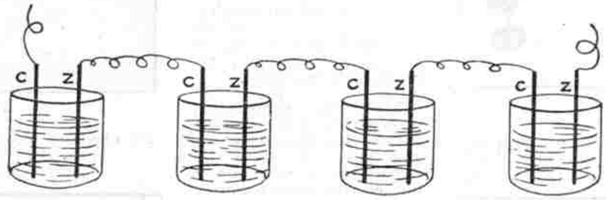


Fig. 3. Connecting in Series

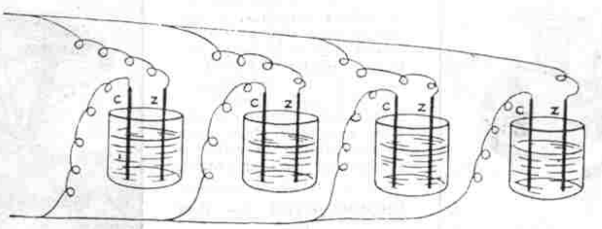


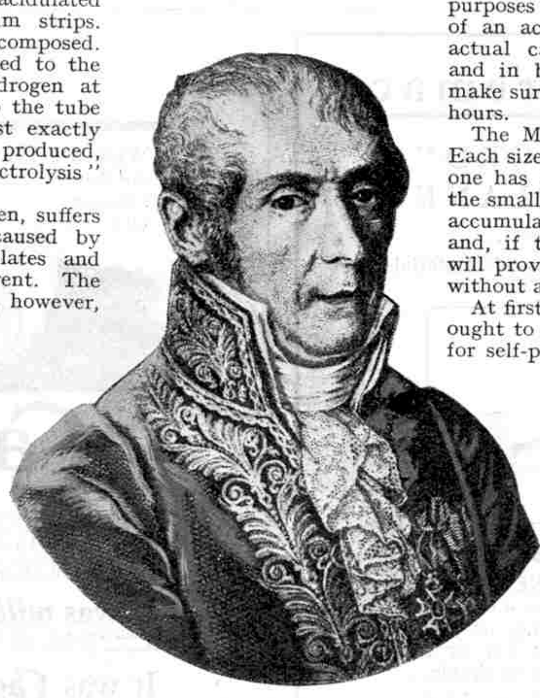
Fig. 4. Connecting in Parallel

It is possible also to increase both volts and amperes by a combination of the two methods of connecting.

The cells we have already described are called "primary" cells, and are quite different from "secondary" cells, or accumulators. Accumulators do not produce a current on their own account, but act as storage tanks from which we may draw a supply of current whenever we want it.

If we pass a current through water to which has been added a little sulphuric acid to increase its conducting power, the water is split up into the two gases of which it is composed—hydrogen and oxygen. An apparatus for demonstrating this consists of a glass vessel having two strips of platinum, called "electrodes," which are connected to a battery of Daniell cells. Two tubes, closed at one end, are filled with the acidulated water and inverted over the platinum strips. When the current flows, the water is decomposed. Oxygen is formed at the strip connected to the positive pole of the battery, and hydrogen at the other strip, and each gas rises into the tube above it, displacing the water. Almost exactly twice as much hydrogen as oxygen is produced, and the process is called the "electrolysis" of water.

A voltaic cell, as we have already seen, suffers from the defect called polarization, caused by hydrogen collecting on one of the plates and thus obstructing the flow of the current. The layer of hydrogen does more than this, however, for it causes further trouble by setting up a "back" or opposing electro-motive force tending to produce a current in the opposite direction. In the electrolysis of water a similar opposing electro-motive force is set up, and when the battery current is stopped and the platinum strips are connected, a current begins to flow in the reverse direction, and continues to flow until the two gases have recombined and the strips are once more in their original state. In this way the apparatus acts as an accumulator, for an electric current is supplied to it and it gives back another current.


Alessandro Volta

It is important to understand that this apparatus—as is the case with allother accumulators—does not actually store up electricity, but energy. We may say that the electrical energy supplied to it is converted into chemical energy, and that this chemical energy is then converted back again into electrical energy. For practical purposes, however, this apparatus is not of much service.

The first really useful accumulator was made in 1878 by Gaston Planté. The electrodes consisted of two strips of sheet lead made into a roll, but not touching each other, and placed in dilute sulphuric acid. A current was passed through, first in one direction and then in the other, and after several reversals of current one lead plate was found to be changed into a spongy condition, and the other was coated with peroxide of lead. This process is called "forming." When the process was complete, the accumulator was ready to be charged and used.

In present-day accumulators the lead rolls are replaced by lead grids coated with a paste of red lead oxide and sulphuric acid. The effect of passing the charging current through a cell with plates of this kind is to take oxygen away from the red lead oxide of one plate, leaving spongy lead, and to add this oxygen to the red lead oxide of the other plate, thus forming the brown peroxide. During discharge, that is while the accumulator is being used to supply a current, this oxygen goes back to its original place and the current continues until the surfaces of both lead plates become chemically negative. The accumulator, of course, may be charged and discharged over and over again.

All modern accumulators, except the very smallest, have several pairs of plates, all the positive plates being connected together, and all the negative plates together. This has the same effect as connecting voltaic cells in "parallel," that is more current is produced.

The electro-motive force of a single accumulator cell is about two volts, and in order to get a higher voltage several cells are connected in "series."

Accumulators are rated as regards their current-giving capacity in "ampere-hours." For example, an accumulator that will give a current of six amperes for one hour, or of three amperes for two hours, is said to have a capacity of six ampere-hours. Sometimes accumulators are rated by their "ignition" capacity, that is their capacity when used to supply current for ignition purposes in petrol motors. The ignition capacity of an accumulator is about twice as great as its actual capacity for supplying a steady current, and in buying an accumulator it is necessary to make sure that the capacity stated is actual ampere-hours.

The Meccano accumulator is made in two sizes. Each size gives a current of four volts, but the larger one has a capacity of 20 actual ampere hours and the smaller one of eight actual ampere hours. These accumulators are well designed and strongly made and, if the simple instructions are followed, they will provide a thoroughly reliable source of current without any trouble.

At first sight it appears as though the accumulator ought to provide an ideal means of supplying power for self-propelled vehicles of all kinds. In practice, however, there are great drawbacks. The weight of a battery of accumulators large enough to run a car with a heavy load is tremendous, and this is, of course, so much dead weight. Further, the sudden and heavy demand for current when such a vehicle is started on a steep up-gradient not only necessitates frequent recharging but is ruinous to the accumulator.

More success has been achieved with accumulator-driven locomotives. They are not in general use, but have proved satisfactory in special cases. Locomotives of this kind are largely used, for instance, in mines and factories where pollution of the atmosphere by smoke must be avoided.

More recently an electric locomotive has been built in America that derives its power from a storage battery of 120 cells weighing more than 39 tons. The locomotive is capable of hauling a train weighing 3,000 tons. The provision for recharging in this case is of interest, a gas engine on the locomotive itself being connected to a generator. By the use of this method the locomotive may be kept continually running for 24 hours.

Electricity Applied to Meccano

II.—The Dynamo and the Electric Motor

IN last month's article of this series we dealt with the production of electricity by means of primary cells and the storage of energy in accumulators. We must now pass on to the principles that underlie the production of electric current on the large scale required in everyday life.

In order to understand the generating of electric current by dynamos and the utilisation of the current in electric motors and other apparatus, it is necessary to have some knowledge of magnetism. Magnetism probably was known and studied before electricity, as the result of the common occurrence in certain parts of the world of a stone that has the peculiar power of attracting iron. This lodestone, as it is called, is a mineral containing iron, and the name magnet probably was derived from Magnesia in Asia Minor, where the mineral was found in large quantities.

If a piece of lodestone is hung up by a thread it always comes to rest pointing almost due north and south. This fact was known to the Chinese at a very early period and is mentioned by a Norwegian writer who lived a thousand years ago. The end of the stone that points approximately in the direction of the earth's north pole is known as the "north-seeking" pole, or more commonly the "north" pole of the lodestone, while the opposite end is the "south-seeking" or "south" pole. It was from this power of pointing to the north that the lodestone acquired its name, which is derived from the Anglo-Saxon word "laeden," meaning to lead.

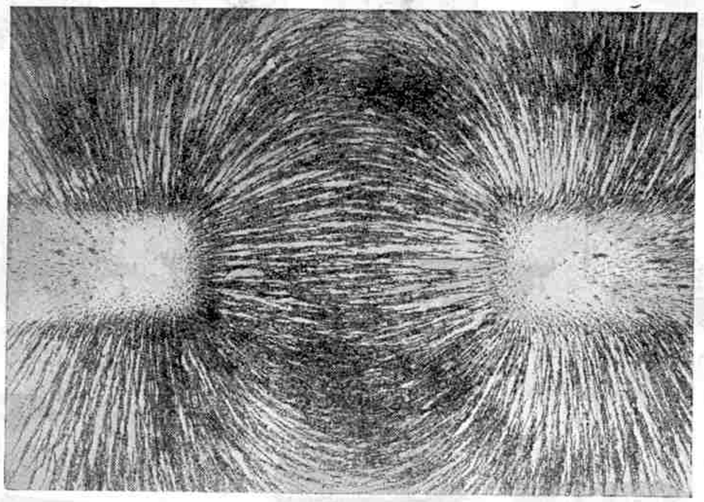


Fig. 1. Lines of Magnetic Force of Two Opposite Poles

At a later period it was found that pieces of steel could be made into artificial magnets that were better in many respects than the natural ones. The simplest method of making a piece of steel into an artificial magnet consists in stroking it repeatedly in one direction from end to end with one pole of a piece of lodestone. If the north pole of the lodestone is used for this purpose then the end of the piece of steel last touched by the lodestone will be the south pole of the new magnet. Soft iron also may be magnetised in this manner and, indeed, much more easily than steel but on the other hand it soon loses its magnetism whereas the hard steel retains it.

Pieces of iron may be magnetised temporarily without actually touching them with a magnet. If, for instance, one end of a bar magnet is brought close to but not touching the end of a piece of soft iron, the latter becomes magnetised and acquires the power of attracting iron filings or another piece of iron. As soon as the magnet is taken away, however, the magnetism of the soft iron disappears. This process is known as magnetisation by induction. It is interesting to repeat this experiment with a piece of glass, paper or wood between the magnet and the piece of iron and it will be found that these substances do not interfere with the action of the magnet. On the other hand if a sheet of iron were interposed the piece of soft iron would remain unmagnetised.

If a small magnet is suspended by a thread we shall find that like the lodestone it takes up a north-and-south position. We shall also find that if we bring near each end of it in turn the ends of another similar magnet the two north poles and the two south poles will repel one another but the north pole will attract the south pole and vice versa. Thus it is evident that whereas both poles of a magnet attract unmagnetised iron or steel the similar poles of two magnets repel one another while the opposite poles attract each other.

If a thin layer of iron filings is spread over a sheet of cardboard and a magnet is moved to and fro beneath the sheet, the filings stand up on their hind legs, as it were, as the magnet approaches them and follow it about as if pulled by invisible strings. Actually the magnet does act by means of invisible strings that are known as lines of magnetic force. These lines proceed from the poles of a magnet in certain definite directions and although we cannot actually see them it is quite easy to show how they work. In order to do this a magnet is placed beneath a sheet of cardboard or glass upon which iron filings are sprinkled thinly and evenly. The sheet is then tapped gently with a pencil. This tapping causes the filings to jump up from the surface of the glass so that they are momentarily freed from friction with it. During that momentary freedom the influence of the magnet is able to re-arrange the filings according to the direction of the lines of the magnetic force that issue from it. The filings thus provide us with a map showing the general direction of the lines of force.

By using different combinations of two or more magnets a great many very interesting maps may be made in this manner. Fig. 1, for instance, shows the lines of force between two opposite and mutually attractive poles of two bar magnets. It will be seen that the lines appear to stream across from one pole to the other. If the experiment is repeated with two similar poles the lines of force do not stream across but after proceeding a certain distance turn aside as if pushing one another away.

Any space containing lines of magnetic force is usually described as a magnetic field.

We are now in a position to understand why a freely suspended magnet always points north and south. The earth itself acts as a huge magnet having one pole in the north of Canada and the other in the antarctic continent, and a magnet points north and south because of the influence of the earth's magnetic poles upon the poles of the magnet. The earth's magnetic pole in Canada must be regarded as the south pole because it attracts the pole of the magnet that we have agreed to call the north pole.

The peculiarity of a magnet of pointing approximately north and south is made use of in the compass. In its simplest form this consists merely of a magnetised needle pivoted so as to swing freely over a card marked with the points of the compass. This form works well on land but for use on ships a more elaborate arrangement is necessary. In the mariner's compass the single needle is replaced by several thin strips of steel magnetised separately and suspended side by side. These are fastened to the underside of a circular card and suspended in a bowl made of copper, which is a non-magnetic metal. In order to keep this bowl in a horizontal position no matter how the ship may be rolling, it is supported by "gimbals," which consist of two concentric rings attached to horizontal pivots and moving in axes at right angles to one another.

