THE WONDERS OF GRAVITY

NEWNES

PRACTICAL MECHANICS

FEBRUARY

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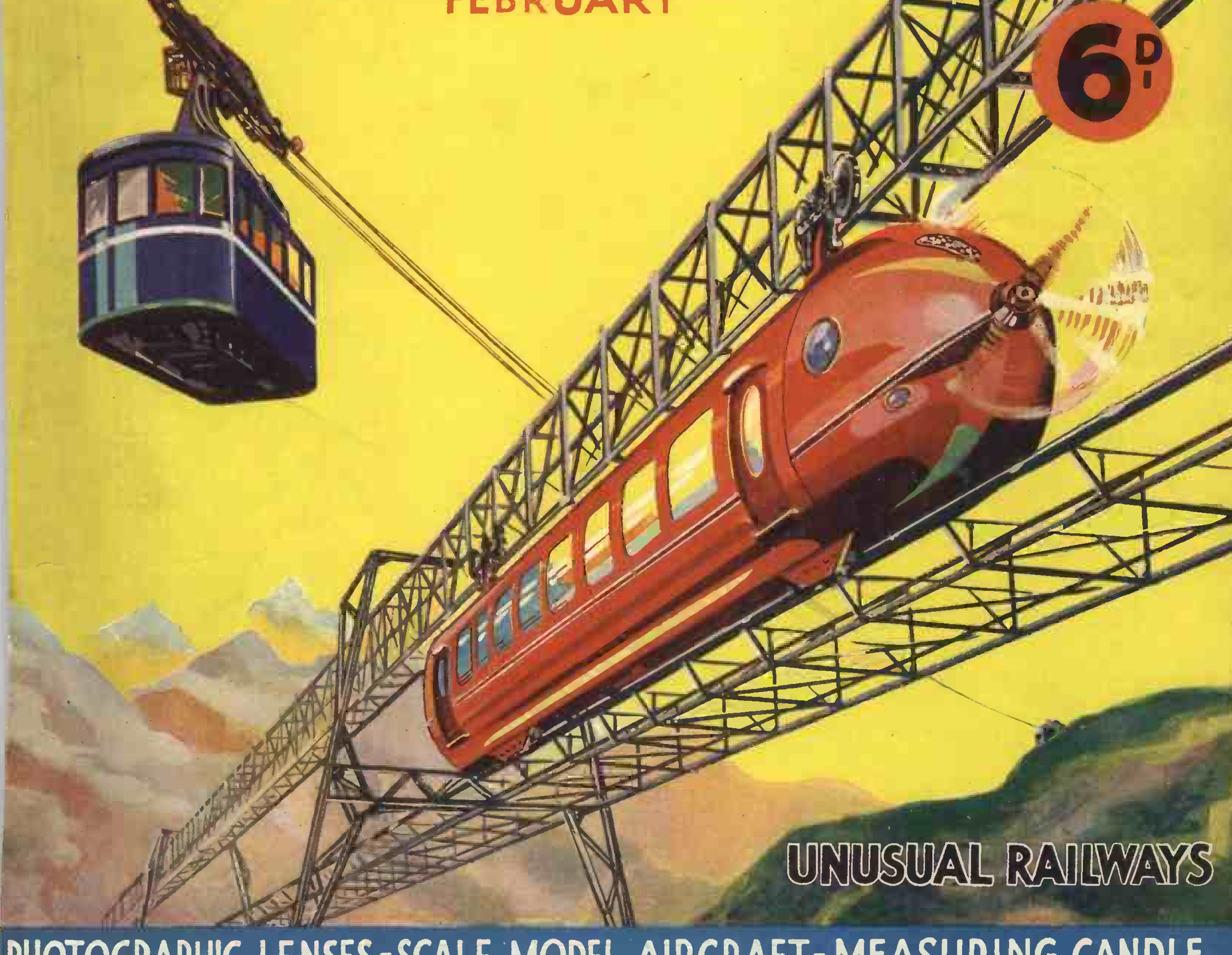


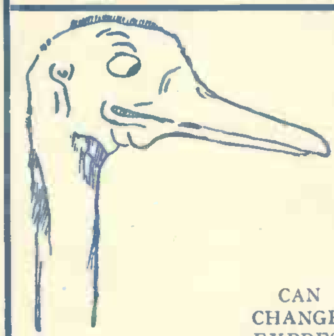
UNUSUAL RAILWAYS

PHOTOGRAPHIC LENSES - SCALE MODEL AIRCRAFT - MEASURING CANDLE POWER ELECTRICALLY - A WORKING MODEL STEAMER - MODEL SUBMARINES - AN INEXPENSIVE RECORDER - NIGHT FLYING KITES - THE STORY OF THE TALKING MACHINE - LATHE WORK - LATEST TOOLS & NOVELTIES ETC

OPEN LETTER TO PARENTS

Dear Sir or Madam,—When your children first arrived they brought with them a wonderful lot of sunshine. Later you became proud of the intelligence they displayed, but still later you became anxious as to what would become of them in the future. Perhaps you were anxious when you visualised them as grown men and women. Even with plenty of money it is not always easy to select the right career, and a parent is sometimes inclined to ask advice of some relative, and in ninety-nine cases out of a hundred that relative knows nothing at all about the possibilities of employment. Why not let me relieve you of some of your anxieties? In fact, why not let me be their Father? We do not profess to act as an employment agency, but the nature of our business compels us to keep an eye upon the class of men and women that are wanted and who wants them. There are some people who manufacture an article and put it on the market to sell. We do not do that; we work in exactly the opposite direction. We find out what employers want and we train our students to fill those jobs. We have to be experts in the matter of employment, progress and prosperity. If you have any anxieties at all as to what your sons or daughters should be, write to me, or better still, let them write to me personally—Fatherly Advice Department—and tell me their likes and dislikes, and I will give sound, practical advice as to the possibilities of a vocation and how to succeed in it. Yours sincerely,

J. H. Bennett



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Jim Duck **Art Dept. 76.**

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Notes, News and Views

New Air Speed Record

AT Istres, recently, M. Raymond Delmotte, flying a Caudron racing monoplane with a 380 h.p. Renault engine, broke the world's speed record for land machines over a 3-kilometre course, at an average speed of 504 kilometres an hour (315 m.p.h.). The machine was of the well-known "Rafale" type, and was fitted with a retractable under-carriage, and a new inverted air-cooled six-cylinder engine of 9·5 litres capacity.

Britain's Latest "Pocket" Submarine

H.M.S. *SHARK*, the new 20-ft. submarine, which was completed at Chatham in October last, was recently put through her paces in the Channel. She has a breadth of only 24 ft. and displaces 670 tons, yet she can "taxi" over 2,000 miles on the surface, or at full power, can travel at nearly 16 miles per hour. The comparatively small craft has rapid driving qualities which are probably unequalled by any other submarine. It can perform a "crash dive" in thirty seconds, and once under water is extraordinarily simple to handle. In the forward part of the submarine are mounted six tubes for discharging the powerful 21-in. torpedoes. The pressure of a button in the control room would send one or more of these deadly "tin fish" racing towards the target at 45 knots. On deck two small quick-firing guns are mounted for use against hostile aircraft. The *Shark* is also equipped with high-power radio, many safety devices, including an escape tube, a control tower divided into two watertight sections, and submarine signalling apparatus.

Talkies Above the Clouds

JUDGING by a successful demonstration recently by Gaumont British Equipment Ltd., the time may not be far off when passengers in long-distance air-liners may be provided with talkie programmes to while away the time when rushing through space above the clouds at over two miles a minute. The demonstration took place in a Hillman "Rapide" six-seater mail plane, and the instrument used was a 16 mm. portable standard projector, with batteries and a screen 2 ft. × 1 ft. 6 in., erected just behind the pilot's cabin, 10 ft. from the projector. The films used were non-inflammable.

Plastic "Glass"

ACCORDING to a recent report, British scientists have succeeded, after years of research work, in producing an amazing new plastic material which has the appearance of the finest glass. It is stated that the new substance, which is derived from coal tar, can be moulded to any shape; is only half the weight of glass; is almost unbreakable; and is a far more efficient transmitter of light than optical glass. In its original form it is a liquid which solidifies into a tough, transparent substance, which in its properties is a mixture of ivory and glass. The fact that it is practically unbreakable, and so light, will make it invaluable for the windows of cars, and especially for aircraft. Another important quality of the new substance is the ease with which it can be cut and machined. When raised to a temperature of about 120° F. it softens and can be worked with ease.

THE MONTH'S SCIENCE SIFTINGS

A new Parsons' turbine engine, known as the "Simplex Unit," was recently completed for use in low-powered cargo vessels. The new engine, which should prove a great boon to "tramp" shipping, is designed for 1,500 to 2,000 horse-power, and is claimed to be lighter than a reciprocating engine of the same power.

A remarkable American locomotive, streamlined throughout its entire length so as to diminish air resistance by about 35 per cent. at high speeds, was recently tested on the New York Central Railroad. The engine, which is of 4,075 horse-power, is of the 4-6-4 type, and the tender is carried on two six-wheeled bogies.

A new type of helicopter, specially designed for air transport in cities, is being built by the Blackburn Aeroplane and Motor Coy. The new machine has a fuselage like a normal aeroplane, with seats for passenger and pilot. There are no wings, but a normal tail unit is provided.

The Air Ministry have prepared two new wireless stations at Lympne (Kent) and Pulham (Norfolk) to relieve the pressure on the control tower staff at Croydon, and thus increase the safety margin of air travel.

The New "Blue Bird"

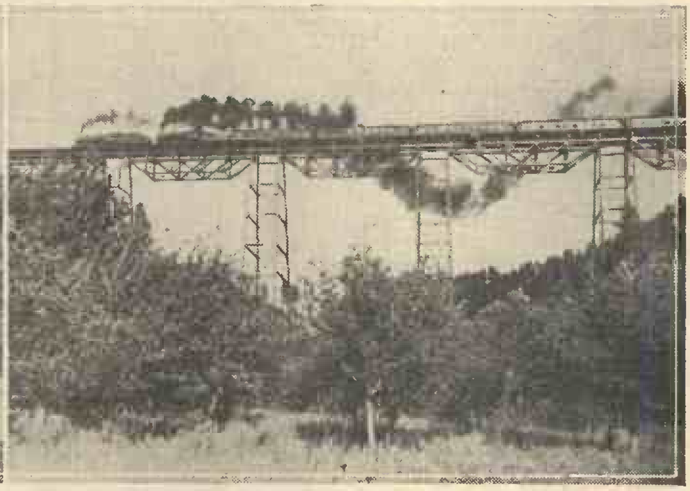
SIR MALCOLM CAMPBELL'S new car, "Blue Bird," with which he hopes to reach a speed of 300 m.p.h. at Daytona Beach, is indeed a remarkable machine. In its new shape the great car is streamlined, so that it somewhat resembles a whale or large dolphin. There is a huge finned tail at the rear, its tip rising above the head of the driver as he sits at the wheel. The huge flattened bonnet, covering the engine's double bank of cylinders, has a wide slit in front resembling a mouth, the purpose of which is to admit cooling air to the radiator and engine. The engine, which is the same one that raised the world's record to 272·46 m.p.h. at Daytona two years ago, is a 12-cylinder Rolls-Royce, developing about 2,500 h.p. The car is 28¼ ft. in length, and weighs 4¾ tons. The capacity of the petrol tank is 40 gallons, and the engine consumes it at the rate of 2·9 gallons a minute.

A New Low-priced Piano

THE fact that the piano has not been able to maintain its old prominent position in home music in recent years cannot reasonably be ascribed solely to the popularisation of radio or a whim of fashion in music, but rather to the comparatively high price at which pianos were sold and bought in the past. Confronted with this trend, the German piano industry made the most strenuous efforts to evolve and produce some really cheap and yet good instruments for use by the broadest masses of the population. The new pianos now placed on the market as a result of years of experimental work in applied acoustics constitute a truly wonderful achievement. For some years past now small house pianos have been widely used in the Scandinavian countries, and were traded there as piano-chords, and have, as a matter of fact, grown more popular from year to year. The new German popular piano is now produced and sold at about half the price of the ordinary upright, and some wonderful models are, according to our information, to be exhibited at the coming Leipzig Spring Fair in 1935, which opens in March, and will in all probability prove the centre of attraction at the Musical Instrument Fair there.

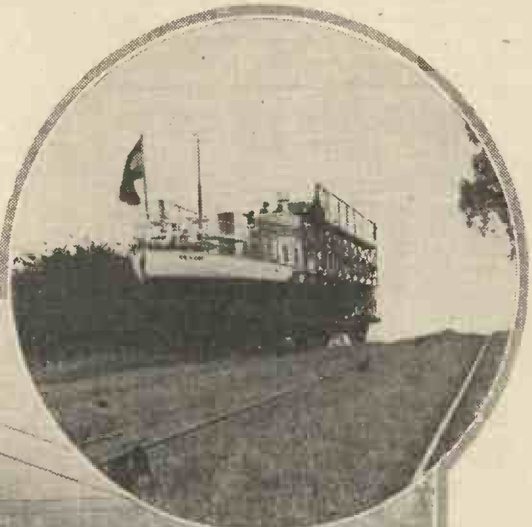
UNUSUAL RAILWAYS

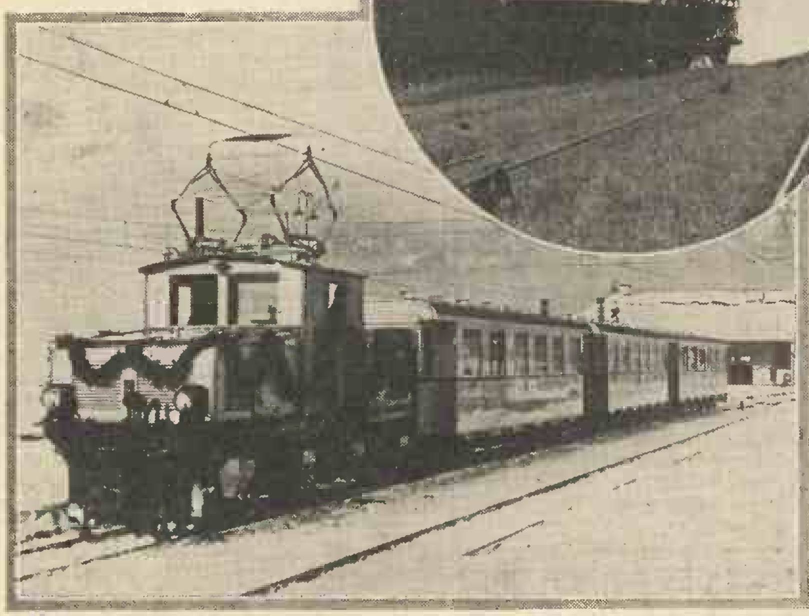
Railways which have been Adapted to Suit Unusual Geographical Conditions are Often of Unfamiliar Types. It is by Means of These that Otherwise Inaccessible Places are Reached. Several Good Examples Exist in Great Britain.



(Left) This mountain suspension railway, which was the first ever built of this type, is 280 yd. long. The most delicate part of this railway is the cable, which consists of 100 cast-steel wires 35 mm. thick. (Right) A striking view of the Northern Pacific's North Coast Limited crossing the Marent Viaduct, which is about fourteen miles west of Missoula, Mont., in the Rocky Mountains. This piece of modern engineering is 797 ft. long and 226 ft. high, the highest on the Northern Pacific system and in the north-west.

TRAINS in Britain have few violent gradients to negotiate; they keep to the plains. Should a range of hills appear to threaten their advance, they pass unceremoniously through some tunnel; minor ravines gape in their path, and they merely take to their bridges. However much our railways may show an example to the world in other respects, elements are lacking from the point of view of those who might like to take up for a time the cult of the unusual where methods of travel are concerned.





The Bavarian Alp Railway which was opened quite recently. The new line is joining the cities of Garmisch-Partenkirchen and Eibsel, in South Bavaria; and (inset) The "Oberland" Canal, from Elbing (West Prussia) to Deutsch-Eylau (East Prussia). A little way behind Elbing the boat leaves the water to climb a mountain. It is a singular experience to travel on terra firma by boat. This is repeated four times before all mountains are taken, and the small boat can return to its familiar element. This unique canal trip is the outcome of a great technical feat. Twenty locks would be required if the mountains had to be negotiated by lock-system. The problem has been solved in a technically most interesting way, which also draws visitors to the otherwise monotonous, deserted district.

Before severing attention on our own island, however, we may glance at the illustration of the George Binnie "Railplane," which plays its part in a system of transport that has been erected at Milngavie, near Glasgow. This system is considered safe and rapid, and may prove to be a great advantage as a secondary line of communication in industrial areas. The system is intended to be built over existing railways of more conventional type, and its main object is to mitigate against congestion on the ground-level track by diverting a proportion of passengers and goods along the auxiliary route thus provided.

The Shortest Railway

The shortest railway in the world is at Los Angeles in California, and is perhaps more in the nature of an open-air lift than a train. At all events, it climbs as many feet as it travels laterally. Extending merely along one side of a single block of buildings built on land that slopes steeply at an angle of about 45 degrees, it employs two cars inter-connected by a cable which passes over a pulley at the top in such a way that one car, ascending, passes the other one, descending at exactly the halfway mark. Thus the weight of the descending car assists the ascent of the other. The principle is fairly common, and (though this does not apply to the railway in question, which is electrically driven) may be used to operate a similar system entirely by means of what is called "potential" energy, that is to say, the energy which a mass of substance possesses simply by virtue of its position, or height. A heavy load of water is allowed to flow into a suitable tank in the topmost car, while a corresponding load is allowed to drain away to waste from a similar tank in the lower car. The consequent difference in weight between the two cars, as soon as the brakes are released, allows the heavier car, in descending under its own weight, also to draw its counterpart up the slope. At the completion of the run the process is repeated, in a reversed sense, so that the car which was the lighter as it ascended now becomes in turn the heavier, in readiness for the next journey. The name of the Los Angeles railway is "Angels' Flight," and the fare is only five cents, or twopence halfpenny, single.

"Amphibian" Travel

Unique "amphibian" craft ply between the East Prussian towns of Elbing and Deutsch-Eylau. A stranger embarking on a canal boat might be surprised to find it suddenly taking to the land, and climbing a mountain! Yet that is what happens. Twenty locks would be required if the mountains had to be negotiated by lock system, and the time taken in so doing would be nearly double. In the forty-mile journey, four mountains are crossed by rail. To see this strange means of communication, visitors are drawn to the otherwise monotonous and deserted district. For a boat to take to rails is rather a reversal of the principle where in some parts of the world, notably between Italy and Sicily, railway trains take to the water. That is to say, trains proceed from the mainland on to ferries, and without disembarking their passengers, proceed to the other shore.

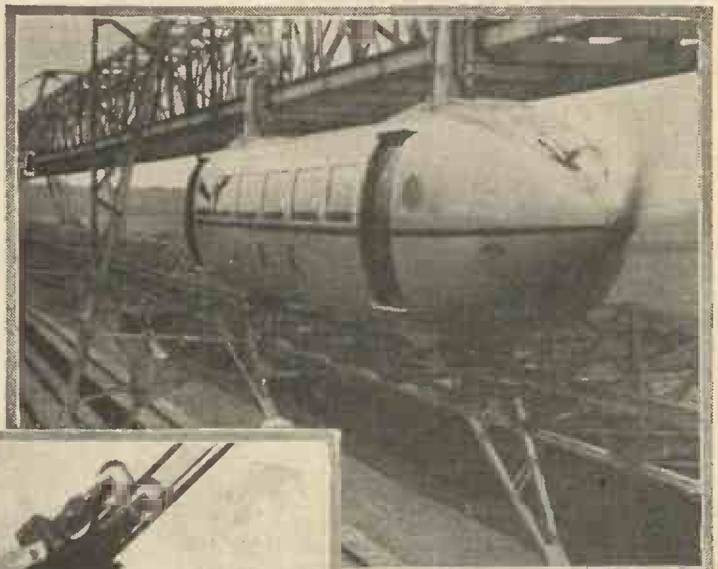
Suspension Railways

There is something particularly attractive about suspension railways, which, in the more mountainous parts of Europe, are not uncommon. In an accompanying illustration is shown the first mountain-suspension-railway of the world to be constructed. It was opened at Loschwitz, near Dresden, on May 6th, 1901. This railway is 280 yd. long, one terminus being 240 ft. higher than the other. As in the Los Angeles "Angels' Flight," the weight of the descending car assists the ascent of the other, the two being joined together by a cable which encircles a power-driven pulley at the upper end of the system. The cable consists of a hundred steel strands, each of a diameter of 35 mm., and is frequently renewed. Safety brakes are also fitted.

Most suspension railways of this kind are built purely for the benefit of tourists, or perhaps we should include the various hotel proprietors in their neighbourhood! At Engelberg, in Switzerland, there is a suspension railway, or *téléférique*, to use the French-coined word, a view of which is illustrated on this page. Operating at a height of 6,000 ft., the cabin is made entirely of aluminium, and carries fifteen passengers.

Another illustration shows the Nebelhorn cable railway in Southern Germany. Its terminus is at the village Oberstdorf, and a means is thus provided for tourists to avail themselves of magnificent views of some of the most beautiful mountain scenery in Bavaria.

A railway of similar purpose, if of different construction, is the Bavarian Alp Railway. The illustration of it shows the first train, suitably decorated, proceeding on its way after the official opening.



The George Bennie Railplane system of transport that has been erected at Milngavie, near Glasgow. This system is considered safe and rapid and is of necessity required in industrial centres owing to congestion of roads. The transport by this method of mails, perishable goods, etc., is cheap and is essential for the opening up of new and undeveloped countries. The system is built over existing railways and the Railplane takes all passenger traffic, and thereby relieves the railways for high-speed goods traffic.

There are several other suspension railways worthy of interest, notably the "Téléférique du Salève," at Veyrier, in Haute-Savoy. Again two cabins are used, one ascending as the other descends. They run along steeply-sloping cables, over-hanging the countryside far below, in gigantic spans of no less than 4,000 ft. In Harzburg, in Germany, there is another example of a similar system by which it is possible to project oneself to a height of 1,600 ft. in the short space of four minutes.

(Above) At Engelberg, in Switzerland, a marvellous suspension railway carries one along mountainous country at a height of 6,000 ft. The cabin constructed entirely of aluminium, can carry fifteen people; and (Left) The Nebelhorn cable-railway, the terminus of which is the village Oberstdorf, in South Germany.

Mono-rail Systems

The various mono-rail systems, either experimental or otherwise, which have come into being are worth more than passing reference. The "Railplane" mentioned earlier in this article is of mono-rail construction, in this case the car hanging suspended from the rail above. In these conditions the car is in a state of stable equilibrium; if, in other words, it were swung to one side it would tend to return under the force of gravity to its former position. Far more interesting are cars which run on a single track placed vertically below their centre of gravity. With such conditions they would be in a state of unstable equilibrium, that is to say, that though they might remain upright for a time, the slightest side force deflecting them would cause them to fall. It is interesting to note that there is a third state of equilibrium, namely, neutral equilibrium, bodies subject to which will neither fall nor return to their original position after having been deflected. A billiard ball on a horizontal flat surface is an examples of this. Low-rail monorail systems have been constructed in which their state of unstable equilibrium is counteracted by light supplementary rails to resist the comparatively slight side forces.