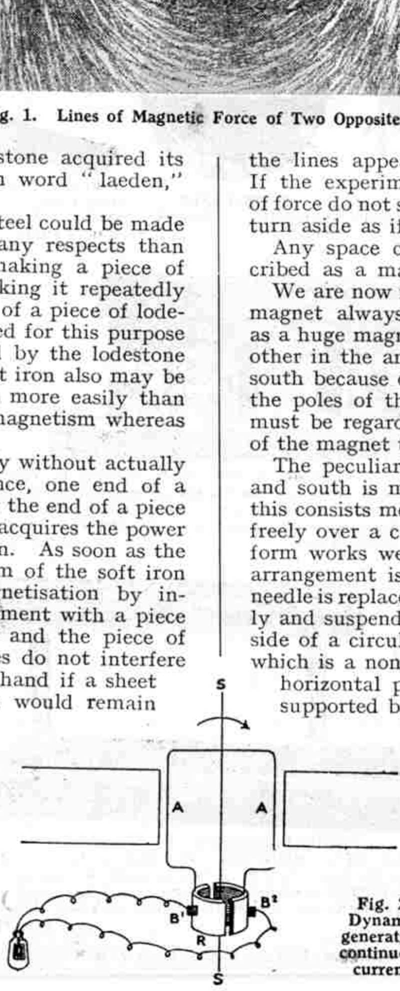


Fig. 2. Dynamo generating continuous current

The compass needle does not point to the true geographical north pole and for practical use it is necessary to know by how many degrees the direction shown by the compass varies from true north. This angle between the magnetic and the geographical meridians is called the "declination," and has been determined by careful survey for places all over the world.

The first indication of the close connection that exists between electricity and magnetism resulted from a discovery made by a Danish scientist named Oersted who found that when he held over a compass needle a wire carrying an electric current, the needle was deflected to one side or the other. Another connection between the two was discovered by Sturgeon, an English investigator, in 1823, who found that a bar of iron becomes a magnet when it is surrounded by a coil of wire through which electric current is passing. The bar regains its magnetic power only during the passage of the current and loses it as soon as the current is cut off. An arrangement of this kind is known as an electro-magnet and it plays a very important part in electrical mechanisms of almost all kinds, ranging from the electric bell to the giant crane that picks up huge masses of iron or steel, and lets them go again in obedience to the movements of a small switch that controls the current.

Another interesting fact is that a spiral of insulated wire through which a current is flowing shows all the powers of a magnet and, in addition, has the peculiar property of drawing or sucking into its interior a rod of iron. Such a spiral is called a "solenoid" and it has many valuable practical applications.

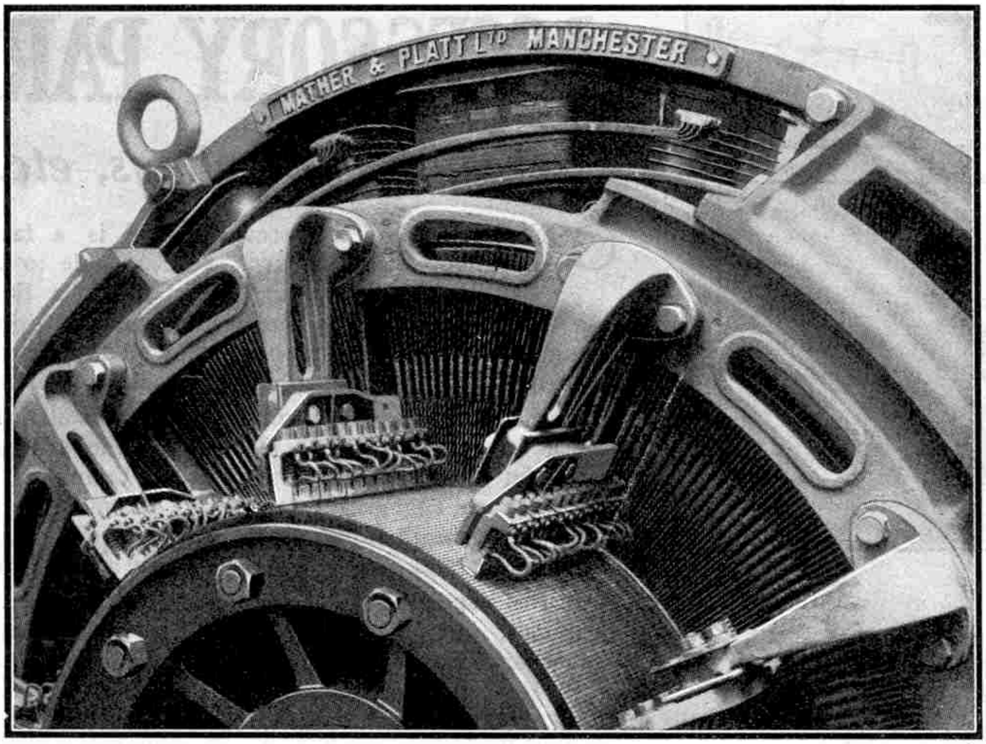


Photo courtesy of] [*Messrs. Mather & Platt Ltd.*

Fig. 3. Close-up view of large dynamo, showing the carbon brushes pressing on the copper segments of the commutator. The poles and their windings are also seen, at the top of the photograph

Sturgeon's investigations led to the even more important discoveries with which the name of the great English scientist Faraday is associated. These discoveries led to the development of the dynamo and the electric motor which to-day play an essential part in industry and transport throughout the world.

Faraday discovered that a current of electricity could be produced, or "induced" to use the correct technical term, in a coil of wire either by moving the coil towards or away from the magnet or by moving the magnet towards or away from the coil. A magnet is surrounded by a field of magnetic force and Faraday found that the current was induced when the lines of force were cut across. Making use of this discovery Faraday constructed the first dynamo. He also discovered that if an electric current is passed through a coil of wire suspended freely between the poles of the magnet, the coil revolves and this discovery led to the development of the electric motor.

Fig. 4 is a diagram of a dynamo in its simplest form. Between the poles of the magnet, N and S revolves a coil of wire A^1 A^2, 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 B B 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.

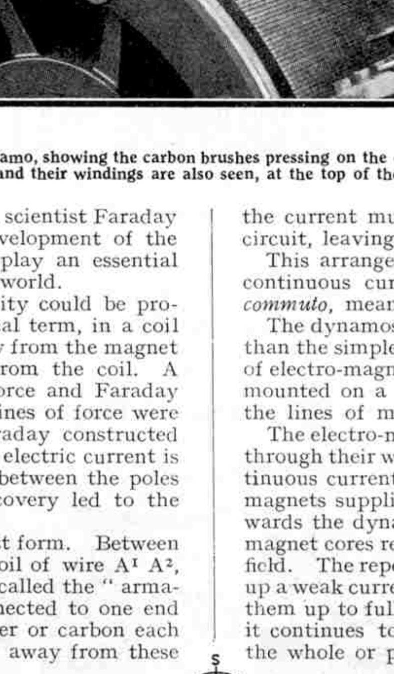


Fig. 4. Dynamo generating alternating current

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

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

The difference between a direct and an alternating current dynamo lies in the rings, and the new arrangement is shown in Fig. 2. In place of the two rings in Fig. 4 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 continuous current is called a "commutator," from the Latin *commuto*, meaning "I exchange."

The dynamos used in actual practice are much more complicated than the simple device we have just described. Each one has a set of electro-magnets, and the armature consists of many coils of wire mounted on a core of iron, which has the effect of concentrating the lines of magnetic force.

The electro-magnets in a dynamo require a current to be flowing through their windings before they acquire magnetic powers. A continuous current dynamo starting for the first time has its electro-magnets supplied with current from an outside source, but afterwards the dynamo will always be able to start again because the magnet cores retain sufficient magnetism to set up a weak magnetic field. The repeated cutting of the feeble lines of magnetic force sets up a weak current which, acting upon the magnets, gradually brings them up to full strength. Once the dynamo is generating current it continues to feed its magnets by sending through them either the whole or part of its current.

What has just been said applies only to continuous current dynamos. An alternating current dynamo cannot feed its own magnets, and these are supplied with current from a separate continuous current dynamo, which may be of quite small size.

Bearing in mind what we have learned about the principle on which the dynamo works, it is quite easy to understand the principle of the electric motor. Suppose, for instance, we wish to use as a motor the dynamo illustrated in Fig. 2. First of all we take away the lamp and substitute for it a second continuous current dynamo. We (*Continued on page* 1097)

Famous Trains—*(continued from page 1059)*

at the inclination mentioned, more particularly between Gretna and Lockerbie. But this is nothing to the "Bank" itself, which rises from Beattock for 10 miles continuously at between 1 in 88 and 1 in 69. For the $39\frac{3}{4}$ miles from Carlisle to Beattock 48 minutes are allowed, but the ensuing 10 miles require 21 minutes and it is quite possible that a minute or two gained between Lockerbie and Beattock may be added to the climbing time.

In the next $2\frac{1}{4}$ miles the railway drops at 1 in 99 into the valley of the Clyde, and remains in it, more or less, all the way to Glasgow. Actually the river is crossed six times—at Elvanfoot, Crawford, Lamington, near Carstairs, Uddingston and then just as the railway enters the Central Station at Glasgow.

After Elvanfoot the fall is gradual for $10\frac{1}{2}$ miles to Lamington, and then there are undulations for 15 miles past Symington and Carstairs to Craigenhill Summit, whence there is a steep and continuous fall for $15\frac{1}{2}$ miles at between 1 in 99 and 1 in 135, to Uddingston. High speeds are seldom attained on these falling grades, going north, as the descent from Beattock Summit to Lamington winds considerably, and down from Craigenhill coalmining country is traversed, which means moderated speed on account of subsidences. So speeds much in excess of 60 m.p.h. are unlikely, and cautious travelling is amply allowed for in the schedule of the train.

Twice between Carlisle and Glasgow it is possible to take water from track-troughs, which a couple of years ago were laid for the first time in Scotland near Floriston, about seven miles from Carlisle, and just south of Carstairs, in preparation for the long West Coast runs since instituted. Eleven sets of track-troughs in all are therefore available over the $401\frac{1}{2}$-miles' journey between Euston and Glasgow.

Mention has been made previously of our departure from Carlisle at 3.50 p.m.; 4.38 p.m. should see us through Beattock and 4.59 p.m. breasting Beattock Summit, at a speed of between 20 and 25 or 30 miles an hour. At 5.17 p.m., having covered with ease the $17\frac{1}{4}$ downhill miles from Summit in 18 minutes, we are drawing up at Symington, under the shadow of the bold Lowland summit known as Tinto Hill. Passengers are not allowed to leave or join the train either here or at Carlisle—the "*Royal Scot*" is, indeed, a strictly "limited" express, conveying passengers for Glasgow and Edinburgh only—but the stop is for the purpose of detaching the Edinburgh portion, for which we shall see waiting, in all probability, a Caledonian 4-4-0 engine.

At 5.20 p.m. we are away again, and as 50 minutes proves all too ample an allowance for the $35\frac{1}{2}$ miles from Symington down to Glasgow, the chances are that, given a clear road, we shall finish our journey before time. Last time I travelled on the train we rolled into Central Station at 6.3 p.m., no less than 12 minutes early by the public arrival time of 6.15 p.m. In the working timetables the scheduled time of arrival is 6.10 p.m.; but so easy is the task of haulage to the new "Royal Scot" engines that a booking of $7\frac{3}{4}$ hours from London or even less, would cause them little concern. Let us hope that, ere long, it will be possible to travel from London to the chief Scottish cities at a throughout average speed of 50 miles an hour and that the "*Royal Scot*" will be one of the trains to do it!

Choose your own Christmas Present!

It is a wonderful sensation to sit down and study illustrations and descriptions, and select your own Christmas present. Try it!

In our pages this month there are advertisers' announcements of all kinds of splendid toys, books, and all manner of articles for giving pleasure to boys at Christmas. We are going to make at least one boy happy by giving him the very thing he wants from amongst the articles advertised in our columns.

Look carefully at *all* the advertisements and decide which article you would like the postman to hand to you on Christmas morning. Write the name of it on the top of your postcard, marking it No. 1. Then write the name of the article that you would like second best and mark it No. 2. Do this with six articles altogether, write your own name and address at the bottom in very plain letters, and send the postcard to "Christmas Presents, *Meccano Magazine*, Binns Road, Liverpool."

To the sender of the list that corresponds most nearly in order of merit with the total voting we will post the article that heads his list, to reach him on Christmas morning.

"Christmas Presents" postcards must reach us not later than 17th December.

Landing Ocean Mails—*(cont. from page 1034)*

designed so that the resulting force passes normally through the base of the tower, thus rendering extensive foundations unnecessary. When not required for use, the conveyor can be raised by the winch, swung clear of the dock by hand, and lowered into any desired position.

While the number of mail bag and parcel-post packages landed at Plymouth from ocean liners already amounts to many thousands monthly, the installation and successful working of this conveyor must tend to increase still further the popularity of Plymouth as a port of call.

Model Building Contests—*(cont. from page 1075)*

a reversing lever, steering gear, and brakes on the rear wheels. The elevation and extension of the escape are controlled by hand wheels and regulated by pawl and ratchet mechanisms.

Robert Whittingham's entry is in the form of a Meccano Orrery. Although simply constructed and using few parts, this forms a most interesting model. The rotation of the Earth and its satellite, the Moon, are reproduced, as well as the progress of both bodies round the Sun. The latter, by the way, is represented by a candle, the light from which serves to illustrate the phenomena of day and night on the Earth.

Readers will observe from the illustration that the First Prize-winning model in Section C represents a tramcar of the type used in Manchester. The method of attaching the trolley arm to the roof of the car is open to criticism, but taken on the whole, I regard this model as an excellent piece of work.

James Yates' entry is in the form of a single-deck motor 'bus. It is fitted with lamps, leaf springs, a door giving admission to the driver's seat, and another at the rear of the coach. The road wheels consist of 3" Pulleys fitted with Dunlop Tyres.