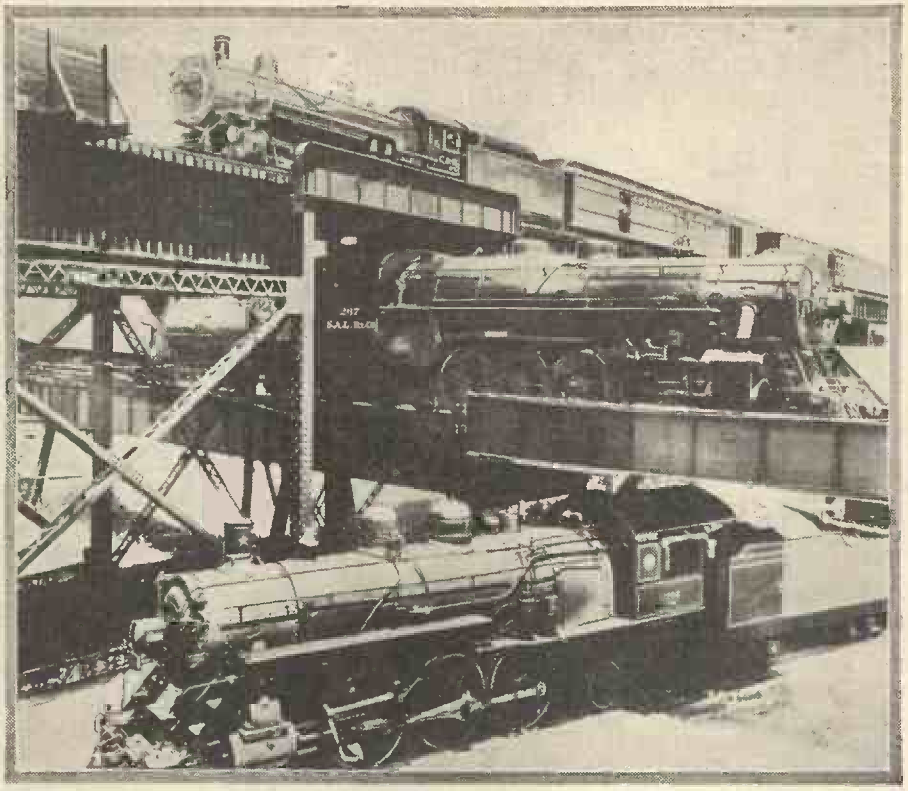
By far the most interesting means of maintaining equilibrium in such cases, however, is mechanically, by gyroscopic action. Just as a spinning top tends to remain upright, so a monorail car, having a heavy enough spinning flywheel suitably incorporated in its construction, will tend to remain upright also. Complications occur, however, when the car is in motion. With but one gyroscope the car could only proceed in a straight path or take either left-handed or right-handed turns (not both) according to the direction of rotation of the gyroscope. Brennan, inventor of the world's most famous monorail car, overcame this difficulty by incorporating two gyroscopes rotating in opposite directions.

The principles of the Brennan monorail car are sound enough in their way, but they have not been developed commercially. The chief advantage is that of speed, while the chief disadvantage is that of decreased reliability. A mechanical breakdown is always possible with any system, and whereas a normal train in such circumstances would merely come to a halt, a monorail car on the other hand would fall over, perhaps when travelling at speed, and the consequences would be serious. In the Brennan system, however, this disadvantage was eliminated.

Interesting Bridges

Returning again to the railways which carry fare-paying passengers, two interesting photographs are reproduced in these pages of bridges in America. The first shows the Marent Viaduct in the Rocky Mountains. It is 797 ft. long and 226 ft. high, and is the highest bridge in the Northern Pacific Railway system. The other shows a cross-section at Richmond, Virginia, the only place in the world where three trunk lines going in different directions interesect at the same place, though on three levels. The three lines are the Chesapeake and Ohio, the Seaboard Air Line, and the Southern Railroad.

Who can tell what future surprises railways have in store for us? Some will say that the march of aviation will force them to the wall, and that in time they will be left to deteriorate and die altogether, but with an atmosphere congested with aircraft, many will probably still prefer surface-transport to the more modern type, and if any there be who are averse to travelling in "a predestinate groove," they may soon find that aircraft, adhering in paths rigidly laid out for them by automatic direction-compelling contrivances, will find their journeyings no less circumscribed.



This cross-section at Richmond, Va., is the only place in the world where three trunk lines going in different directions meet each other in the same place. The three lines are the Chesapeake and Ohio, Seaboard Air Line, and Southern Railroad.

MASTER PILOTS OF THE AIR

THE fifth official British Master-Pilot's Certificate has just been issued to Captain A. B. H. Youell, of Imperial Airways. The Master-Pilot's Certificate was instituted by the Air Ministry five years ago, but it was not until early in 1934 that the first award was actually made, the requirements for the certificate being such that only pilots of exceptional air experience both by night and day, can hope to obtain one. Applicants must, for example, hold a current licence as issued to pilots flying for hire or reward; also a licence as an aircraft navigator; and both these licences must have been in force for at least five years. The applicant must also have flown at least 1,000 hours as a pilot of civil aircraft during the five years prior to his application; and, in addition, a considerable night-flying experience is called for, including a minimum of twenty night flights above land and sea, each beginning and ending during the hours of darkness, and lasting for at least an hour. The four previous holders of the Master-Pilot's Certificate are all airmen of Imperial Airways, viz., Captain L. A. Walters, Captain J. Spafford, Captain F. D. Travers, and Captain E. S. Alcock.

Regular Air Services

It was at the early age of sixteen that the latest recipient of this much-coveted distinction, Captain Youell, entered the field of aviation, his first task being the distinctly humble one of mending punctures in the tyres of aeroplane wheels. That, however, did not satisfy him for long, and within a year he was flying one of the biplanes at the flying school where he was employed; while not long afterwards he found himself a war pilot on the Western Front, flying fighting-planes in combat with the enemy. Surviving the perils of active service, Captain Youell became associated when peace came with an aeroplane joy-riding organisation, touring Europe with this concern, and giving exhibition flights as far north as Sweden.

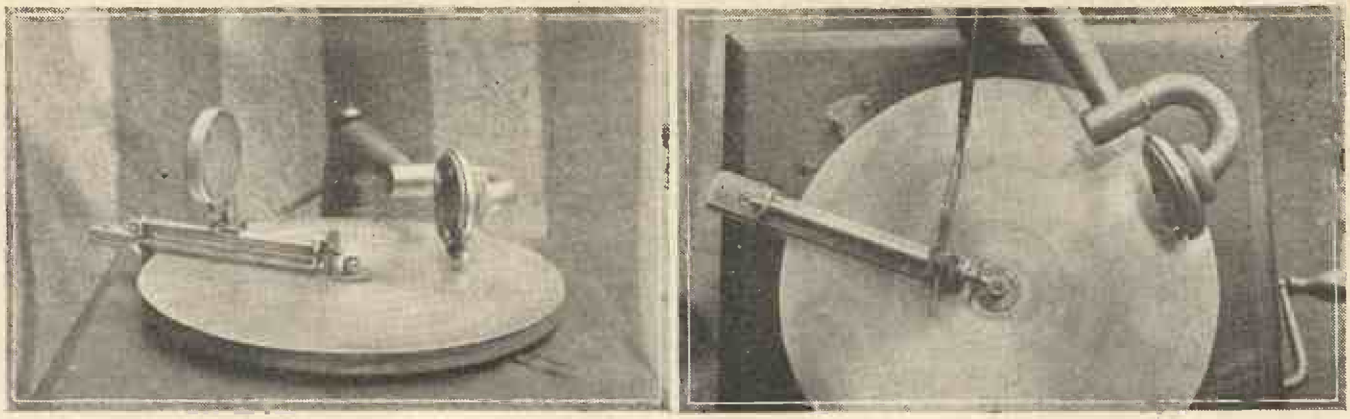
Then, with the development of regular air services between London and the Continent, Captain Youell became an air-line pilot, and has been flying big passenger air liners ever since. Altogether, since he first became a pilot seventeen years ago, Captain Youell has flown approximately 1,000,000 miles, and has carried 40,000 passengers. The distinction of having gained Master-Pilot's Certificate No. 1 is held by Captain Walters, who began flying in 1918, and who, prior to joining Imperial Airways just over ten years ago, already had 1,000 hours of flying to his credit. According to the latest figures available, Captain Walters has now completed 8,398 flying hours, mostly over the European air routes.

Captain Dudley Travers, holder of Master-Pilot's Certificate No. 2, learned to fly in 1917, and afterwards saw war service in Macedonia, Egypt and South Russia. After the war he became a pilot on the Salonika-Constantinople air-mail; subsequently operating for a time his own private air-taxi service, and joining Imperial Airways in 1926.

Continental Air Routes

Another of the holders of a Master-Pilot's Certificate, Captain Spafford, was flying on the Continental air routes until the end of 1931, when he was posted to the Near East Division of Imperial Airways at Cairo.

Captain Alcock, who succeeded in obtaining his Master-Pilot's Certificate not long ago, is a younger brother of the late Sir John Alcock, who made the first non-stop Atlantic aeroplane flight in 1919. Captain Alcock, after a period of service in the Royal Air Force, joined Imperial Airways in 1929, and is now piloting four-engined air liners on the Empire route between Egypt and India.



Two photographs showing the recorder in use.

A CHEAP HOME RECORDER

The following is a description of a recorder made almost entirely from scrap, the only component needing a lathe being the track-rod.

TO commence, turn up the track rod from $\frac{3}{8}$-in. mild-steel rod with a thread of 50 to the inch. The ends are also turned down to $\frac{3}{16}$ in. for distances of $\frac{3}{8}$ in. along from one end, and $\frac{5}{8}$ in. along from the other (see Fig. 1). Care should be taken when turning this to see that it is being done in the right direction. That is, when the gramophone turntable is revolving in a clockwise direction the thread must travel from right to left, looking from the front of the gramophone.

The next parts to be made are the bearings for the rod, and also the supporting strip; these being made from mild steel. The bearings are made with $\frac{3}{4}$-in. by $\frac{3}{32}$-in. mild steel, while for the supporting strip, 1 by $\frac{3}{16}$-in. mild steel is used, although the same size metal could be used for both. The sketches explain the construction of these parts.

Next make the tracker, which is the part that forces the sound-box over the record blank. This is a piece of $\frac{1}{8}$-in. mild steel rod ($\frac{5}{32}$ in. or $\frac{3}{16}$ in. could be used here) bent to shape as shown. This fits into a length of brass tubing which is flattened out at one end, and drilled in two places to take 8 B.A. screws. A loop of thin strip iron is then attached by means of the two screws (see Fig. 3). This is for fastening to the tone-arm of the gramophone.

The other parts of the tracker consist of a piece of phosphor-bronze bent to shape and fastened, by means of a screw, a washer, and a spring-washer, to a piece of brass rod threaded both ends and drilled through at right-angles to the threads. This hole accommodates the shaped rod which is set with a grub-screw at the other end of the brass rod.

Ballasting the Tracker

To hold the tracker down on to the track rod a weight must be fastened to the rod. This weight is made with a cocoa-tin lid filled with lead. Before pouring in the molten lead, an electrical terminal with a projecting thread must be placed through the side of the tin, which is cut to receive this. When the lead has cooled, the rough edges may be filed off with a smooth file and the whole painted if desired (omitting the thread). If the terminal has a tendency to move about in the lead it must be soldered into position until it is perfectly rigid.