John Warren Davis, the Third Prize-winner in this section, submitted two models. One is a neat model biplane and the other is a pleasing representation of a suspension bridge.

Electricity and Meccano—*(cont. from page 1083)*

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 stage the commutator 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. The operation of an electric motor is thus based on the attraction between unlike poles and the repulsion between similar poles.

Having dealt briefly with the more important principles of electricity, we shall proceed next month to describe the construction and use of some simple but essential pieces of electrical mechanism.

Toys for Christmas

Hamley's Branches are now showing a fine selection of toys and games and an interesting afternoon may be spent examining them. A good way to choose what you would like for Christmas is to take a pencil and notebook and make a list of the things you like best, then the choice can be narrowed down later.

Hamley's, by the way, have prepared a fine catalogue and if you send them your name and address, they will send a copy free of charge. This is a great help if you live too far away to visit their Showrooms. The catalogue is packed from cover to cover with hundreds of illustrations and you should be sure to mention the "*M.M.*" when asking for your free copy.

Electricity Applied to Meccano

III.—Simple Meccano Electrical Apparatus

THE preceding articles in this series, which appeared in the last two issues of the "*M.M.*," dealt with the elementary principles of electricity, and in this article we describe some simple but very interesting apparatus that may be constructed by combining the ordinary Meccano parts with the special Meccano electrical accessories. We would recommend every Meccano boy who has not already done so to read the two earlier articles before starting work on the models, since a rudimental knowledge of the elements of electricity is almost essential if the best results are to be obtained from the application of the science to Meccano model-building.

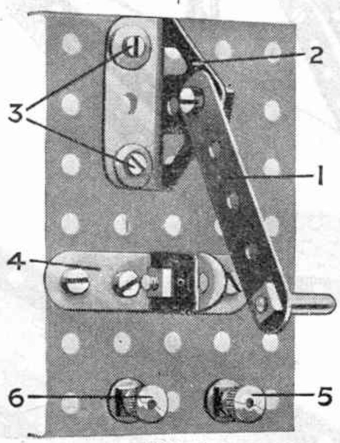


Fig. 3

In this article, and in others that will appear in subsequent issues, we shall describe not only complete electrically-operated models but also numerous devices, such as switches, electro-magnets, etc., which may be adapted to, or used with great advantage in connection with, ordinary Meccano models.

A list of Meccano electrical parts is included on this page. These parts may be obtained separately and used in conjunction with the ordinary Meccano accessories, for which purpose they are specially designed.

MECCANO ELECTRICAL PARTS

Part No.			s.	d.
Part No. 301.	Bobbin	each	0	4
„ „ 302.	Insulating Bush	doz.	0	6
„ „ 303.	Insulating Washer	„	0	3
„ „ 304.	6 B.A. Screws	„	0	6
„ „ 305.	6 B.A. Nuts	„	0	3
„ „ 306.	Terminal	each	0	1
„ „ 307.	Silver-tipped Contact Screw	„	0	5
„ „ 308.	Core or Pole Piece	„	0	3
„ „ 309.	Coil Cheek	„	0	3
„ „ 310.	Lamp Holder	„	0	3
„ „ 311.	Best Metal Filament Lamp	„	0	6
„ „ 312.	27 Gauge Bare Iron Wire, per length of 30″		0	1
„ „ 313.	26 Gauge SCC Copper Wire, Reels of	50 yds.	2	3
„ „ 314.	23 Gauge SCC Copper Wire, „	25 „	2	0
„ „ 315.	22 Gauge Bare Copper Wire, „	4 „	0	3

In constructing Meccano electrical apparatus it will frequently be necessary to insulate a Strip or Plate, etc., from some other part of a model. The necessary insulation is obtained by using Insulating Bushes or Washers in conjunction with 6 B.A. Bolts. A 6 B.A. Bolt is secured to the Strip and at the same time insulated from it by placing an Insulating Washer against one side of the Strip and an Insulating Bush against the other, and passing the bolt through both. Other Meccano pieces may then be mounted on the shank of the bolt and secured in place by a nut.

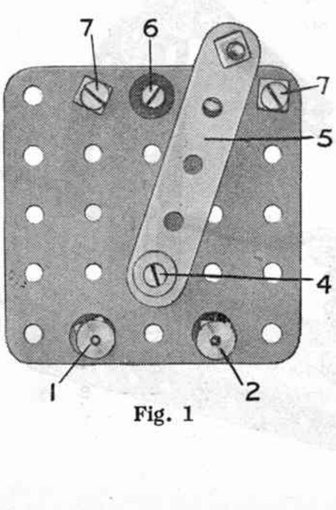


Fig. 1

The Insulating Bushes and Washers are somewhat similar in appearance and both are constructed of fibre. The Washer, however, is of a red colour while the Bush is black, and the latter is fitted with a small ridge which fits inside a Meccano standard hole, thereby preventing the shank of the bolt from making contact with the metal part to which it is attached. These parts should always be employed when using a 6 B.A. Bolt.

A complete terminal is constructed by mounting a 6 B.A. Bolt in the manner described and threading on its shank a Meccano Terminal (part No. 306).

It will be observed from the list of parts that four different kinds of wire are included in the electrical accessories. The first of these (part No. 312, 27 Gauge Bare Iron Wire) is of a very high resistance and is intended for use in constructing resistance controllers or speed regulators, etc. Part No. 313 (26 Gauge Cotton Covered Copper Wire) should be used for winding bobbins to form electro-magnets, etc., and part No. 314 (23 Gauge Cotton Covered Copper Wire) is intended for all ordinary connecting purposes. The 22 Gauge Bare Copper Wire (Part No. 315) is designed for use on the few occasions when it is desired to transmit current over an exposed wire, such as in the case of an overhead wire for tramway or locomotive models.

Meccano Switches

In constructing Meccano electrical models a switch of some kind or the other is nearly always required. Two or three different types of switch are shown in these pages. Any one of these may be incorporated in a model and used to start or stop a motor, to light lamps, or for numerous other similar purposes.

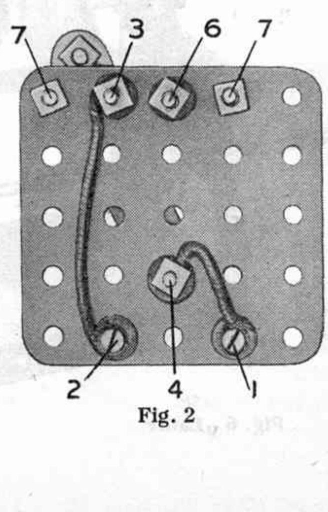


Fig. 2

Fig. 1 shows a simple "stud" switch. It is mounted on a $2\frac{1}{2}'' \times 2\frac{1}{2}''$ Flat Plate carrying two terminals, 1, 2, which are constructed in the manner already described and, therefore, insulated from the plate. The terminal 2 is connected by an insulated wire to a 6 B.A. Bolt 3 that is insulated from the plate by a Bush and Washer (see rear view of switch, Fig. 2), while the terminal 1 is connected to the 6 B.A. Bolt 4. The latter is also insulated from the plate and carries the 2½" Strip 5 forming the switch arm. The Strip 5 is spaced from the plate by a nut placed beneath it on the shank of the bolt, and a metal Washer should be placed beneath the head of the bolt to ensure proper contact with the Strip. The nuts on the bolt 4 should be adjusted so that the switch arm 5 moves stiffly. A Threaded Pin secured to the end of the Strip 5 forms a convenient handle and two ⅜" bolts 7, secured by a nut placed on each side of the plate, act as stops. A second insulated 6 B.A. Bolt 6 is mounted in the position shown; this is not connected electrically, since it merely forms a rest for the switch arm when the switch is placed in the "off" position.

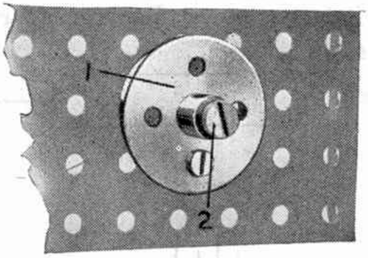


Fig. 4

When the arm 5 is placed over the bolt 3 the circuit is completed, for the current is able to flow from the terminal 2 through the switch arm and back to the terminal 1 via the bolt 4 and short length of wire connected to it. One of the terminals 1, 2 should be connected to the Accumulator and the other terminal to tne Motor or lamp, etc., which it is desired to control. The remaining connections consist, of course, of a wire from the second Accumulator terminal to the second terminal of the Motor or lamp. The appearance of the switch will be improved if small labels are pasted beneath the bolts 3 and 6 to indicate the "on" and "off" positions of the switch arm.

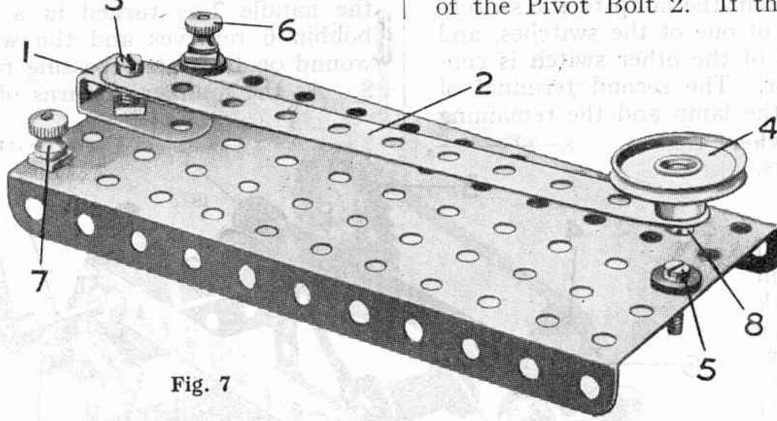


Fig. 7

Another type of switch having exactly the same functions as that just described is shown in Fig. 3. This type is known as a knife switch, since the circuit is completed by forcing a thin blade-like lever between a forked contact piece. An important advantage of this switch lies in the fact that the contact surfaces are kept always clean by reason of the scraping action caused by thrusting the switch arm into its place.

The arm 1 in this switch is pivoted by bolt and lock-nut (see Standard Mechanism No. 263) to a Trunnion 2, which is insulated from the base of the switch by means of Insulating Bushes and Washers placed on the two 6 B.A. Bolts 3. The contact piece consists of two 1"×1" Angle Brackets 4 bolted to the base plate (a 3½"×2½" Flanged Plate) and having their protruding ends slightly bent as shown in order to grip the switch arm more readily. The terminal 5 is threaded on a 6 B.A. Bolt insulated from the base and connected by a piece of covered wire to one of the bolts 3; the second terminal 6 is connected by another piece of wire to one of the bolts securing the Angle Brackets 4 to the Flanged Plate. The connections to the Motor, etc., that it is desired to control are similar to those in the switch first described.

Push-Button Switch

A remarkably neat Meccano switch is shown in Fig. 4. This is of the push-button type and may be used in connection with electric bells, buzzers, flash lights, etc., as well as in innumerable Meccano models. It consists essentially of a Flanged Wheel 1 and Pivot Bolt 2. A small compression spring, obtained by cutting two or three turns off part No. 120b (Spring for Spring Buffer), is placed between the head of the bolt and the boss of the wheel. The contact piece consists of a 6 B.A. Bolt secured with its head immediately beneath the shank of the Pivot Bolt 2. If the switch is mounted on a metal base as in the illustration the contact bolt must be insulated, of course, by means of fibre Bushes and Washers.

In making the connections, one wire should be secured to the ½" bolt holding the Flanged Wheel in place and another to the insulated contact bolt. The circuit is completed by pressing down the Pivot Bolt, which is prevented from falling out of position by a nut placed on its extreme inner end.

Two-Way Switch

Yet another type of switch is shown in Fig. 5. This is a two-way switch, and is designed to complete one or other of two separate circuits. The contact pieces 1 are formed from Flat Brackets secured to 1"×1" Angle Brackets, which are insulated from the base plate in the usual manner. The tops of the contact pieces are bent slightly, as may be seen in the illustration, to facilitate engagement with the switch arm.

The terminals 2 and 3 are mounted on 6 B.A. Bolts passed through the base plate and the 1"×1" Angle Brackets, an Insulating Washer being placed on the shank of each bolt, of course, between the plate and the brackets. It will be noticed that the nuts beneath the terminal caps are pressed against the 1"×1" Angle Brackets, so that the latter are in direct contact with the terminals. The switch arm consists of a 2½" Strip pivoted by means of bolt and lock nuts (S.M. 263) to a Trunnion 4, which is also insulated from the base plate. The terminal 5 is mounted in exactly the same way as the others.

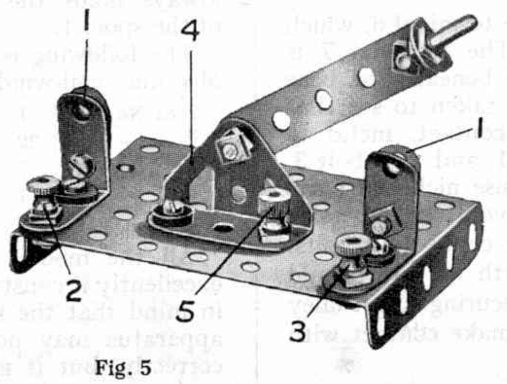


Fig. 5

The functions of a switch of this type should be clear on reference to the diagram (Fig. 6). The drawing is intended to represent two-way switches arranged to control an electric light from two different points. A circuit similar to this is frequently used to control a light over the staircase in electrically-equipped houses, where the lamp may be switched on from the foot of the stairs and put out again from a second switch at the top, or vice versa. The circuit is extremely simple and we have little doubt that Meccano boys will find numerous uses for it. It is equally applicable, of course, to the control of an Electric Motor.