The next thing to be made is the gearing, which consists of two plain gears of 1 in. and $\frac{1}{16}$ in. diameter, $\frac{1}{32}$ in. thick, and having 99 teeth, this being the number of teeth on the gears used in the recorder described in this article, although any number of teeth will do providing they are not less than 40 in number. The larger the teeth, the more "back-lash" there will be, with a consequent movement of the tone arm.

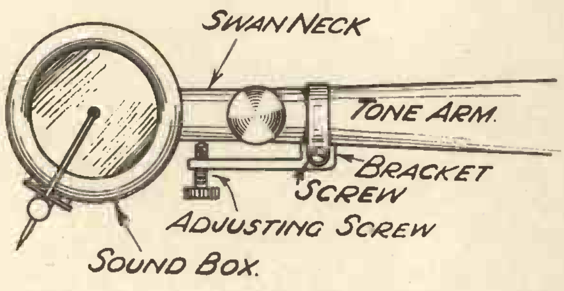


Fig. 2.—Details of the adjusting screw fitted to the tone arm.

One of the gears is drilled out to make a perfect fit on the gramophone centre-spindle, and a cycle-tyre valve collar is soldered over the hole, this being to steady the gear when on the spindle. The other gear-wheel is fitted with a flanged bush of brass made to the dimensions shown and wedged on to the $\frac{5}{8}$-in. end of the track-rod.

The sketches show how the whole thing is assembled. Although the gears are straight-cut, they will "bite" when placed at right-angles to each other. They will be found to run quite smoothly even when placed at 45 degrees to each other.

The reason why the tracker itself is not soldered or otherwise fastened solidly to the piece of brass rod is that, while the tracker is at the beginning of its arc, it is slightly on the skew, but when at the centre or "peak" of the arc it is dead in line with the track-rod. The sound-box could easily be exchanged for an electrical recorder which would not inconvenience the recorder

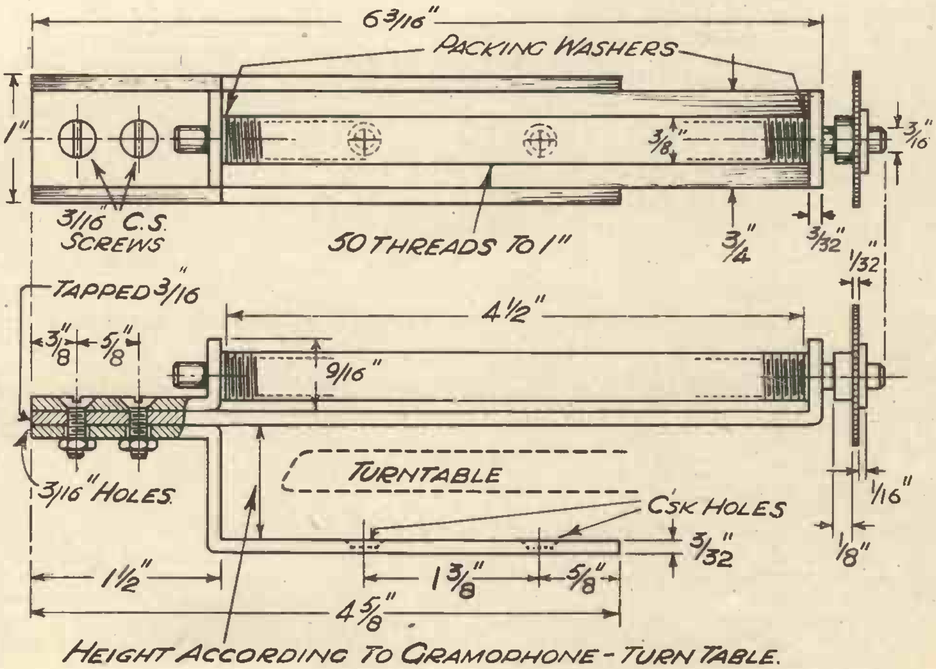


Fig. 1.—A plan and side view of the tracking rod.

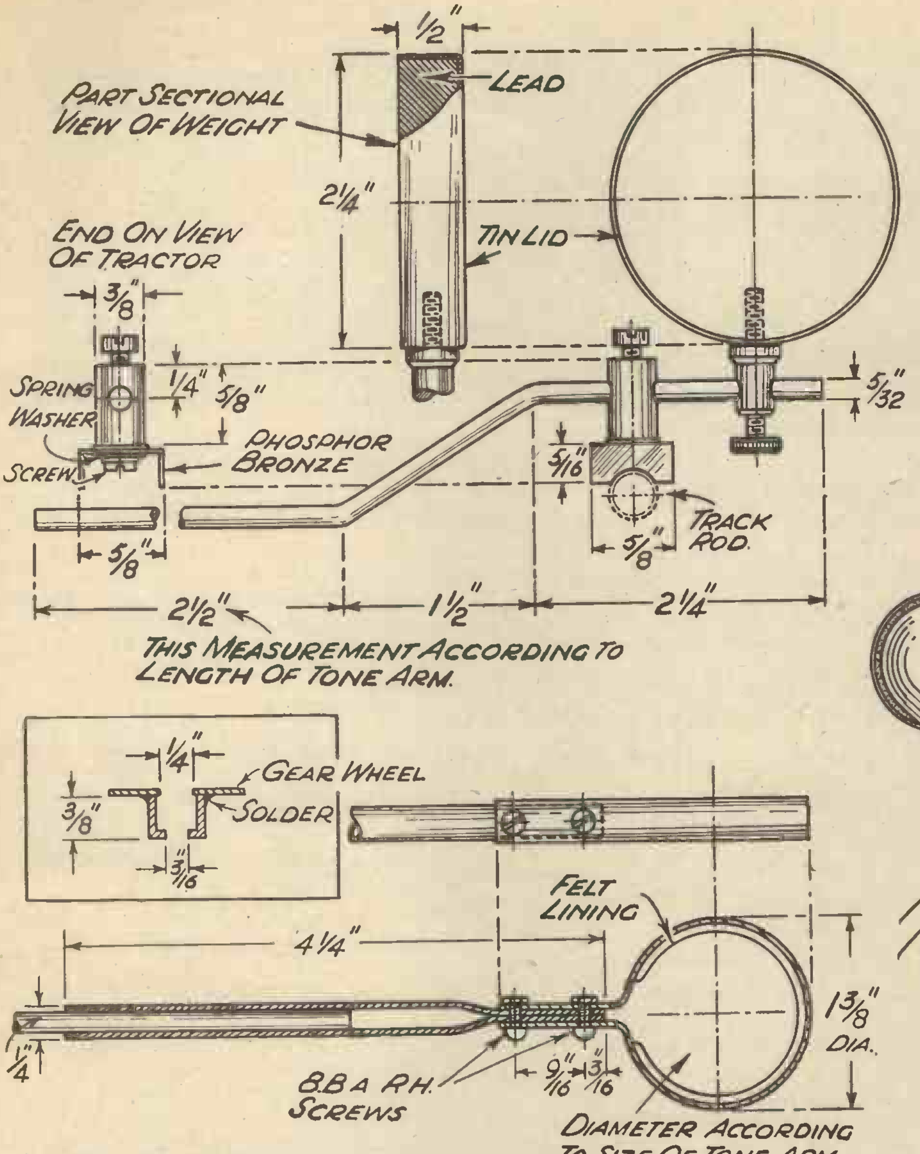


Fig. 3 and 4.—(Top) constructional details of the tracking rod, weight, etc., and (below) a sectional view of the spindle gear.

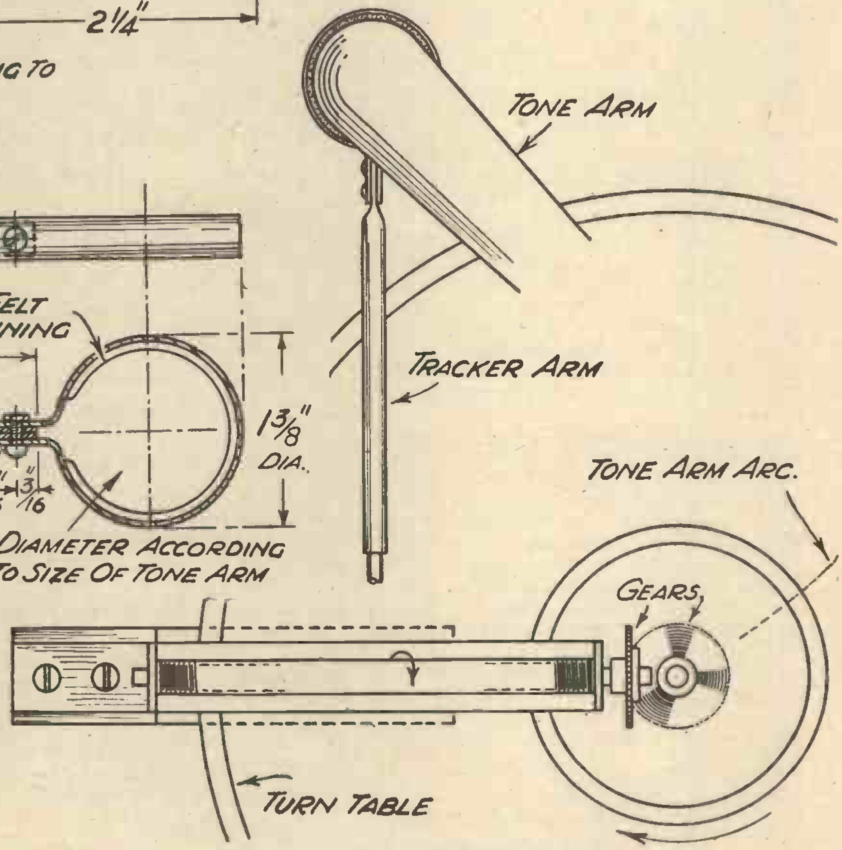


Fig. 5.—The method of adjusting the track rod.

in any way. If a sound-box is used the adjusting screws which regulate the diaphragm should be slightly loosened, this making it easier to vibrate.

Adjustment

Before fixing the track-rod supporting strip to the gramophone (by removing the turntable and driving two short woodscrews through the strip and into the cabinet top, or, if it is not wanted to deface this, by employing clamps for this purpose), it should be adjusted to its correct position, this being carried out in the following manner:—

Swing the tone arm over to the opposite side to the customary position and hold the support down on to the cabinet top with your hand. With the sound-box set at 45 degrees, the needle should be the same distance from the centre of the track-rod on one side of it as it is at both ends on the other side. A glance at Fig. 5 will explain this. The turntable should turn over at about 60 r.p.m., and the voice or musical instrument sung or played into the existing horn.

Aluminium discs are used with an ordinary needle, and they give surprisingly good results when replayed with a fibre needle. Plastic "blanks" were not tried, but if used, an addition to the mechanism of the recorder will be needed in the form of an adjustable "lift" for the sound-box or electrical recorder. This could be made as shown in Fig. 2. Another point that may be noticed when recording is that the tracker arm is rather unstable. This can be overcome by the addition of a piece of strip or square metal spanning the arm and the tone arm.

Plastic Compound for Stopping Leaks

A PLASTIC compound known as Pluvex, which is now available in handy, collapsible 8-oz. tubes, is intended for use in filling cracks in slates, tiles, and asphalt or concrete roofs, or leaks in zinc and lead roofs and gutters, greenhouse lights, or in other places where water percolates. It is pointed out that repairs are easy to carry out with the plastic material, which when squeezed out from the tube is spread with a knife or small trowel. When in place, the strip of Pluvex compound, it is claimed, is waterproof in all conditions, remains unaffected by water, frost, the heat of the sun, and never becomes brittle. The compound is marketed by The Ruberoid Co. Ltd., Lincoln House, 296–302 High Holborn, London, W.C.1.