It will be seen that two switches, each exactly the same, are required. In the diagram the lamp is shown "off," but operation of either switch will cause it to be illuminated. Similarly, if the lamp is on, movement of either switches will extinguish it. The wiring connections will be easy to follow from the diagram ; one wire is led from the lamp to the switch-arm terminal (5 in Fig. 5) of one of the switches, and the corresponding terminal of the other switch is connected to the Accumulator. The second terminal of the latter is connected to the lamp and the remaining terminals 2, 3 on the switches are wired together in pairs.

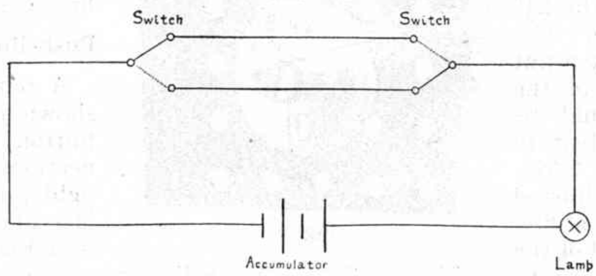


Fig. 6

Meccano Tapper

The tapper key illustrated in Fig. 7 is designed to form a simple make-and-break contact apparatus. A device of this kind will prove extremely useful when making electrical experiments. It consists of a 5½″×2½″ Flanged Plate, to which a Single Bent Strip 1 and a 5½″ Strip 2 are directly attached by a ¾″ Bolt 3. A convenient knob is formed by a 1″ Pulley Wheel 4 secured by its set-screw to the shank of a ¾″ Bolt 8 passed through the end of the 5½″ Strip 2.

The contact piece consists of a 6 B.A. Bolt and nut 5 insulated from the plate and connected by an insulated wire to the terminal 6, which is also insulated from the plate. The terminal 7 is connected by another length of wire beneath the base plate to the bolt 3. Care should be taken to see that the Strip 2 makes good electrical contact, metal to metal, with the Single Bent Strip 1 and the bolt 3, and in such cases it is advisable to use nickelled parts in preference to coloured ones, to avoid the necessity of removing the enamel around the connecting bolts. If enamelled Strips are used, a length of wire should connect the bolt 3 to the bolt 8 securing the Pulley Wheel 4, since the latter bolt must make contact with the stud 5.

Coil-Winding Machine

Fig. 8 shows a coil winder. This apparatus is devised specially for winding insulated wire round the Meccano Bobbins, part No. 301, when constructing electro-magnets, etc. The model is very simple and may be constructed in a few minutes. When complete it will wind the Bobbin quickly and evenly, thus obviating the tedious process of laying on the wire by hand.

The spool of wire 1 is mounted loosely on the 4½″ Rod 2, to which is secured a 2″ Sprocket Wheel 3. The latter is connected by chain to a 1″ Sprocket Wheel 4 secured to the 3½″ Threaded Rod 5. The Meccano Bobbin 6 is secured to this Rod 5 by means of two nuts. When the handle 7 is turned in a clockwise direction, the bobbin 6 revolves and the wire from the spool 1 is wound on to it after passing round the 1″ loose Pulley 8. As the number of turns of wire on the bobbin increases it will be found that the Pulley 8 slides along its Rod, thereby guiding the wire always in the correct position. Hence, once the bobbin is started, it is unnecessary to touch the wire by hand unless, of course, some accident occurs to upset the uniformity of the layers on the bobbins.

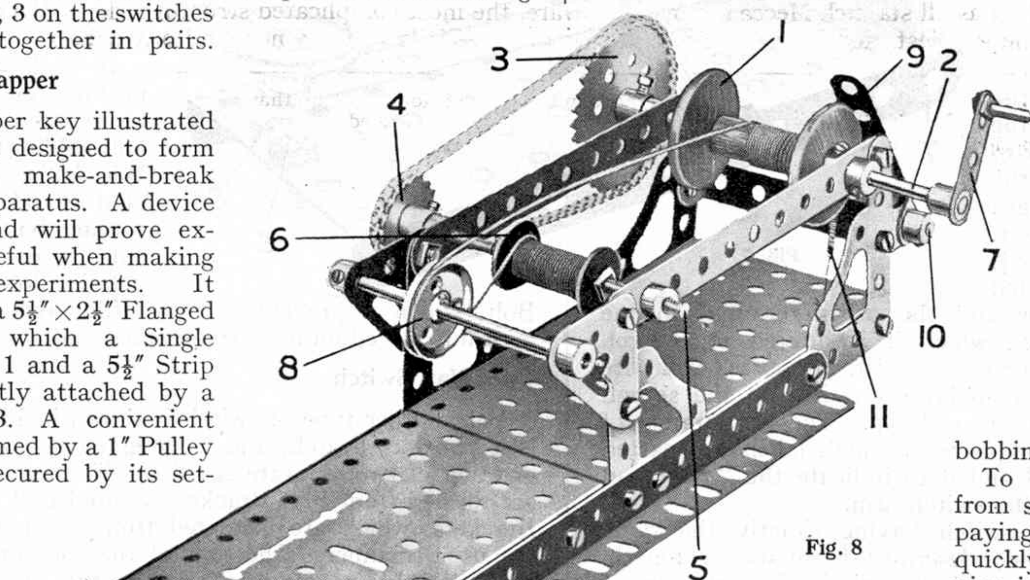


Fig. 8

To prevent the spool from spinning round and paying out the wire too quickly, the following device is adopted. A 2½″ Strip 9 is bolted to a Double Bracket, which is free to pivot about a 1″ Rod 10. This Rod is journalled in another Double Bracket bolted to a 2½″×½″ Double Angle Strip in the rear of the model, and a short length of Spring Cord 11 is tied to the centre hole of the Strip 9 and to some fixed portion of the model. The tension of the Spring Cord should be adjusted so that it always holds the 2½″ Strip firmly against the edges of the spool 1.

The following is a list of parts required to build the Meccano coil-winder :—

2 of No. 2	1 of No. 22A	2″ of No. 58	1 of No. 95
3 " " 5	22 " " 37	10 " " 59	1 " " 96
2 " " 8A	2 " " 37A	1 " " 62	4 " " 108
2 " " 11	1 " " 48A	1 " " 80A	1 " " 115
1 " " 15A	2 " " 52	14″ " " 94	2 " " 133
1 " " 16			

All the models described in this article will work excellently if constructed carefully, but it must be borne in mind that the slightest fault in a piece of electrical apparatus may not only prevent the model working correctly, but it may also cause considerable damage.

Electricity Applied to Meccano

IV.—Meccano Electric Telegraph System

In last month's "*M.M.*" we described how various types of switches and a Coil-winding Machine could be built with the aid of the Meccano Electrical Parts. This month we shall endeavour to show how a simple but extremely interesting telegraphic system may be constructed.

Many "*M.M.*" readers are the happy owners of wireless sets, and at times some may have thought and said things about Morse signals which so often break into an enjoyable broadcast programme. To learn the Morse code requires a good deal of patience and practice, but when one is proficient many enjoyable hours can be passed by listening in to the various Morse stations on the different wave lengths. For example, weather reports—a very useful feature in these days—are frequently sent out in Morse by the Air Ministry, whose call sign is G.F.A. Also much enjoyment can be derived from following the messages from ships and coast stations.

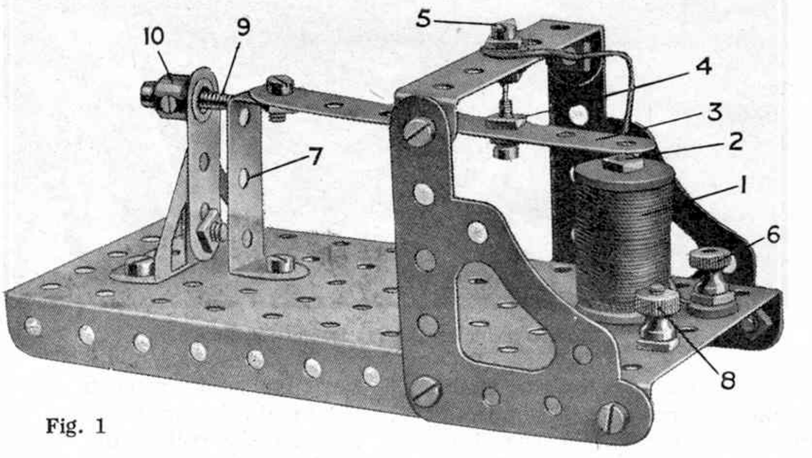


Fig. 1

In order to become an efficient interpreter or sender of messages in Morse, a Morse "key" and "buzzer" are necessary. The former instrument is a type of switch which, when manipulated, causes the buzzer to emit the long and short sounds of the Morse code. Both instruments may easily be made in Meccano and the models about to be described are capable of giving good results if careful attention is paid to their construction.

The magnet coil 1 in the buzzer (Fig. 1) is a Meccano Bobbin wound to capacity with No. 26 S.W.G. Copper Wire. The Meccano coil-winder described last month should be used to wind the Bobbin. The latter is secured to the Flanged Plate by a Core Piece 2, whose upper end forms the pole of the magnet. Above the coil is the 3½" Strip 3 which constitutes the vibrating armature, a Contact Screw 4 being bolted to it as shown in the illustration. A second Contact Screw 5 is mounted on a 2½" Double Angle Strip and insulated from it by means of an Insulating Bush and Washer. One end of the coil winding is brought to this contact 5, the other end being taken to the insulated Terminal 6.

If the Accumulator is connected directly to the Terminals, the current passes through the turns of the coil 1, across the contacts 4 and 5, along the armature 3 and by passing down the 1½" Double Angle Strip 7, which supports the armature 3, it returns to the Accumulator through the Flanged Plate and uninsulated Terminal 8. The current must follow a path of very low resistance in passing through the metal framework of the model. In view of this, the use of nickelled parts is preferable to that of coloured parts, as the enamel on the latter tends to insulate the various parts from each other. If enamelled parts are used, a wire connected between the Contact Screw 4 and the Terminal 8 will assist the flow of the current.

Since the current flows through the coil the latter becomes magnetised, of course, and the armature is attracted to it. This results in breaking the circuit feeding the magnet, for the Contact Screws are drawn apart. But immediately this happens the magnet becomes de-energised and is unable to hold the armature; the latter therefore flies back and makes contact again with the screws 4 and 5. The cycle of operations is then repeated at an extremely rapid rate, and the vibrations of the armature produce a musical note.

A ¾" Bolt 9 inserted in a Threaded Crank 10 presses against the 1½" Double Angle Strip 7; by increasing or diminishing the pressure of the bolt on the Double Angle Strip the pitch of the note may be varied to suit individual requirements.

THE MORSE CODE

A . –	J . – – –	S . . .
B – . . .	K – . –	T –
C – . – .	L . – . .	U . . –
D – . .	M – –	V . . . –
E .	N – .	W . – –
F . . – .	O – – –	X – . . –
G – – .	P . – – .	Y – . – –
H	Q – – . –	Z – – . .
I . .	R . – .	

Numerals

1 . – – – –	6 – . . . .
2 . . – – –	7 – – . . .
3 . . . – –	8 – – – . .
4 . . . . –	9 – – – – .
5 . . . . . or .	0 – – – – – or –

Punctuations, etc.

Full Stop . . . . . .
Comma . – . – . –
Commencement of work – . – . –
End of work . – . – .
End of Transmission . . . – . –
Please send (K) – . –
Understood (R) . – .
I have something for you (QTC) – – . – – – – . – .
I have nothing for you (QRU) – – . – . – . . . –
Gale Warning (TTT) – – –
Signal of Distress (SOS) . . . – – – . . .
Interrogation . . – – . .

Morse Key

A Morse Key must be capable of two important adjustments, viz., the gap, that is the vertical movement of the bar of the key, and the tension of the spring. In the key about to be described, both these adjustments may be effected.

The front contact 1 (Fig. 3) and the back contact 2 consist of 6 B.A. Bolts insulated from the Flanged Plate, which forms the base of the model, and secured to it by two nuts. The contact 1 is connected to the insulated Terminal 3 by a short length of wire beneath the plate, and contact 2 to the insulated Terminal 4 by a similar means.

The corresponding portions of the contacts 1 and 2 are mounted on the bar of the key as shown in the illustration. That corresponding to the contact 1 consists of a ¾" Bolt 5 carried in the spider, or centre collar, of a Universal Coupling that is secured to the bar of the key by two nuts and bolts. A Washer inserted under the head of each bolt prevents their shanks binding on the ¾" Bolt 5. By turning this Bolt the vertical movement of the bar, or gap as it is termed, may be diminished or increased according to whether the Bolt 5 is screwed in or out of the "spider." The portion of the contact 2 mounted on the bar takes the form of a 6 B.A. Bolt 6 secured to a Double Bracket 7. Both the contacts on the bar are in electrical connection, through the frame of the model, with the Terminal 8; hence the entire model should be constructed of nickelled parts for the same reasons as those stated in connection with the model buzzer. If enamelled parts are used a wire should be taken from the Terminal 8 to each of the bar contacts.

The ¾" Bolt 9 is carried in a "spider" in a like manner to the adjustable front contact bolt 5, and presses on the head of a Spring Buffer 10. By screwing the ¾" Bolt in or out of the "spider" the Buffer is compressed to a greater or lesser degree. The key may thus be adjusted to suit one's hand, for some people prefer a light, and others a strong, tension on the spring.

Simple Buzzer and Key Circuit

Having constructed both models it only remains to connect them together. The necessary connections for sending in one direction only are shown in Fig. 2. A suitable length of 23 Gauge copper wire is taken from one of the Accumulator terminals and attached to a terminal of the buzzer (it is immaterial which one). The other buzzer terminal is connected to the Terminal 4 of the key, and a length of wire is taken from the Terminal 8 of the key to the remaining terminal on the Accumulator. When the key is depressed the current flows from the Accumulator along the bar of the key, etc., across the back contact 2 (Fig. 3), to the Terminal 4, and then through the buzzer back to the Accumulator.

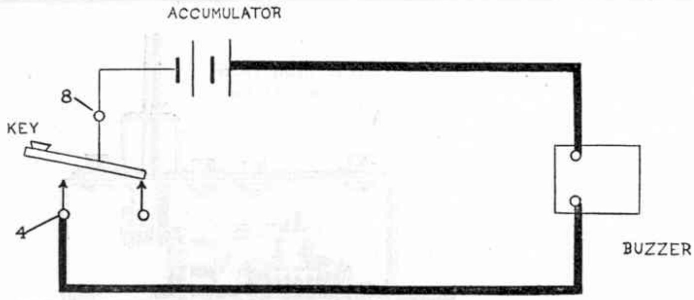


Fig. 2

"*M.M.*" readers would do well to practice the Morse Code on the Meccano set described above. Letters in the code consist, of course, of a series of dots and dashes, which are produced on the buzzer by pressing on the key for short or long intervals. A list showing the Morse equivalents to the alphabet, numerals, and the more important punctuations, etc., is included on these pages.

When sending a message the key should be manipulated by placing the first and second fingers of the right hand on the knob of the key and working the wrist up and down, keeping the fingers perfectly still. A dash should be three times the length of a dot, and until one is proficient it is a good plan to raise the hand slightly from the knob between each letter in order to preserve the correct spacing. A slightly longer interval must occur between each word.

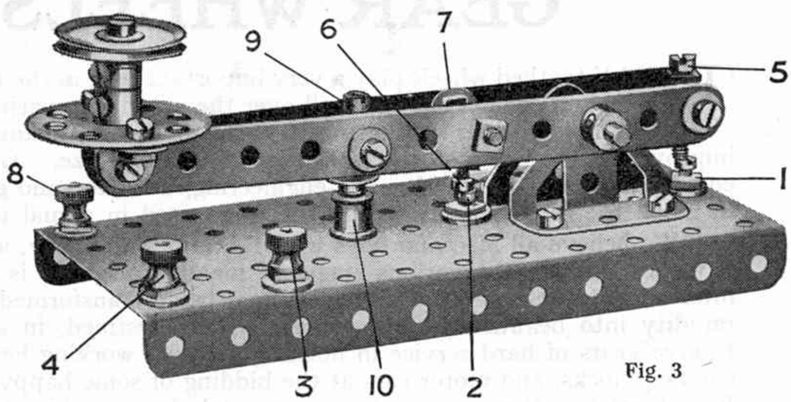


Fig. 3

After a time it should be possible to send and receive Morse code messages at quite a useful speed. One may then endeavour to listen-in to some of the slower Morse stations.

It is well known how resistance affects the current flow in a wire, and why, if the length of wiring in a circuit is increased, it is necessary either to increase the applied voltage or increase the gauge of wire in order to keep the current in the circuit at the same value. Therefore when we are rigging up our stations we must bear in mind that while the 4-volt Accumulator will enable messages to be sent over a distance of approximately 25 yards it would be necessary to double the voltage by connecting two 4-volt Accumulators in series, if it is required to send messages over a distance of 50 yards, and so on. As most boys have not access to two or more accumulators, it is proposed to show how the same results may be obtained by other means.

Supposing two points are connected by a single wire of, say, 23 gauge, having a resistance of two ohms. Then if the two points are joined by a second wire of the same gauge and length as the first, in addition to the latter, we shall find that the resistance is now only 1 ohm. Wires arranged in this manner are said to be in parallel. In the above case the two wires in parallel reduce the resistance by half, and three in parallel would bring the resistance down to one third of the original, because we have in reality increased the cross sectional area of the resultant conductor by adding two or more wires in parallel.

We have therefore a convenient means of increasing the range of our set without increasing the voltage of the Accumulator. For by having two wires in parallel we should be able to transmit 50 yards instead of the 25 yards possible with only the single wire.

Two-Way Circuit

After making the simple buzzer and key circuit just described, we may devote our attention to the setting up of a double circuit set. Two buzzers and two keys are required, and by arranging the wires two or more in parallel, it should be possible to send and receive messages from a friend's house some distance away. It is scarcely necessary to add that a great deal of fun, not to mention instruction, may be obtained with an arrangement of this kind.

The necessary connections are shown in the diagram, Fig. 4. All lines drawn thick are conductors which for long distance work may be composed of several wires in parallel. Let us call the two stations A and B. Connect the positive terminal of the Accumulator to terminal 8A, and the negative terminal to 8B. Terminal 4A is connected to 8B′ and 8A′ to 4B. The remaining connections, which need only be short, are: 3A to 6A′ and 3B to 6B′.

When the operator at A presses his key the current flows from the Accumulator along the bar of the key and through the back contact to the buzzer at B. After leaving the buzzer, the current passes to the bar of the key at B by way of the front contact, and then on to the negative terminal of the Accumulator. When the operator at B presses his key, the path of the current is reversed, for it flows from the Accumulator through the key at B and via 4B, 8A′, 3A, and the key at A, back to the Accumulator, thereby causing the buzzer at A to sound.

The best way to send and receive messages on a set of this description is to have a call sign for each station. For example, one station might be called ABC and the other XYZ. This procedure is adopted in actual practice, for every telegraph as well as wireless station has a call sign. Thus, for London the sign might be TS and for Manchester MR. If the operator at London desires to call Manchester he would repeat the call letters MR thrice. After a pause he would again repeat them, continuing to do so until answered by Manchester.

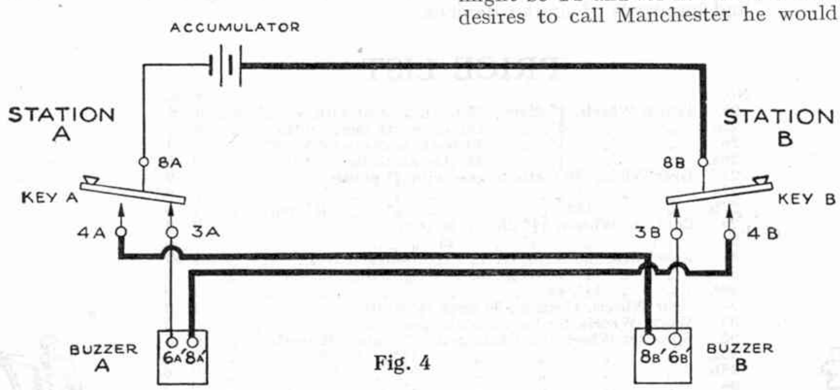


Fig. 4

In the wireless service a different procedure is adopted. Suppose a ship having the call sign MME desires to get into communication with Niton (GNI). The letters GNI are sent thrice, then the French word DE followed by the ship's call sign. An interval of 3 minutes must elapse before the call can be repeated. When the coast station accepts the call, it sends the ship's call signal thrice, its own once, followed by " K," signifying that the ship may proceed with the communication. Meccano boys may obtain much fun and entertainment by corresponding with each other on the Meccano telegraph set if they follow out the methods outlined above.

Electricity Applied to Meccano

V.—A Meccano Shocking Coil, Electro-magnet, and Signal

These articles are intended to draw every Meccano boy's attention to the numerous fascinating uses to which the Meccano electrical parts may be put. The first two articles of the series dealt with the elementary principles of electricity, and the second and third articles described various Meccano switches, a coil-winding machine, and a Meccano electric telegraph system. Below we describe an electro-magnet of the type that can be used in model cranes, etc., a shocking coil, and an electrically-operated semaphore railway signal. All these models are constructed from a few ordinary Meccano parts used in conjunction with the special electrical accessories.

THE importance of the electro-magnet in nearly all electrical appliances was remarked upon in the article in this series which appeared in the December, 1927, "*M.M.*," and in the course of the article it was shown how its magnetic field was similar to that of an ordinary bar-magnet of the permanent type. Hence the former type of magnet may be substituted with advantage for the latter. A permanent magnet is liable to become de-magnetised through rough usage and its power is extremely limited, whereas the effect of an electro-magnet may be very powerful indeed. Moreover, the magnetic force of the latter type may be turned on or off at will.

An electro-magnet depends for its lifting power upon two factors, namely, the number of turns of wire constituting the magnet winding, and the number of amperes—that is, the amount of current—in the turns. A current of ten amps. flowing through ten turns of wire will produce a weak magnetic effect, but if we increase the number of turns to one hundred, a magnet ten times more powerful will be obtained. In technical terms the power of a magnet is gauged by the number of "ampere turns," which measurement is obtained by multiplying the number of amperes flowing along the wire by the number of turns in the magnet.

The above will become more clear if we recall that a straight conductor is surrounded by a magnetic field, as explained in a previous article. If the conductor is wound into a close spiral the magnetic field of each adjacent turn will be augmented, thus producing a greatly enhanced effect.

Having briefly sketched the elementary principles of the electro magnet we may describe the construction of a working model in Meccano. Nearly all the models described in this article, and the majority of those that will appear in subsequent issues, will embody a magnetic coil in some form or other, but the model about to be described is a simple electro-magnet of the type that in actual practice is sometimes attached to the hoisting hook of a crane and used for lifting masses of iron and steel, etc.

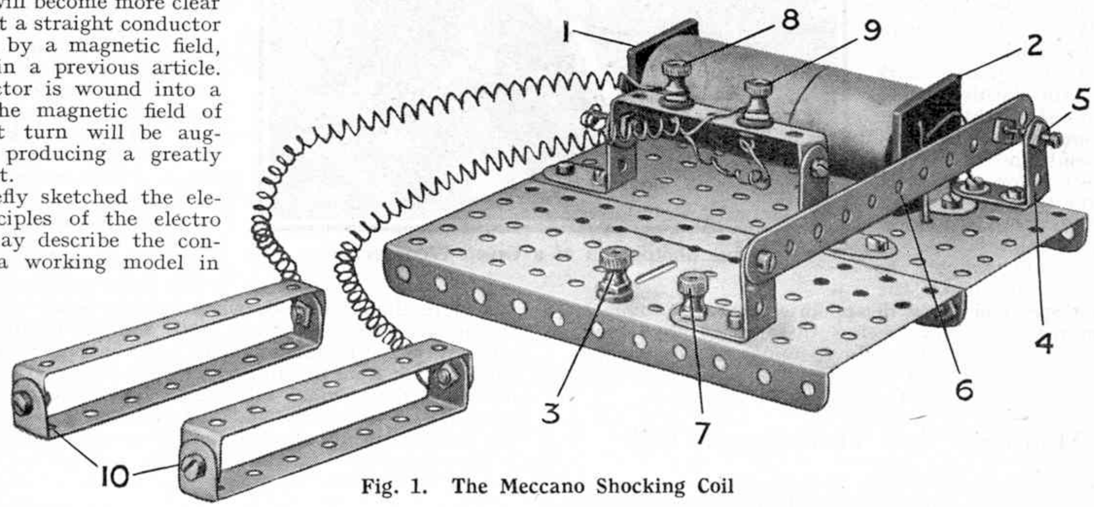


Fig. 1. The Meccano Shocking Coil

The Meccano Electro-magnet

To construct the Meccano electro-magnet (Fig. 2) first wind two Bobbins to full capacity with either 23 or 26 SWG wire. A magnet wound with 23 gauge wire will be more powerful than one wound with 26 gauge wire. This is due to the fact that the "23" wire has a lower resistance per unit of length than the "26"; therefore, a larger flow of current will be carried by the former, and a more powerful magnetic effect will be produced from a given voltage.

Some interesting results may be tabulated to show the relative weights that can be lifted by magnets wound with 26 and 23 SWG copper wire, the same voltage being used in each case, of course. In the Meccano models it will be found that magnets wound with 23 SWG wire have a fewer number of turns than those wound with the other wire. This, of course, is due to the fact that the slightly larger diameter of the wire prevents the same number of turns being accommodated on the Meccano Bobbin. A magnet wound with 26 gauge wire has a higher resistance than one wound with 23 wire, so we must increase the applied voltage if we wish to maintain the current at the same value as in the lower resistance coil assuming, of course, that both magnets have equal lengths of wire used in each case. This is in accordance with the ampere-turns law quoted above.

The Bobbins of the Meccano magnet are attached to the yoke 1, which is composed of three 1½" Strips, by the Pole Pieces 2. A wire protruding from one of the magnet coils should be connected to one wire of the second coil, and in order to select the proper wires for connection, it should be imagined that the current, starting from the input end (represented by the wire attached to the accumulator) of the first coil, flows round that coil in a clockwise direction. It then passes to the second coil and flows round it in an anti-clockwise direction. By connecting the two magnets in this way, one is given a North and the other a South polarity.

The two leads to the coils should be of sufficient length to permit the magnet being raised and lowered by the crane. The hoisting cord may be rove round the 1" Pulley 3, which turns upon a 1" Axle Rod journalled in a Cranked Bent Strip 4 bolted to the yoke 1.