A Novel Fire Engine

A NEW type of motor fire engine, in the form of an enclosed car, and possessing several novel features, has been constructed for the Lancaster Fire Brigade by Merryweather & Sons, of Greenwich. The body, which is streamlined, affords complete protection for ten firemen. There are two doors on each side, and all windows are arranged to slide down. All the seats are arranged as hose lockers. In addition to a five-lamp lighting set, there is also a spotlight for fog, and a powerful searchlight, which can be used on or off the car. A double or triple-extension ladder can be carried on the roof.

A New Air Port

A NEW air port is to be developed at Hanworth to provide extra accommodation for aircraft. It is intended to build a new hangar, with a floor space of 12,000 sq. ft., and extra equipment to be installed will include lighting for night flying.

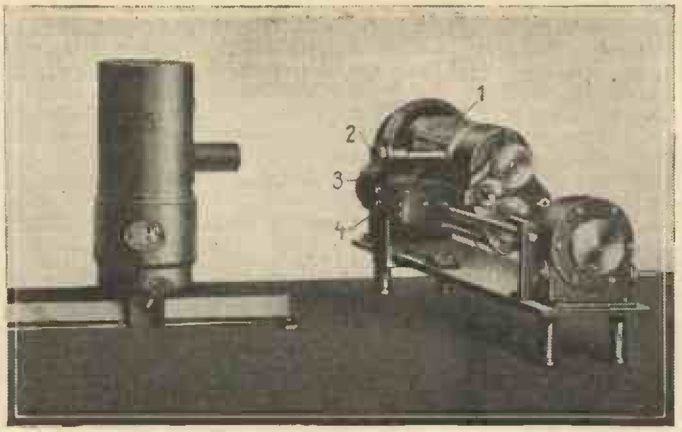


Fig. 3.—An illustration of part of an actual picture telegraphy apparatus, using the principles illustrated by Fig. 2.

WIRELESS PICTURES

By H. J. BARTON CHAPPLE, Wh.Sch., B.Sc. (Hons.).

So much attention has been given of late to the subject of television that the developments in wireless pictures have rather been overlooked. Picture telegraphy (to give it the correct designation) has made considerable strides, however, and after all, if only the process of transmission could be speeded up (a claim to which effect has already been made in America) the result would be a form of television.

NEWSPAPERS, Government officials, army, navy, air force, civilian aviation, etc., all find a particular use for picture transmission either by wire or by wireless, the various systems in use being employed for the purpose of obtaining a facsimile of any photograph or document over great distances in a space of time measured only in minutes. The art is by no means a new one, for various methods of facsimile telegraphy have been in use for nearly a century, and although, of course, the early schemes were quite crude from the point of view of the results obtained, very close resemblance to modern methods can be traced in many of the mechanisms.

Early Schemes

The first attempts, in which, of course, radio did not figure, as the science was then unknown, were directed towards the transmission of visual messages, printed letters or code signs being sent from point to point by electro-mechanical, electro-optical and electro-chemical machines. One of the early inventors was Alexander Bain, who used an electro-chemical telegraph, while the name of Bakewell has also long been associated with this pioneer work. It is generally conceded that Bakewell's drum or cylinder with its travelling stylus or marker, bears a very intimate similarity to present methods, except that his electro-chemical methods have given way to more accurate and greater detailed photographic schemes.

A simple impression of his machine is given in Fig. 1. The drum and screw thread along which the stylus travelled at a slow rate were geared together and revolved by a motor whose speed was accurately governed. The machines were identical at both transmitting and receiving ends, but strapped round the transmitter drum was a tin-foil cylinder on which the message or picture was drawn with a non-conducting ink. As the drum revolved, current passed into the single telegraph line, linking both ends when the stylus made contact with the foil, but ceased to flow at those moments when it passed over the non-conducting ink message. At the receiving end a sheet of chemically prepared paper revolved synchronously with the transmitter, reproducing the message as a tracing on the paper surface.

Progress

The standard of "scanning," if one is permitted to use that modern word in connection with early picture-telegraphy efforts, was 100 lines to the inch, and for ordinary messages this gave a printed replica, on an average, of twenty-five words to the minute. As time progressed, and light sensitive devices were developed, photo-electric cells and modulated light sources found their place in the transmitting and receiving ends respectively.

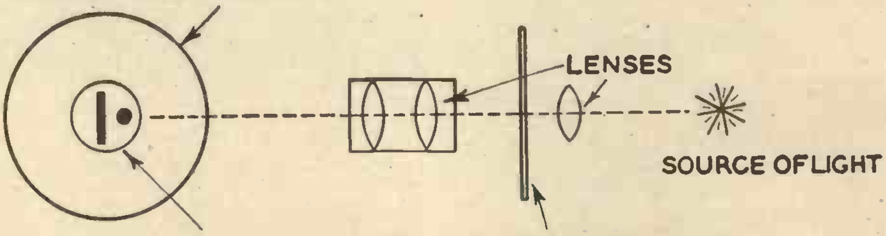


Fig. 2.—Details of a more up-to-date apparatus, using a photo-electric cell.

One modern scheme of this character is shown in Fig. 2. As before, there is a rotating cylinder made, however, from transparent material, and located inside this is an efficient photo-electric cell connected up to a multi-stage valve amplifier. The photograph or message to be transmitted by wire or wireless is stretched round this drum and an intrinsically brilliant source of light is focussed through a small diaphragm on to the cylinder. Fig. 3 indicates an actual part of the mechanism built up on these lines: (1) being the message fixed to the drum; (2) the diaphragm and focussing lens; and (5) the source of light in a suitable screening cover.

As the drum revolves, variations of light corresponding to the typed or written message, or the half-tone gradations of the photograph, pass right through the drum and influence the electrodes of the photo-electric cell. The cell in turn converts the light variations into equivalent terms of voltage signals which are amplified and transferred to the line, or modulate the carrier-wave of the radio transmitter for radiation to the receiving end.

Here, the varying signals are amplified and made to modulate a source of light either directly as, for example, a neon lamp of special design; or alternatively by means of a light valve such as a Kerr cell. The resultant light signals are focussed on to another drum rotating in synchronism and maintained in this condition automatically by incoming synchronising pulses. The drum is surrounded

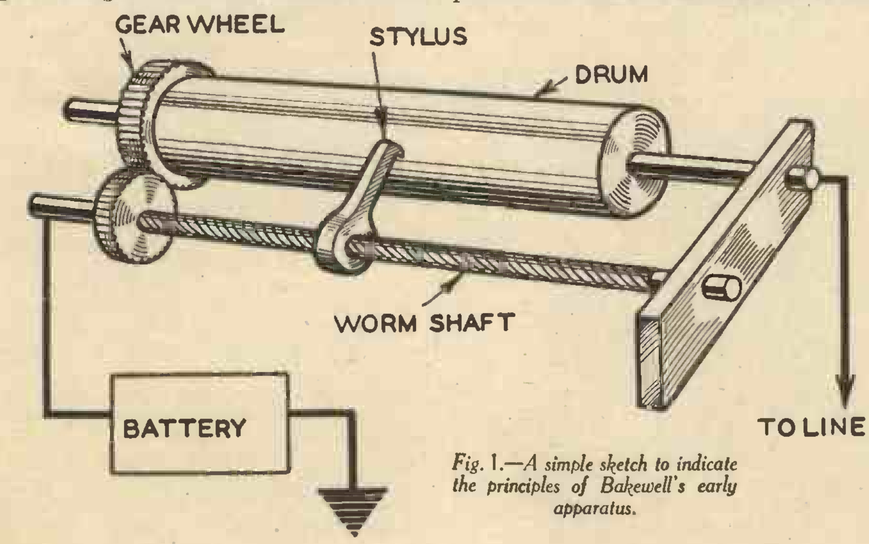


Fig. 1.—A simple sketch to indicate the principles of Bakewell's early apparatus.

by photographically sensitised paper which, of course, responds to the light signals and in this way builds up a picture as a series of closely formed lines of varying intensity. Pictures transmitted in this way at a relatively slow speed contain a large proportion of the original detail of the transmitted picture, evidence of this fact being available by referring to the pictures seen in the daily newspapers where the caption indicates that they have been received in the editorial offices by picture telegraphy methods.

Fultograph

No doubt many readers can recall the Fultograph service of wireless pictures which was sponsored by the B.B.C. three or four years ago. The apparatus used was the invention of Captain Otho Fulton, and could be connected to a suitable type of radio receiver. In appearance it resembled somewhat an early phonograph and the pictures which were received were sepia coloured, being recorded on a revolving drum covered with a moistened and chemically treated paper. Across the paper moved a stylus and the pictures were produced by an electrolytic action, needing washing and treatment after the record had been made in order to secure a permanent copy.

At the time the results achieved were very promising, but after a trial period of several months the B.B.C. service was terminated, although several continental stations continued to provide a daily service. One of the machines used in the home, together with examples of the pictures obtained is shown in Fig. 4. The system suffered a little from lack of synchronisation while the vagaries of radio reception, especially when interspersed with atmospherics, sometimes resulted in pictures which were distorted. Fulton, however, is continuing his work in America and has now produced a machine in which the paper is used dry, a stylus electrode freeing iodine in the paper in the form of dark brown marks to give the required picture half tones. The line analysis used has varied in this apparatus from 60 to 120 per inch.

Other Methods

Also in America, Hogan has designed what has been termed a "radio pen" in which black-and-white images are traced by a magnetic pen on a continuous roll of paper. This gives a 60-line detail, the images being some 3 in. wide. It is connected to a modern type radio receiver and one of its suggested applications is for the production of messages and writing overnight, so that at the breakfast table the user will have all the latest news recorded both pictorially and in type.

Fig. 4.—A wireless picture receiver with examples of photographs obtained.

Another home facsimile system developed in the same country is that due to Young, of the R.C.A. The apparatus is one of the most promising yet devised for home use since no ink or paper preparation is necessary, the "inking" being brought about by the employment of carbon paper. It appears that the roller is made with a single spiral of piano wire embedded in it, but raised above its surface very slightly. It is the purpose of this wire to press through a combined layer of carbon and recording paper against a bar mounted parallel to the drum axis. The double motion of cylinder rotation and horizontal movement of contact point between bar and drum produces continuous closely spaced lines, and the picture is impressed by magnetically varying the pressure between the bar and the wire, interposed between which is, of course, the carbon and recording paper.

For synchronisation purposes in many of the picture telegraphy methods, temperature-controlled tuning forks are used to generate absolutely steady correcting or driving pulses, the signal at the transmitting end controlling the receiving end by periodically transmitted signals sent over a special line or incorporated in the picture signal. It is claimed that by methods of this character an accuracy of one part in a hundred thousand is possible. In the Young method just described the process gives a gradation of 100 lines to the inch, it being stated that half tones of good detail are secured.

The apparatus installed for newspaper or Government office work is far more elaborate in character but the principles involved are essentially similar. For commercial purposes pictures are now regularly transmitted across the Atlantic, while in connection with the recent record-breaking aeroplane flight from England to Australia, it will be recalled that a series of pictures were transmitted from Australia for several hours, these being joined together eventually in order to give a short length of topical film for showing at cinemas up and down the country.