The magnet may be fitted to almost any Meccano Crane, and much fun and interest can be gained by using it in place of the hoisting hook. The load is dropped whenever required by switching off the current.

Induction or Shocking Coil

In the article on "The Dynamo and the Electric Motor" in the "*M.M.*" for December, 1927, reference was made to the great discovery by Faraday of electrical induction. As there stated (page 1083) the first step in the discovery was the demonstration that a current of electricity could be induced in a coil of wire either by moving the coil towards or away from a magnet. This discovery led to the construction of the dynamo.

The induction of a current is due to the cutting across of the lines of force of the magnet by the coil. Instead of the magnet a solenoid or spiral coil of wire carrying a current may be used to produce the lines of force and Faraday actually used a solenoid in this manner. A further step was taken when the relative positions of the coils were left unaltered and the current in one of them was started and stopped alternately. This led to the invention of the induction coil.

In its usual form this instrument consists of two coils, one wound outside the other. The inner coil is called the primary coil, as it carries the current used to produce the lines of magnetic force, while the outer coil is the one in which the current is induced, and is called the secondary coil.

When the current is switched on in the primary coil the latter becomes an electro-magnet and lines of force come into existence. These are cut across by the secondary coil, so that the effect is exactly the same as if a coil carrying a current were moved towards the secondary. If the current is now switched off an induced current in the opposite direction is produced in exactly the same manner. By switching on and off with great rapidity by means of a current interrupter, an alternating current is induced in the secondary coil.

The great value of the principle of induction is that the voltage of the induced current may be increased by using more turns of wire in the secondary coil, the voltage set up being nearly proportionate to the relative number of turns in the two coils. If the primary coil has 100 turns and the secondary coil 2,500 turns, then the voltage in the secondary circuit will be nearly 25 times as great as that in the primary circuit. In the model to be described the primary circuit consists of about 200 turns and the secondary of about 1,500. This gives a voltage ratio of about seven, and thus the use of a four-volt accumulator will produce an alternating current in the secondary of approximately 28 volts.

The instrument is made more efficient by inserting a core of soft iron within the primary, as this causes the lines of force to be crowded into a smaller area. The core also plays an important part in the type of interrupter used in the present model. At one portion of the circuit the primary current is made to pass from the point of a screw to a vibrating strip, the latter being close to one end of the core. Immediately the current is switched on the core becomes an electro-magnet and attracts the strip towards it, thus breaking the connection with the point of the screw. The primary current is thereby cut off and as the core loses its magnetism the vibrating strip swings back and makes contact once more with the screw. The current is thus restarted, only to be interrupted again immediately, so that the device switches the primary current on and off automatically in the manner required.

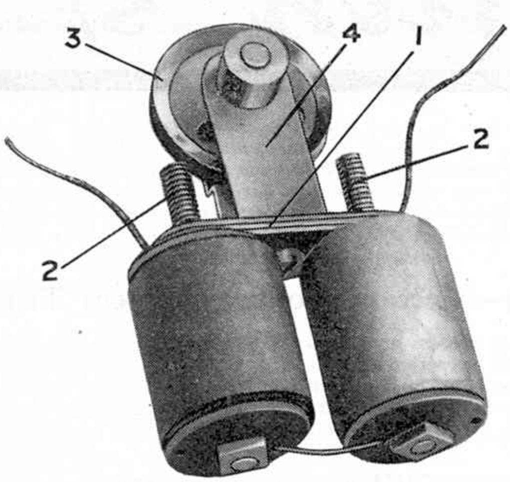


Fig. 2. The Meccano Electro-magnet

Construction of the Model

Let us now turn our attention to the construction of the Meccano model. The core of the primary consists of four $4\frac{1}{2}''$ Strips laid one upon the other, on which are pressed two Coil Cheeks 1 and 2. These Strips are carefully covered with insulating tape or stout brown paper to prevent their sharp edges cutting the insulation of the winding.

The primary winding, which is wound on the core, consists of two layers containing approximately 200 turns of No. 23 SWG copper wire, the two ends of the wire being led through the two small holes in the Cheek 2. Care should be taken to wind the turns on evenly. When completed, the primary winding must be covered with insulating tape, etc., to insulate it from the secondary winding. This must be done carefully as the whole coil will have to be dismantled if a breakdown in the insulation occurs.

The secondary winding consists of ten to twelve layers of 26 SWG wire, or approximately 1,500 turns. It is advisable to cover this also with insulating tape or paper, etc., to add to the appearance of the completed coil.

The coil is bolted to the Flanged Plate forming the base of the model by two Double Brackets secured at each end of the core. One end of the primary winding is brought below the base plate to the insulated terminal 3, and the other end is connected to the $1'' \times 1''$ Angle Bracket 4, which is insulated from the Flanged Plate.

This Angle Bracket carries a special Meccano silver-tipped Contact Screw 5, a similar screw being carried on the vibrating $5\frac{1}{2}''$ Strip 6. This forms the interrupter. The $1'' \times 1''$ Angle Bracket to which the $5\frac{1}{2}''$ Strip 6 is bolted, has a Terminal 7 in metallic contact with it. The Accumulator is joined across the terminals 3 and 7, thus completing the primary circuit. The two ends of the secondary winding are brought out to the insulated terminals 8 and 9, to which the leads to the handles 10 are attached.

The strength of the shock imparted through the handles 10 may easily be regulated by adjusting the gap between the Contact Screws. This causes the "make-and-break" to become faster or slower as the case may be, thereby varying the speed at which the primary magnetic field cuts the secondary turns.

The amusement which may be obtained from the model is almost inexhaustible and many ways of using it will occur to our readers.

Electric Semaphore Signal

As most "*M.M.*" readers are aware, power signalling is rapidly superseding manual operation on all our great railway lines. The former method is divided chiefly into the electric and pneumatic systems of operation. Electricity has been chosen as the means of operating our model, and when completed it will form a very useful addition to any miniature railway. The semaphore is pulled down by the action of a plunger, which is drawn into a solenoid coil when the current is switched on, and is returned to the "danger" position immediately the current ceases.

The general construction of the model should be quite clear from the illustration, and it is only necessary to describe the operation of the solenoid and its attendant mechanism.

The solenoid 1 is a Meccano Bobbin wound to capacity with 26 SWG insulated wire. When winding the bobbin a few inches of each end of the wire are left free so that they can be used later to connect the coil windings to the terminals 2 and 3. One of these terminals must be insulated from the Flanged Plate forming the base of the signal. The $1\frac{1}{2}''$ Rod 4, termed the plunger, slides freely in the centre of the bobbin, and when the current is flowing it is drawn into the core of the solenoid. This action is explained by the well-known principle that a solenoid will draw all magnetisable objects into its core, with a force depending directly upon the number of turns of wire on the bobbin and the current flowing.

The plunger 3 is attached by an End Bearing to the freely pivoting $2\frac{1}{2}''$ Strip 5, and when drawn down, it causes this Strip to move, so pushing the semaphore arm down through the medium of the connecting Rod 6. The top of this Rod 6 is attached by another End Bearing to a double-arm Crank 8 (part No. 62b) secured to the short Rod carrying the Signal Arm (part No. 158a or 158b). Immediately the current is shut off the signal returns to the "danger" position, owing to the weight of a $1''$ loose Pulley and the Rod 6 acting on the longer arm of the lever 5.

The solenoid is held in position on the base Plate by two $1\frac{1}{2}''$ Angle Girders 7 clamped together by $1''$ Threaded Rods. The Angle Bracket 9 forms a stop to support the Strip 5 when the signal is at "danger." Care should be taken to see that the plunger is perfectly free to move in the core of the bobbin, otherwise the model will fail to work satisfactorily.

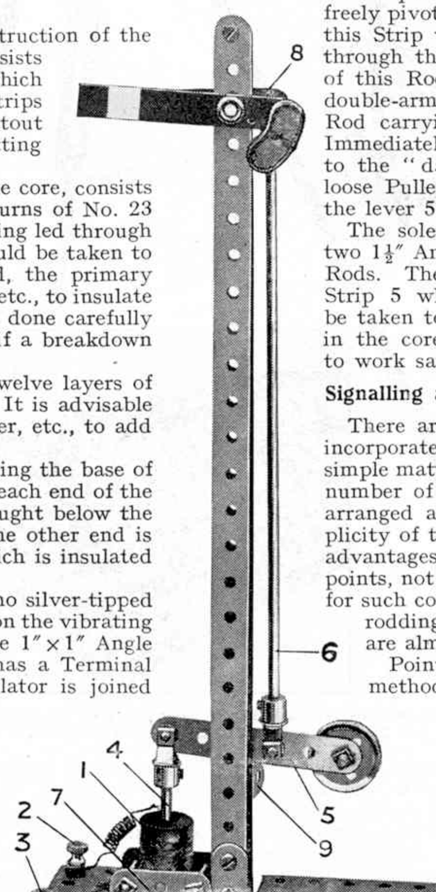


Fig. 3. Electric Semaphore Signal

Signalling a Model Railway Electrically

There are many ways in which electric signals may be incorporated in miniature railway layouts. It is quite a simple matter, for example, to equip a signal cabin with a number of switches operating an equal number of signals arranged at various points along the track. In the simplicity of the control arrangements lies one of the greatest advantages of the electrical method of operating signals and points, not only in model railways but also in real railways, for such complications as levers, wires, pulleys, bell cranks, rodding, etc., necessary in the ordinary manual methods are almost entirely eliminated.

Points can also be operated electrically, of course. The methods of operation most commonly employed in model railway layouts use either solenoids or electric motors. In the latter method the motor is connected to the points operating lever by suitable gearing and, usually, a rack and pinion movement. The solenoid method is the simplest and will no doubt appeal more readily to the majority of model railway enthusiasts for economical reasons, although both methods may be carried out entirely with Meccano parts.

Actually, two solenoids should be used, the plunger of each being connected to the tongue of the points so that the latter may be pulled one way or the other, merely by directing the current first to one solenoid and then the other.

Electricity Applied to Meccano

VI.—A Meccano Galvanometer and Other Models

These articles are intended to draw every Meccano boy's attention to the numerous fascinating uses to which the Meccano electrical parts may be put. The first two articles of the series dealt with the elementary principles of electricity, and subsequent articles described various Meccano switches, a coil-winding machine, a Meccano electric telegraph system, electro-magnets, and other simple apparatus. Below we describe an accurate Meccano instrument with which resistances in electrical conductors, etc., may be determined, and two simple electric Motors. All these models are constructed from a few ordinary Meccano parts used in conjunction with the special electrical accessories.

THE first model with which we shall deal this month is a galvanometer. This is of a somewhat scientific nature, but it is easy to make and much fun and interest can be obtained from its use. By building models of this type a Meccano boy will add very materially to his knowledge of electrical science, and the deeper understanding that he gains of the principles involved will enable him to build more elaborate and still more interesting electrical apparatus.

The galvanometer is used very largely in electrical work as a detector of weak electric currents, and is an invaluable instrument. The fact that a practical galvanometer may be constructed from Meccano parts is a striking tribute to the adaptability of the Meccano system. It shows that there is no exaggeration in the statement that the principles of any mechanical or electro-mechanical apparatus can be demonstrated clearly and easily with Meccano.

The Meccano Galvanometer

In essentials the model consists of a coil of fine wire having a large number of turns, in the centre of which swings a freely suspended magnetised needle. It has been pointed out in the earlier articles in this series that a coil of wire carrying a current produces a magnetic effect. When a weak current flows through the coil here used, it produces a comparatively strong magnetic field, owing to the large number of turns through which it passes, in accordance with the ampere-turns law explained last month. The magnetic field due to a current passing through the coil interacts with that of the needle, and the needle moves in an effort to balance these effects. The principle of this apparatus is employed in many types of voltmeter and ammeter, etc.

Fig. 1 shows the model galvanometer connected to a Meccano Wheatstone Bridge (which is described later) and Fig. 2 is an enlarged view of it.

The coil 1 consists of approximately 70 turns of 26 S.W.G. wire. To form the coil the wire may be wound round some circular object, such as a glass tumbler, etc., and when completed it should be shaped into an ellipse, as shown. The strands of wire at the top of the coil are separated into two groups, and a space is left between the groups in which the needle support is suspended. The completed coil is bound in one or two places with thread to prevent the windings becoming disturbed, and is mounted on the 5½″ x 2½″ Flanged Plate forming the base of the instrument. It is held in position by the Double Bent Strip 2. The two ends of the coil windings are brought to two insulated Terminals 3 and 4.

For the needles it will be necessary to magnetise two ordinary darning needles of fair size. As explained in a previous article, they may be magnetised by stroking them with one pole of an ordinary bar magnet. Note carefully which end of each needle points to the magnetic north, and mark the ends distinctly to prevent confusion. The needles are pushed halfway through a narrow strip of stout paper, as shown, with their poles in opposite positions. This means that the south pole of one needle must be on the same side of the paper strip as the north pole of the other. Two needles so arranged are described as an " astatic " pair, which means that they have no directive magnetic tendency. If the needles were separated they would each point to north and south in the ordinary way, but since they are connected together with their poles arranged in opposite directions, they neutralise each other.

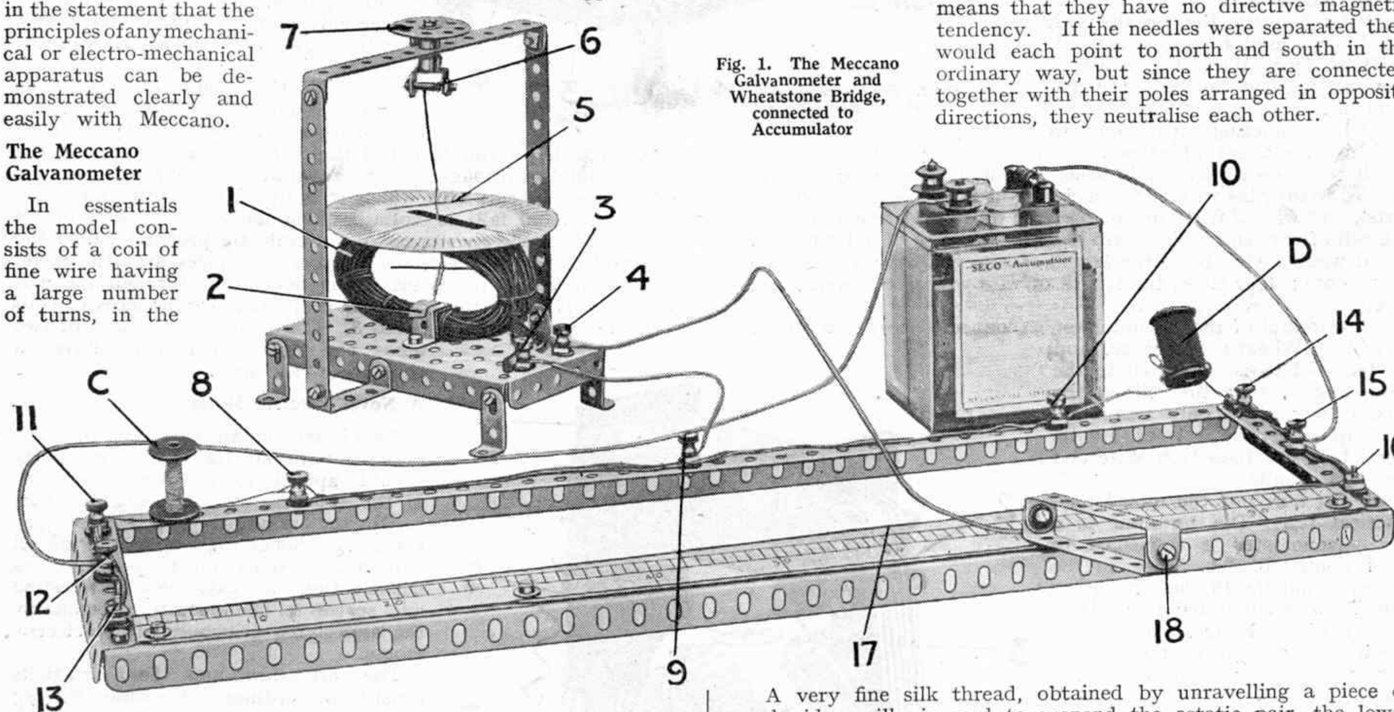


Fig. 1. The Meccano Galvanometer and Wheatstone Bridge, connected to Accumulator

A very fine silk thread, obtained by unravelling a piece of embroidery silk, is used to suspend the astatic pair, the lower needle being arranged in the centre of the coil 1. The thread is attached to a ¾″ Bolt mounted in the Fork Piece 6, which is secured by a similar bolt to the Bush Wheel 7. The latter may be rotated for the purpose of setting the needles at right angles to the longitudinal axis of the coil. To prevent the needle from swinging from side to side, the lower end of the supporting paper strip is attached to the top of the Double Bent Strip 2 by means of another short length of silk thread, which is secured to the Double Bent Strip by a piece of gummed paper.

The silk threads are secured to the paper strip by gum or glue. It is a good plan to apply a little glue to the needles to keep them in position in the paper.

It is often necessary to ascertain the resistance of a coil or a length of wire in order to find what kind of battery is necessary to produce certain effects. For instance, if a 4-volt electric motor is to be run by a current passing through long wires a 4-volt accumulator may not give sufficient current on account of the extra resistances. A knowledge of the resistance of the connecting wires used will enable the experimenter to find out definitely whether a 4-volt or a 6-volt accumulator should be used.

A simple means of finding resistances is afforded by using the galvanometer in conjunction with the next model to be described.

The apparatus represented by this model is known as a Wheatstone bridge.

A Meccano Wheatstone Bridge

The construction of the framework of the Meccano Wheatstone bridge will be obvious from the illustration (Fig. 1). The scale consists of a strip of paper or cardboard accurately divided into a hundred divisions and stuck on top of 12½″ and 5½″ Flat Girders bolted to the front 18½″ Angle Girder of the model. The three terminals 8, 9 and 10 are insulated from the frame by means of Insulating Bushes and Washers, and are connected together by four strands of 23 S.W.G. Wire. The object of using four pieces of wire is to reduce the resistance between the terminals to a minimum. For the same reason the two groups of terminals 11, 12, 13, and 14, 15, 16, are connected in a similar manner. The connecting wires are all visible in the illustration. It is necessary that all the terminals should be insulated carefully from the framework. Extra nuts are placed on the bolts beneath the terminals 13 and 16 and used to secure a length of Bare Iron Wire 17, which is stretched tightly between the two terminals.

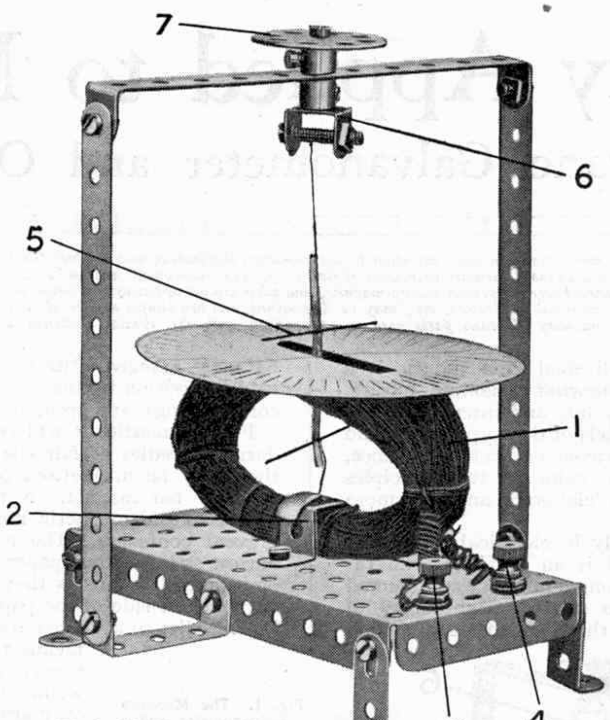


Fig 2. The Meccano Galvanometer

Before conducting experiments we shall require a set of standard resistances. For this purpose it will be necessary to obtain some No. 36 S.W.G. Single Cotton Covered Wire (this wire is not included in the Meccano Electrical parts), and wind 2 ft. 10 ins. of the wire on to a Meccano Bobbin. The coil of wire so obtained will have a resistance of half an ohm. A coil wound with twice the length of wire will have a resistance of one ohm; four times the length of wire will give 2 ohms, and so on.

One terminal of the Accumulator is connected to the terminal 12 of the Wheatstone bridge, and the terminal 15 is connected to the metal link between the cells of the Accumulator, since only two volts are required. The use of 4-volts would heat the Bare Iron Wire and affect the results.

We can now put the model to a practical test. The terminal 4 of the galvanometer is connected to the insulated 6 B.A. Screw in the end of a handle 18, and its other terminal 3 is connected to the terminal 9 of the bridge. D is a coil of wire the resistance of which we wish to discover, and C is the standard resistance coil—say of 2 ohms—inserted between the terminals 11 and 8. To make the test, the Bare Iron Wire 17 is touched with the tip of the 6 B.A. Bolt in the handle 18. The needle of the galvanometer probably will deflect and it will be necessary to touch the wire 17 opposite various points on the scale until the needle shows no appreciable deflection. When this result is obtained the bridge is said to be "in balance." If a balance cannot be obtained with the 2 ohm standard coil C, it will be necessary to try another coil of a higher or lower value.

It will be clear from Fig. 1 that the current from the Accumulator has two paths available in passing from terminal 12 to terminal 15. In one of these it passes down the straight wire 17 laid along the scale and in the other it flows through the 2 ohm resistance coil C and the coil D of unknown resistance, other resistances in this path being so small as to be of no importance.

Between the terminals 12 and 9 on the one side and 9 and 15 on the other in the second of these two paths there will be falls in voltage proportional to the resistances offered by the coils C and D, and by moving the terminal 18 along the wire 17 a point may be found dividing this wire into two portions in which the same falls in voltage occur. In other words, the point found on the wire 17 and the terminal 9 are at the same voltage and there is no electro-motive force tending to cause a current to flow from one to the other. This is indicated by the absence of movement of the galvanometer needle, as no current will then flow through the instrument. If the movable terminal 18 is brought into contact with the wire 17 at other points, current will flow through the galvanometer coil and the needle will be deflected to one side or the other.

When the point at which no current flows has been found, the resistance of the coil D may be determined by a simple calculation. As the wire 17 is of the same diameter throughout, its resistance is uniform and the proportional lengths into which it is divided by this point give the proportional falls in voltage along the wire and also in the two coils. As the resistances of the coils are proportional to the voltage falls across them, the relative resistances are also given.

If, for instance, the point giving no current through the galvanometer is 25 on the scale, the proportional resistances of coils C and D are 25 to 75, or 1 to 3. Coil C has a resistance of two ohms and thus coil D must have a resistance of six ohms.

A Novel Electric Motor

An electric motor that can be built entirely with standard Meccano parts should appeal to all Meccano boys. If the brushes, etc., are adjusted correctly the armature will rotate very rapidly, although of course the model will not produce much power. Its construction is extremely interesting and serves to demonstrate very clearly the underlying principles of the electric motor.

The armature and field magnets consist of ordinary Meccano Strips; strictly speaking these sections of the motor should consist of soft iron, but the steel Strips will serve the purpose quite well.

The construction of the model should be commenced by winding the field magnet 1. The core of this magnet consists of four 4½″ Strips laid one upon the other and pushed through two Coil Cheeks (part No. 309). The core should be wound with about 500 turns of 26 S.W.G. wire, and the completed coil may be covered with brown paper, etc., to enhance the finished appearance of the model. Each side limb of the field magnet consists of four 2½″ Strips 2 and two 2″ Strips 3 secured together by ¾″

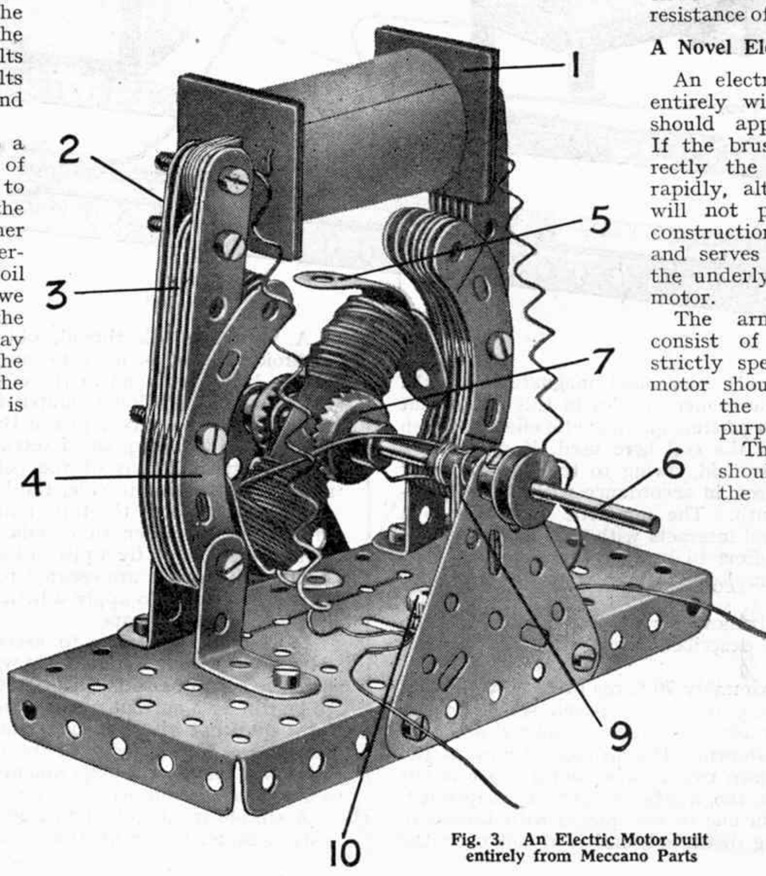


Fig. 3. An Electric Motor built entirely from Meccano Parts

Bolts. The upper ends of these Strips are spaced apart by Washers placed on the $\frac{3}{4}$" Bolts, and their lower ends are inserted between seven $2\frac{1}{2}$" small radius Curved Strips 4. The two sets of Curved Strips 4 form the tunnel in which the armature 5 rotates.

The armature consists of two $2\frac{1}{2}" \times 1"$ Double Angle Strips laid back to back with the $4\frac{1}{2}$" Rod 6 secured centrally between them. The Strips must be bound with adhesive tape or gummed brown paper to retain them in position and to prevent their edges from damaging the insulation of the armature winding.

The armature is wound in the following manner. Take 6 ft. of 23 S.W.G. wire and double it to find the centre. Then lay the wire diagonally across the centre of the armature so that there is an equal length on both sides. Then, using one half of the wire, wind it on to one half of the armature, and do the same with the remaining half of the wire.