Another very important application is in connection with the transmission of weather maps or charts for use by ships at sea, or aeroplanes. Then, again, for tracking criminals the police make use of a service to send photographs or fingerprints, and doctors have consulted distant specialists for assistance in diagnosing difficult medical cases by transmitting X-ray photographs of the patient. The point that has to be stressed is that with the greatly improved forms of still picture transmission using a radio link together with the early promise of a high definition television service, the day of a very complete visual service for home enjoyment is not far distant.

CHEMIST *VERSUS* CRIMINAL

The establishment of a crime laboratory by Lord Trenchard mobilises a powerful force of scientific criminologists against the law-breaker. The scientist has many methods of detecting the hidden traces of crime. In some cases the existence of a convicting clue could only be known to the super-criminal, or the master-forger.

INFRA-RED photography is used for detecting blood-stains. A murderer may wash out every visible trace of blood from his clothing. But an infra-red photograph will show tell-tale ineradicable patches wherever the cloth was wetted with blood.

The Ultra-Violet Ray

The banknote forger has to fear the ultra-violet ray. In a recent case an expert on banknote forgeries was given two notes of high denomination to examine. They were exactly alike. But both had the same series numbers. One must be a forgery. The question was, which? He examined them under a microscope. They were identical, stroke for stroke, and colour for colour, even to the minutest irregularities of the engraving. The watermarks were both genuine. But in ultra-violet light one note looked dead black, the other shone with a blue phosphorescence. A reference to the bank printers showed that the dead-black note was a forgery.

An interesting thing in this case was that the watermarks were genuine. All methods of forging watermarks are detectable by one test or another. It transpired that the forgers were procuring genuine watermarked paper from an accomplice at the official paper mills.

Forging

Forging written documents by alterations and erasures used to be common. Now a Viennese chemist has discovered a method of detecting the age of writing by a method similar to the development of a photographic print. Thus he can almost give a date to any forged insertion, whether on a will, a cheque or bill of exchange. The Gutteridge crime acquainted us with a method of tracing a bullet to the revolver which fired it. In a similar way currency shows the signs of its parent press. Minted coins can be readily distinguished from counterfeit. The expert can tell in a moment whether a counterfeit has been stamped out or cast in a mould.

The recording of finger-prints is the routine of all police forces. But the photography of prints left on the scene of the crime is often an expert matter, needing many tricks only known to the trained scientist.

Pathological Methods

The pathological methods of which Sir Bernard Spilsbury is the great exponent have been familiar features of many poisoning cases. The microscopic examination of hairs, seeds, dust and the rest are the stock-in-trade of every detective story writer.

The admissibility of expert evidence is questioned by some. Often the expert simply gives the police unmistakable pointers to their man. The cast-iron convicting evidence is then left to routine investigation. The laboratory work of the scientist may never be mentioned in the arraignment of evidence. Perhaps the police intentionally withhold such information. It is not always their policy to let the criminal know the powerful weapons which science can use to unmask him.

Lathe Work

— SCREW CUTTING —

By W. H. DELLER

THE principle of screw-cutting, that is as understood by the term when applied to centre-lathes, consists of gearing the lead-screw to the headstock mandrel in such a manner that by revolving the mandrel one turn the lead-screw will rotate sufficiently to carry the saddle forward a distance exactly equal to the pitch of the thread to be cut.

For screw-cutting purposes the saddle is generally connected to the lead-screw by means of a lever-operated split-nut. It will be apparent that to cut a thread of, say, 24 threads to the inch, the saddle and consequently the tool must travel a distance of $\frac{1}{24}$th of an inch for each revolution of the lathe. Thus, the factors governing the gearing ratio are: number of threads per inch required, and the number of threads per inch of the leading screw.

Lead-screws are commonly cut either 8, 6, 4 or 2 threads per inch, but on the class of lathe that the reader is likely to use will not be finer than $\frac{1}{4}$ in. pitch. To cut a thread of 24 threads per inch on a lathe with a screw of this pitch it will follow that, while the mandrel is making one turn, the lead-screw, in order to advance $\frac{1}{24}$th in., must revolve only $\frac{1}{6}$th of a turn; in other words, the mandrel must revolve six times as fast as the lead-screw. Obviously, to do this the gear train connecting the mandrel to the screw must give a speed reduction of 6 to 1.

Fig. 3.—Setting the screw-cutting tool for centre height by means of a centre or screw-cutting gauge.

Therefore, the first step in ascertaining which change wheels to use, is to find the ratio of the gearing to employ by dividing the number of threads per inch to be cut by the number of threads per inch of the lead-screw.

Change Wheels

As supplied with the lathe a set of change-wheels may consist of 22 wheels, all identically bored and key-wayed, ranging from 20 to 120 teeth, each wheel having 5 teeth more than the next smaller, one of the smaller gears, usually a 40, being in duplicate. With lathes having a lead-screw of 6 or 8 threads per inch, the wheels may run from 24 to 100 teeth in increasing stages of 4 teeth.

Having found the ratio, all that needs to be done is to select a pair of wheels having numbers of teeth in the same ratio. As an example, what wheels are required to cut 20 threads per inch on a lathe having a lead-screw of 4 threads per inch? 20 divided by 4 equals 5. The wheel on the lead-screw therefore requires to have five times as many teeth as that of the spindle, or 100 and 20 teeth respectively. As these two gears run on centres that are fixed, some means is necessary to transmit the drive from one gear to the other. Provision is made for this in the slotted quadrant plate which is pivoted off the centre of the lead-screw. Into the slot is fitted an adjustable stud, working on which is a bush having a key to suit the change-wheels. Any convenient-sized wheel is selected as an intermediate gear, and the stud is raised in the slot sufficiently to allow the wheel to pass on to the bush clear of the lead-screw wheel. A smaller gear is put on in front as packing and locked by the nut provided, the intermediate wheel is then dropped into mesh with the lead-screw wheel and the stud locked in the slot, after which the quadrant plate is swung over, until the gear engages the one on the spindle, and locked. In Fig. 1 a simple gear train is illustrated. The top left-hand wheel represents the spindle and the lowest one the screw, the smaller wheels on the screw and in front of the intermediate or idler gear being used as packing.

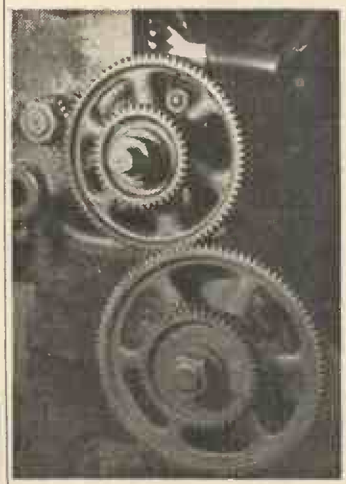


Fig. 1.—Showing a simple gear train.

Compound Trains

Obviously, with the standard wheels the limits of a simple train of gears is represented by a ratio of 6 to 1, 20 being the smallest gear available and 120 the largest; these, by the way, will cover all standard Whitworth pitches from $\frac{3}{16}$ths diameter, and B.S.F. from $\frac{5}{16}$ths diameter up to the largest size likely to be handled, without needing a compound train.

For finer pitches than 24 threads per inch, use will have to be made of compounding the gear train, as, for instance, a screw having a pitch of 30 threads per inch is required. $30 \div 4 = 7\frac{1}{2}$ to 1 ratio. To cut this with a simple train would require wheels of 20 and 150 teeth; as the larger size is not available, recourse is made to a compound train of gears. This consists of splitting the gearing up into two units as it were: one gear on the spindle drives a gear on the stud, a second gear having a different number of teeth is also mounted

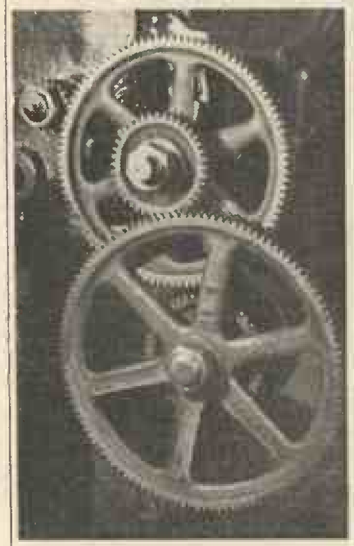


Fig. 2.—A compound train. The gear behind the lead-screw wheel is used as packing.

Fig. 4.—Cutting a thread.

on the stud in front of the first and by virtue of the key in the bush is driven at the same speed. This front or second gear meshes with the wheel on the screw.

Thus, by using a 20-wheel on the spindle to drive a 100 wheel on the stud, giving a reduction of 5 to 1, and the second wheel on the stud having 30 teeth driving a wheel with 120 teeth on the screw, a total reduction of 20 to 1 would be obtained. In the case under review the gears could be split up into two trains to give a first reduction of $3\frac{3}{4}$ to 1 and a second of 2 to 1; or, a first of $2\frac{1}{2}$ to 1 and a second of 3 to 1. To cut 30 threads then, the following gears could be used: spindle 20, driving stud 75. Stud 50, driving screw 100, or, in the same order, 30, 75, 40, 120. This may be expressed as follows:—

Fig. 6.—Showing the screw-pitch gauge in use.

$$\frac{\text{Lead-screw, thds. per in.}}{\text{Thds. required per in.}} = \frac{4}{30} = \frac{4 \times 1}{15 \times 2} = \frac{4 \times 5}{15 \times 5} \times \frac{1 \times 50}{2 \times 50} = \frac{20}{75} \times \frac{50}{100} \text{ or } \frac{4}{30} = \frac{2 \times 2}{6 \times 5} = \frac{2 \times 20}{6 \times 20} \times \frac{2 \times 15}{5 \times 15} = \frac{40}{120} \times \frac{30}{75}.$$

It will be seen that the numerator and denominator in each factor are multiplied by the same number to give suitable wheels, and further, either of the wheels indicated by the numerator may be used as a driver to driven wheels with the same result. Thus, in the last example, 40 could drive the 75, giving a reduction of $1\frac{35}{40}$ths to 1, and the 30 driving the 120 giving a second reduction of 4 to 1, so that $1\frac{7}{8}$ths multiplied by 4 is equal to $7\frac{1}{2}$ to 1 required. The examples instanced do not exhaust the possible combinations that could be used, and in selecting the gears the only point to watch is that those selected will be large enough to permit meshing when the quadrant is swung into position.

A compound train is shown in Fig. 2; the gear behind the lead-screw wheel is used as packing. It is hoped that the explanation has made it clear that the working out of change wheels is only a question of simple mental arithmetic. For the benefit of those who have or may get a lathe having a change wheel plate and are unfamiliar with the terms thereon, Spindle means the head-stock spindle or shaft connected thereto by tumbler gearing. Stud is the stud on the quadrant plate, and Screw is the lead-screw. Alternative markings meaning the same things in the order named, are Spindle-driven, Driver-screw, or Driver-driven, Driver-driven. In both cases where only the first and last columns are marked, it means that only a simple train is needed and, as before stated, any wheel can be utilised as an intermediate.

Cutting a Thread

Having turned the work ready for threading and mounted the wheels, set the screw-cutting tool for centre height and the flanks of the tool square with the work by means of a centre or screw-cutting gauge, as shown in Fig. 3, bring the saddle back so that the tool is well clear with the front of the work. The nut is engaged with the lead-screw and the tail-stock locked hard up against the saddle to form a stop. A cut is put on, noting the position or reading on the cross-slide index. When the tool has travelled a distance along the work equal to the length of thread required, disengage the nut and at the same time recede the tool smartly. Return the saddle up to the stop and put further cuts on as before until the thread fits the female part. Fig. 4 shows a thread being cut, and it will be noticed that the tool is actually cutting and not merely scraping. During the cutting, particularly with deep threads, the tool is advanced slightly several times during the cutting operations, as seen in Fig. 5, but allowing the tool to cut all over on the last one or two cuts to obtain a thread of correct form.