Next take a strip of paper coated with gum and wind it round the armature shaft until a sleeve is formed round the Rod 6 about $\frac{1}{8}$" thick. This corresponds to the commutator. The free ends of the armature coil are now uncovered and shaped to the paper sleeve as shown in the diagram (Fig. 4). The two shaped ends of the wire form the commutator segments. One of these segments is shown at 8, the other one being on the opposite side of the paper sleeve, of course.

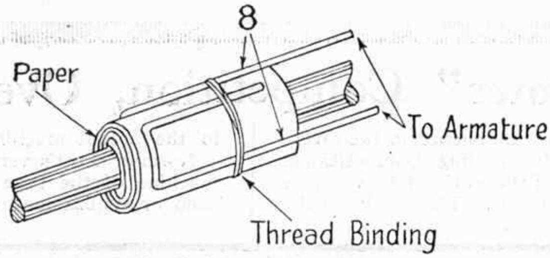


Fig. 4. Detail of Commutator of Meccano Motor

The completed armature unit is clamped in position on the Rod 6 by means of two $\frac{3}{4}$" Contrate Wheels 7, which press very tightly against the Double Angle Strips. The ends of the two Double Angle Strips are rounded as shown so that they rotate freely in the armature tunnel.

The brushes 9 consist each of a length of bare 23 gauge wire, which is doubled to increase its springiness. Each brush is connected to an insulated terminal 10, and arranged to press lightly on opposite segments of the commutator. It is very important that the armature and the segments of the commutator are in their correct relative positions.

If the motor does not run properly it may be assumed that these positions are not as they should be, and the armature must be moved round (while the armature shaft 6 and the commutator are held stationary, of course) until further trials prove the running to be satisfactory.

It only remains now to connect up the ends of the field coil 1 to two terminals 10, which are insulated from the base plate by means of Insulating Bushes and Washers. The wires from the accumulator are also attached to these terminals. Since the motor is of the two-pole type it will probably be necessary to twist the shaft 6 with the fingers to start it. If desired a switch of any convenient type can be inserted in the circuit between the terminals 10 and the accumulator.

Another Type of Motor

The Meccano Motor shown in Fig. 5 is designed on somewhat unorthodox lines and is in striking contrast to the motor described above. The novel arrangement of the armature and commutator should be noted. This is perhaps the simplest type of electric motor that can be constructed.

The combined armature and commutator 4 consists of a Face Plate to which are bolted four $5\frac{1}{2}$" Strips in the manner shown. In each of the holes in the Strips nearest the boss in the Face Plate is inserted a 6 B.A. Bolt, which forms one segment of the commutator.

Each of the two magnets 5 consists of a Meccano Bobbin wound to capacity with 26 S.W.G. wire. They are secured to the frame in the positions shown by Core Pieces. One of the wires from the lower magnet is led to one of two insulated terminals mounted in the base Plate at the rear of the model, and the other wire from this magnet is joined to one wire of the upper magnet. After the motor is erected it may be found necessary to change these connections so that each magnet 5 shall have a different polarity.

The polarity of the coils 5 may easily be determined by means of a pocket compass. If the latter is held near one of the coils one end of the compass needle will swing toward the coil. When the compass is held near the other coil the opposite end of the needle will point toward the coil, thus indicating that one coil has a North and the other a South polarity. If the needles point in the same direction in each case, the connections just described must be altered, and the wire from the lower magnet must be joined to the other wire of the upper magnet.

The remaining wire from the upper magnet is secured to the 6 B.A. Bolt 6. The brush 7, which is also attached to this bolt, consists of a short length of 23 gauge copper wire, scraped clean and bent so that it brushes lightly against the 6 B.A. Bolts forming the commutator segments. The brush should first make contact with a commutator segment when two of the armature arms are equidistant from a magnet. This point is very important, for the model will not work satisfactorily unless the brush is adjusted carefully. The gap between the magnet cores and the armature arms should be as small as possible.

The switch arm is a $3\frac{1}{2}$" Strip pivotally mounted on the $5\frac{1}{2}" \times 2\frac{1}{2}"$ Flanged Plate 2 by means of a bolt and lock-nuts (see Standard Mechanism No. 262). A Flat Bracket 3 forms the switch contact. It is attached to the base Plate by a 6 B.A. Bolt and insulated therefrom by an Insulating Bush and Washer. The Flat Bracket is connected by a short length of wire passing underneath the Flanged Plate to the second insulated terminal at the rear of the model.

Path of the Current

The path of the current through the motor is as follows. From one of the terminals in the rear of the model the current passes through the wire round the lower magnet 5, then through the upper magnet to the insulated bolt 6 and brush 7. From the brush it passes to the commutator, and then through the frame of the model and the switch arm 1 to the Flat Bracket 3, and so back to the second terminal at the rear. The accumulator is connected to these terminals. In the photograph the switch is shown in the "on" position.

When the switch is on, no current will flow unless the brush 7 is in contact with one of the 6 B.A. Bolts of the commutator. Hence it may be necessary to twist the armature slightly in order to start the motor. When the brush 7 makes contact with one of the commutator bolts, the circuit is completed and the cores of the Bobbins 5 become magnetised. The armature Strips nearest the magnets will then be drawn round until they are directly opposite the magnet poles. Immediately they reach this position, however, contact with the brush is broken, the current is switched off, and the cores of the Bobbins 5 lose their magnetic power. The armature, thus set free, will "free wheel" on account of the impetus already given to it and the brush will make contact with the next 6 B.A. Bolt. The cycle of operations will then be repeated.

If enamelled parts are used in the construction of the motor, it may be found necessary to journal the armature shaft in a nickelled Strip to lower the resistance in the path of the current.

Since the circuit is completed through the armature shaft, the bearings of the latter should not be oiled, for this would increase the resistance in the path of the current and lower the efficiency and rotative speed of the motor.

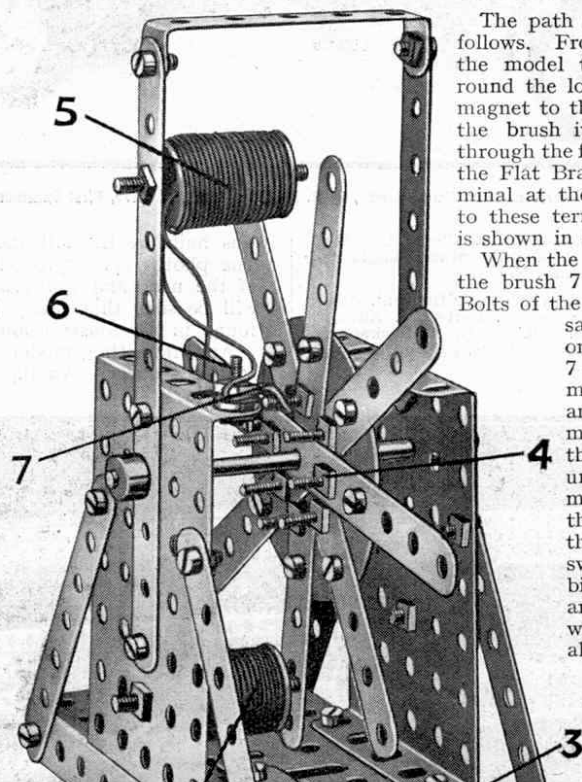


Fig. 5
Another Built-up Meccano Motor

Electricity Applied to Meccano

VII.—An Electric Locomotive and Overhead Wire Transmission

These articles are intended to draw every Meccano boy's attention to the numerous fascinating uses to which the Meccano electrical parts may be put. The first two articles of the series dealt with the elementary principles of electricity, and subsequent articles described various Meccano switches, a coil-winding machine, a Meccano electric telegraph system, electro-magnets, a galvanometer, electric motors, and other simple apparatus. This month we are able to publish particulars of a very efficient and easily-built electric locomotive, and of three different types of overhead wire standards. All these models are constructed rom a few ordinary Meccano parts used in conjunction with the special electrical accessories.

FOR more than a century steam has reigned supreme as the chief method of propulsion on railways. To-day, however, its supremacy is challenged seriously by its rival electricity. The use of electricity as the prime mover on railways has several distinct advantages over that of steam. The one that most concerns the general public—but not necessarily Meccano boys!—is cleanliness; railway stations and rolling stock can be kept much cleaner when freed from the smoke emitted by steam locomotives. This point alone means a considerable saving in railway operating expenses.

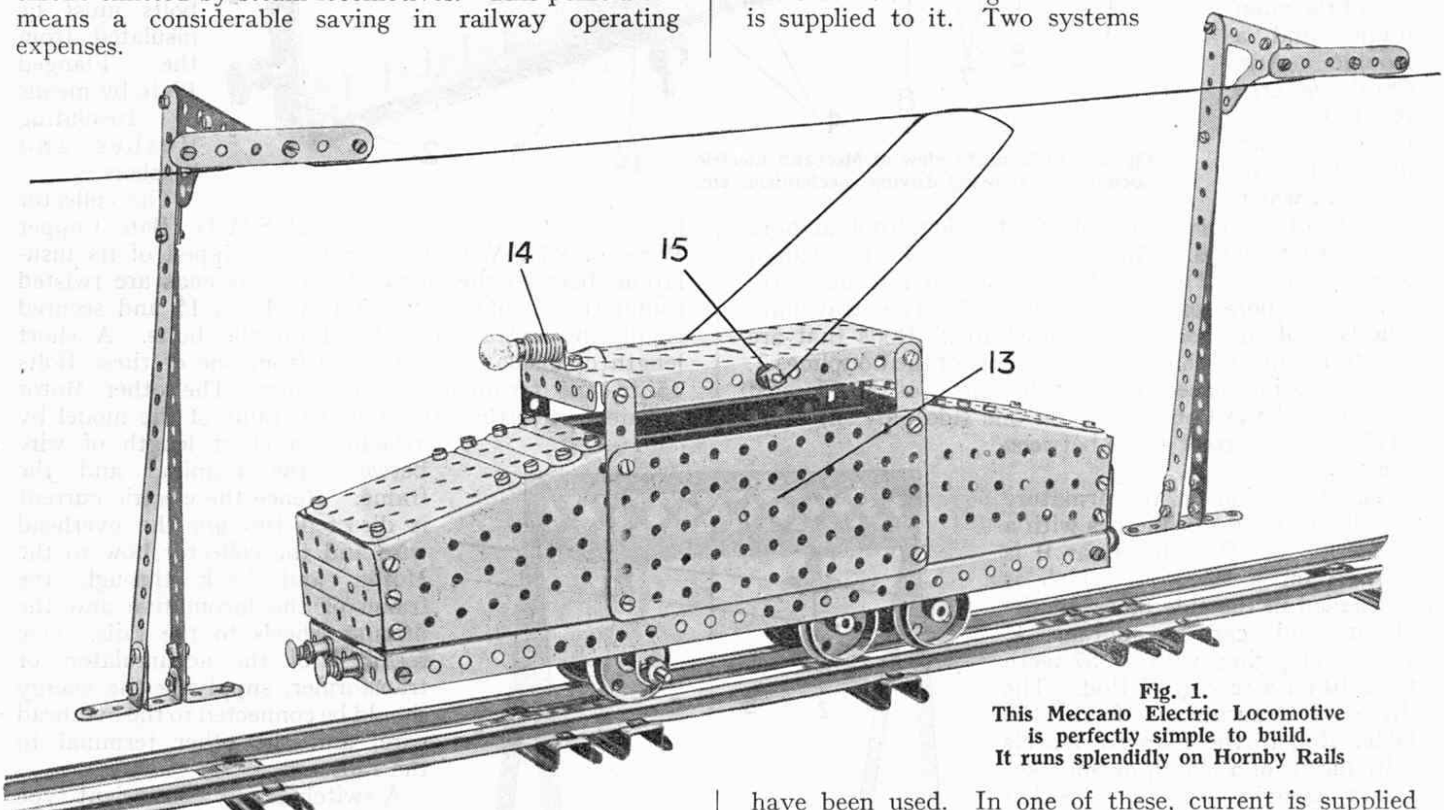


Fig. 1.
This Meccano Electric Locomotive is perfectly simple to build. It runs splendidly on Hornby Rails

Another very important consideration lies in the fact that electric trains are capable of much quicker acceleration. This is a great advantage for heavy suburban trains that are required to stop at several stations situated at comparatively short distances apart. The Southern Railway Company has fully realised these advantages, and it now owns 800 miles of electrically-equipped track, forming the largest suburban electric system in the world.

On the other hand, in the case of long distance trains that stop infrequently, the steam locomotive is likely to hold its own for a very long time to come. The electrification of the great main lines in this country would involve an enormous outlay of capital, for huge power stations would be required with substations for every few miles of track. In addition the change would necessitate the wholesale scrapping of the magnificent express locomotives now owned by our railway companies and the entire reorganisation of the numerous locomotive works.

The most interesting feature of an Electric Locomotive is the method by which the current actuating the motors is supplied to it. Two systems have been used. In one of these, current is supplied from an overhead wire and in the other from a third rail. Electric Railways equipped with the overhead wire system are not very common in this country. Only recently the overhead system on the central section of the Southern Railway was scrapped in favour of the third rail system. On the Continent and in America, however, the method of carrying the current through an overhead wire is regarded more favourably—and is still largely used.

Meccano Electric Locomotive

Our principal model this month is a simple electric locomotive built entirely from Meccano parts and driven by a 4-volt Meccano Electric Motor. It is designed to work on the overhead wire system, but if desired it can easily be converted for third rail working