Where the thread washed out, as on a stud, care must be taken not to allow the tool to travel beyond the point of withdrawal on the previous cut, or the nose of the tool will break. Aim at withdrawing each succeeding cut slightly in advance of the previous one to obtain a gradual wash-out.

This procedure is adopted for all threads per inch that are multiples of the thread on the lead-screw. When threads such as 9, 10 or 11 are to be cut, the nut is not disengaged, but the cut is withdrawn, and the lathe reversed by pulling the belt backwards, or, when the saddle is first brought back against the stop and the nut engaged, a chalk is made on the face of the head-stock cone or on the gear wheel and a corresponding mark made on the front bearing housing or gear guard. Similar lines are made on the lead-screw and lead-screw bracket. The nut is disengaged at the end of the cut as before, and the saddle returned to the stop, which in this case is essential, and the lathe run until both sets of lines coincide at the same time when the nut is dropped in. It should be mentioned that to cut left-hand threads, where the lathe is not fitted with a tumbler gear, two intermediate wheels will be required in a simple train and one intermediate wheel in a compound train. This is necessary to reverse the direction of the lead-screw.

Fig. 5.—The tool should be advanced several times during the cutting operation, as shown.

As distinct from the screw-cutting gauge referred to is the screw-pitch gauge illustrated in use in Fig. 6. Such gauges are made with serrated blades covering various screw pitches. The blades represent sections of threads of different pitches and are correctly formed according to the standard represented, and on this account, apart from finding pitches, are useful for checking thread-form when cutting.

GOOD PROSPECTS FOR THE TECHNICAL SPRING FAIR AT LEIPZIG

ENQUIRIES for the reservation of fair stands at the Great Engineering and Building Fair at Leipzig, taking place from March 3rd to 10th, 1935, are being received in considerably larger numbers than in previous years. The space at disposal in the Machine Tool Hall (Hall 9) has been booked up completely. Of the twenty-eight further entries of machine tool manufacturers not more than six at the utmost can be suited. The remaining firms will show their exhibits in Hall 11, so that the machine tool group in this hall will show a considerable enlargement. In the Electro-technical House, too, all stands have been booked. Also in the group of general mechanical engineering the amount of space rented for the Spring Fair is already considerably in advance of that at the same time in former years. The increase is especially noticeable in the department of Diesel Engines and Foundry Machinery. The hall housing the Building Trade Fair will have no free space left either. It should be noted that the manufacturers of gas implements will be arranging a special exhibition on a large scale in this hall. Judging by the entries received up to date the result may therefore be called an especially gratifying one.

Automatic Needle for Gramophones

The Leipzig Fair is showing a new patented device, the "Goldring Automatic Needle," which should appeal to all users of the gramophone. About 200 needles, *i.e.*, about a standard packet, are filled in, and by an ingenious mechanical device such needles, filled in anyhow, are fed out singly by simply pressing down the apparatus with one finger. The whole device is contained in a small tin casing, made to suit individual tastes.

An Ingenious Typewriter

Many people who cannot afford an expensive typewriter because they use it only occasionally, yet would like to type their letters, etc., are well served by the popular "Carissima" shown at the Leipzig Fair, which is cheap, almost noiseless, and may be operated by one or two fingers only and yet with some considerable speed. It is of the simple adjustable lever type, all parts easily interchangeable, made of high-grade pressed bakelite, the metal parts being nickel plated. There are eighty-seven letters and signs, and the machine can be easily arranged for foreign languages, since the keyboard is interchangeable. The transport of the ribbon $\frac{7}{16}$ in. wide is automatic, and since the total weight of the complete machine is only 4 lb. it can be easily carried about in a brief case.

Showing the neat and realistic appearance of the model, which is capable of the amazing speed of 8 knots.

OUR MODEL SPEEDBOAT "STREAMLINIA"

By "THE CAPTAIN"

Advance details of the special Metre Model Steam Boat designed for "Practical Mechanics" readers. Its speed is in excess of 8 knots. The model bristles with novel features.

A FEW months ago I was told that Messrs. Bassett-Lowke had been asked by the Editor of PRACTICAL MECHANICS to conduct a series of experiments to try and put before his readers something new in model steamboats, something which had a good turn of speed and was not in any way freakish, and which was reasonably cheap to build.

Having acted in the capacity of unofficial tester to this firm on several occasions, I have put hundreds of good boats through my hands at different times.

I was therefore more than pleased when Mr. Bassett-Lowke put into my hands the first of the approved boats and asked me to try it out at the Boxing Day Regatta of the Northampton Model Engineers.

Streamlinia is a metre boat, with a beam of 8 in, and a maximum depth of 4 in. In front view she is rather like the boat in which Miss Betty Carstairs was to have attempted a dash across the Atlantic. The side view shows a snappy-looking launch of the fast-cruiser type with aero-type superstructure, which adds not only to her appearance, but to her performance as well.

Sound Construction.

On receiving her from Messrs. Bassett-Lowke, I took the model home to my workshop and examined her engine.

It is a queer fact that, although there are good hulls, engines and boilers on the market in profusion, and at reasonable prices, there are but few good completed boats on the market. The truth is that the art of putting the correct engine, boiler and lamp into the right hull is one mastered only by a few.

But whoever had built this model had made an exceedingly good job of it.

The engine is a Stuart "Meteor" of $\frac{7}{16}$ in. bore and stroke. The boiler is a new line by Messrs. Bassett-Lowke and the lamp is the Harrison automatic methylated spirit lamp of the larger size, as retailed by Messrs. Bassett-Lowke. The propeller is a "Remod."

On Boxing Day I took *Streamlinia* to the pond at Abingdon Park, Northampton, and set her afloat. My first impression was pleasant surprise at the fact that she floated like a feather, despite the fact that she was carrying a considerable load of machinery. The boiler is not light, nor is the engine cr lamp.

Preliminary Operations.

The boiler was steamed up to 40 lb. per

(Continued on page 244.)

SPECIAL FEATURES OF THE MOTOR BOAT "STREAMLINIA"

This motor boat is being designed and built by an experienced craftsman in Bassett-Lowke's ship model yard, Mr. Percy Claydon, and full reports of the tests and pictures of the finished model, together with complete detailed drawings will be published in the March issue.

A duplicate of this model will be built in the Bassett-Lowke ship works at Northampton, and will be described for model makers by Captain Gordon Berry, and illustrated with photographs taken at different stages of progress.

The boat is metre size, 8 in. in the beam, with slipper stern. Hull carved from the solid. Deck-houses built up. Two patterns will be described—Streamline deck houses and ordinary, the latter being easier to construct.

The steam plant will be a water-tube boiler, automatic spirit-feed lamp, motor engine and Corinthian propeller.

You must build this boat for Easter. A prize will be given by Bassett-Lowke Ltd. for the best attempt, which will be judged by the Editor and Mr. Bassett-Lowke. Parts are available on easy terms.

Mr. P. Claydon, one of Bassett-Lowke's craftsmen, who built the model.

The "Streamlinia" travelling under power. Despite the fact that the model carries a considerable load of machinery, it floats as easily as a feather.

Edison, the creator of the talking machine. A portrait taken towards the end of his life.

THE DEVELOPMENT
MACHINE

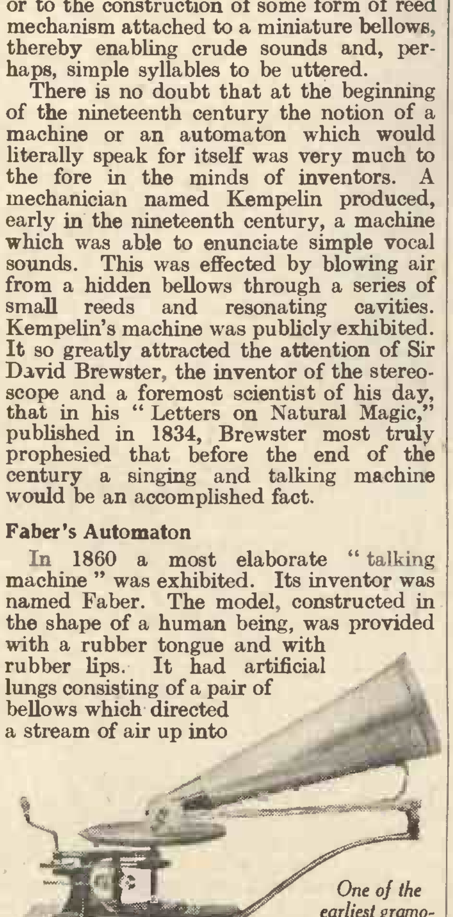
Despite the fact that the talking machine is only a music and speech—and especially speech—is by no Chinese had some method of recording sound, whereby this possible we are never likely to know.

TALES of "speaking heads" crop up here and there in the last thousand years of history. Probably the most famous of these legendary devices is that which is supposed to have been constructed by St. Albertus Magnus, the celebrated Provincial of the Dominicans at Cologne, in the thirteenth century. Roger Bacon, also, at an earlier date, is credited with one of these devices. Very possibly, if there is any semblance of truth in these stories of speaking heads the effect may be ascribed to the ventriloquial powers of the operator or to the construction of some form of reed mechanism attached to a miniature bellows, thereby enabling crude sounds and, perhaps, simple syllables to be uttered.

There is no doubt that at the beginning of the nineteenth century the notion of a machine or an automaton which would literally speak for itself was very much to the fore in the minds of inventors. A mechanician named Kempelin produced, early in the nineteenth century, a machine which was able to enunciate simple vocal sounds. This was effected by blowing air from a hidden bellows through a series of small reeds and resonating cavities. Kempelin's machine was publicly exhibited. It so greatly attracted the attention of Sir David Brewster, the inventor of the stereoscope and a foremost scientist of his day, that in his "Letters on Natural Magic," published in 1834, Brewster most truly prophesied that before the end of the century a singing and talking machine would be an accomplished fact.

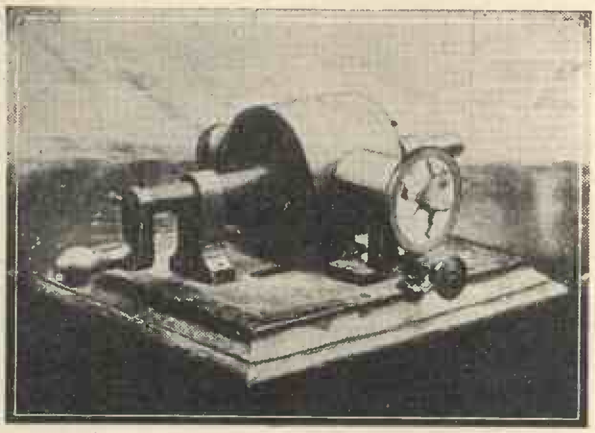
Faber's Automaton

In 1860 a most elaborate "talking machine" was exhibited. Its inventor was named Faber. The model, constructed in the shape of a human being, was provided with a rubber tongue and with rubber lips. It had artificial lungs consisting of a pair of bellows which directed a stream of air up into the mouth. A miniature keyboard concealed in the trunk of the automaton enabled various sounds and even complete sentences to be uttered by the model at the will of the operator. Faber's automaton was the last of its type. Although most ingeniously contrived, it was cumbersome and complicated and, of its very nature, it could hardly ever have been anything other than a mere mechanical curiosity. Besides, about this time, it was beginning to dawn upon the minds of inventors that the lines which they were working along in their endeavours to produce a talking machine were fundamentally wrong. What was required was not a machine which would produce sounds, but rather one which would *reproduce* sound.



One of the earliest gramophones constructed under Berliner's patent. It was hand-turned and took a 7-in. record.

In 1856 a certain M. Léon Scott invented a device which he called a "Phonautograph." It was a device which was undoubtedly the forerunner of the modern sound-recording machine.



The first talking machine in the world. Edison's original phonograph. The reproducing diaphragm (cracked) is seen to the right of the photograph.

Scott's phonautograph comprised a diaphragm to the middle of which was attached a short stubby hog's bristle. This was made to traverse a revolving cylinder covered with lampblack. A short trumpet was attached to the diaphragm assembly. When the lampblacked cylinder was revolved and words were spoken down the trumpet of the instrument the hog's bristle was vibrated and it caused a wavy line to be marked out on the cylinder.

That is as far as Scott went. He had succeeded in recording sound, but, apparently, he never thought about reproducing it. The phonautograph was exhibited to the British Association in 1859, and we are told that a demonstration of it was even given to Queen Victoria, who expressed her interest in the machine. But that is the last we hear of the phonautograph. The next inventor is the renowned Thomas A. Edison, and, with him, came the world's first practical talking machine. It should be noted that although Edison, appropriately enough, termed his machine a *phonograph*, the word itself is of earlier date, having been applied to a sound-producing device which was patented in England in 1863 by an individual named Fenby.

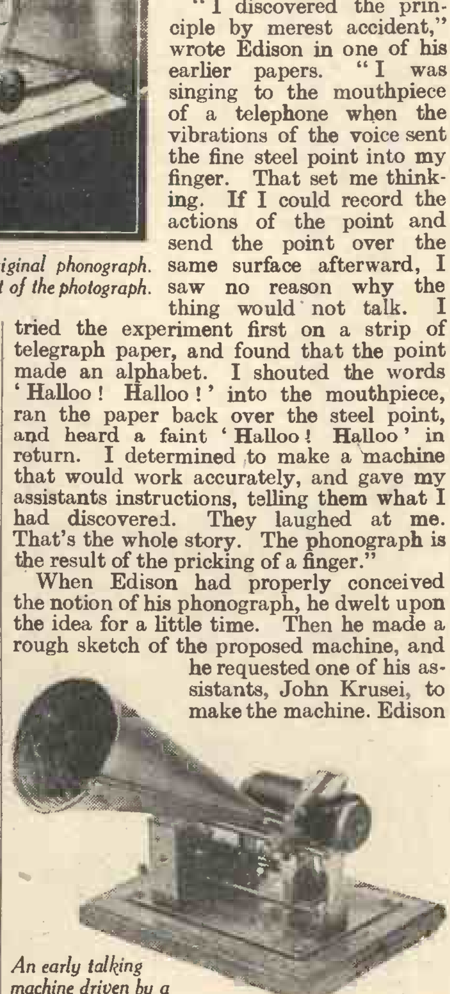
There has been some little dispute concerning Edison's claim to the invention of the phonograph, mainly on account of the fact that in April, 1877, a M. Charles Cros, of Paris, deposited with the French Academy of Sciences a sealed description of an apparatus which afterwards proved to be very similar to that patented by Edison in the following year. Edison's application for his first talking machine patent was made in the United States on December 24th, 1877. The patent was granted on February 19th, 1878. Before this, for some reason or other, Edison had filed an application for an English patent on July 30th, 1877. Hence, although there is always the possibility of two inventors arriving at the same result unknown to each other, it seems tolerably certain that to Edison belongs the honour of having been the first to bring out the world's first sound-reproducing apparatus.

Edison's Discovery

Allow this famous inventor to retail the story of his invention in his own words:—

"I discovered the principle by merest accident," wrote Edison in one of his earlier papers. "I was singing to the mouthpiece of a telephone when the vibrations of the voice sent the fine steel point into my finger. That set me thinking. If I could record the actions of the point and send the point over the same surface afterward, I saw no reason why the thing would not talk. I tried the experiment first on a strip of telegraph paper, and found that the point made an alphabet. I shouted the words 'Halloo! Halloo!' into the mouthpiece, ran the paper back over the steel point, and heard a faint 'Halloo! Halloo' in return. I determined to make a machine that would work accurately, and gave my assistants instructions, telling them what I had discovered. They laughed at me. That's the whole story. The phonograph is the result of the pricking of a finger."

When Edison had properly conceived the notion of his phonograph, he dwelt upon the idea for a little time. Then he made a rough sketch of the proposed machine, and he requested one of his assistants, John Krusei, to make the machine. Edison



An early talking machine driven by a clockwork motor.

OF THE TALKING

little more than fifty years old, the idea of a machine which would produce means new. It has been asserted, and seriously, too, that the ancient messages were conveyed to a distance, although to what extent they found

An original Berliner gramophone record.

said that Krusei was the cleverest mechanic that he ever had. Krusei certainly knew the meaning of the word "hustle." He took Edison's rough drawing and worked upon it for thirty hours. Thus was produced the first phonograph.

Krusei's first phonograph model was a large clumsy instrument. The cylinder consisted of a brass drum, 4 in. in length and 3·4 in. in diameter. It was turned by hand. The surface of the cylinder was indented with a narrow groove, and it was covered with tinfoil. At right angles to the hand-revolved cylinder was a thin ferrotype plate having a projecting stylus attached to its centre. Sound vibrations impinging upon the crude diaphragm caused the stylus to indent the tinfoil on the revolving cylinder, thus creating a more or less faithful sound record. On the opposite side of the cylinder was another diaphragm, this time made of paper. From its centre projected a light rod carrying a short pin rounded at the end. When the cylinder was rotated the pin was brought into contact with the indentations on the tinfoil, and it thus reproduced very faintly the original sounds which had been recorded by the instrument.

For several years Edison's invention "lay on the bench." It was a mere curiosity and nothing more.

Graham Bell

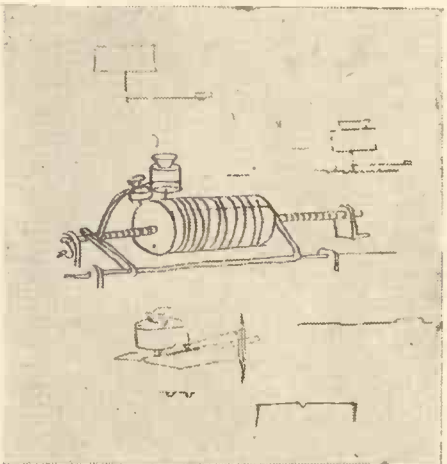
Others, however, were slowly but surely ferreting their way to the attainment of a practical talking machine. Alexander Graham Bell, the inventor of the telephone, and Charles Sumner Tainter, unaware of Edison's patent, which included wax as a recording surface, brought out a machine for recording upon surfaces of this material. To such instruments they gave the name of "Graphophone." Bell and Tainter became opponents of Edison. A law-suit resulted, each of the two parties accusing the other of infringing their patents. Eventually small damages were given to both sides. Afterwards, Edison and Bell and Tainter formed a company—Edison United—for the commercial production of phonographs for home use. In this manner the first phonographs were introduced to the public.

Edison's earliest commercial phonographs were not very successful. For one thing, he was not able at first to duplicate his records. Consequently, every record sold was a "master." That is to say, it was the actual wax record originally made by the artist. When, however, the duplication of cylinder records became possible, Edison's phonographs instantly became popular and a world-wide demand arose for them.

A very famous model. The first commercially produced gramophone. It was spring-driven and it carried a 7-in. turntable. This is the model which enters into Frances Barraud's painting "His Master's Voice."

For many years Edison's most popular machine was his "Gem" phonograph, which went through a long series of "Editions," retailing at two guineas, and which was only finally displaced from the market by the increasing popularity of the "gramophone," as the disc machine was termed.

The present-day disc gramophone was the invention of Emil Berliner. Berliner's "gramophon," as he originally called it,



The first idea of a phonograph. A reproduction of Edison's original sketch of his invention.

was first patented in 1887—ten years after Edison's original patent. For many years, however, Berliner allowed his patent rights to lie dormant. In the early 'nineties he produced a few of his machines. They differed radically from the Edison phonographs, in that their records carried a "lateral-cut" recording. The sound-track

Edison's most popular phonograph. The Edison "Gem" model which, for many years, was a music maker in thousands of homes.

on the Edison cylindrical record was of a "hill and dale" formation. It was made up of indentations of varying depths in the record surface. In Berliner's "lateral-cut" system of recording, which, incidentally, is the system universally applied nowadays, the sound grooves are of equal depth but of varying widths. Consequently, in this latter system the reproducing stylus or needle, instead of being set into an up-and-down motion, as was the case with the Edison phonographs, is moved from side to side. Both these two sound-recording systems have their own definite advantages, although, owing largely to the more compact and less fragile nature of the flat disc record, the gramophone, and, of course, its immediate offspring, the radiogram, has completely ousted the older Edison cylinder phonograph from the market.

The earliest "gramophon" records made under Berliner's original patents had a diameter of 7 in. They carried about 2 in. of recorded surface and their total "playing time" was approximately one and a half minutes. Berliner's original "gramophons" were all turned by hand. They employed a steel needle and instructions were given that the needle should be removed and carefully sharpened from time to time.

The First Spring Gramophones

In 1898 the first spring gramophones were sold in this country. They were manufactured by the Gramophone and Typewriter Company, Ltd., a concern which has now grown into the world-famous Gramophone Company, Ltd., of "His Master's Voice" renown. These early gramophones were, indeed, the first really commercial machines of this type to be put on the market. They employed a single-spring motor, the spring-box being set outside at the rear of the machine. The spring was wound up with a vertical handle. The turntable took the 7-in. Berliner records. A very crude type of mica soundbox was provided and attached to the soundbox by means of a projecting arm was a 14-in. long brass horn. These models were retailed at £5 10s. apiece. Very few of them were made, however, for, almost immediately, improvements in the machines and soundboxes began to be made.

A continental type of phonograph which was marketed in large quantities at the end of the last century.

(Continued on page 246.)

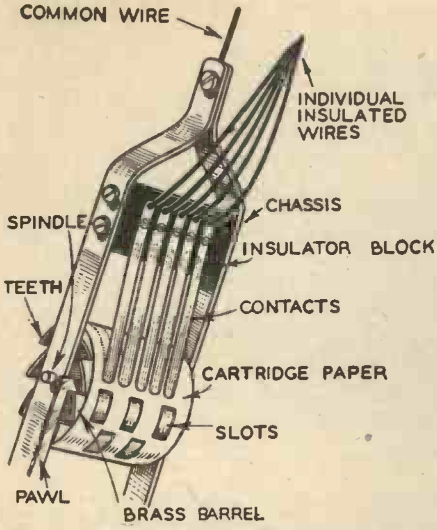


Fig. 3.—The operating end of a rotating-type switch which is connected to the kite string.

KITE-FLYING BY NIGHT

Ingenious Methods of Illuminating Kites with Ordinary Flashlamp Bulbs, Thus Enabling Them to be Seen when Flying by Night.

HERE is a development of the ever-popular kite-flying pastime. The main idea is for the kite to carry a number of small pocket-lamp bulbs and a small battery, so that the kite can be flown at night with interesting effect. No special type of kite is required, nor are any structural alterations necessary. The weight of the lamps and the battery makes little difference to flying qualities, although much depends, of course, on the size of the kite, and the adjusting of weight distribution may require some care. It is, therefore, advisable to make flying adjustments in daylight, as these cannot be easily carried out in the dark. It is necessary to keep the weight of the parts within reasonable limits, but these are fairly wide. A single super-power torch cell used with 1·5-volt bulbs are suitable eqnipment. The cell is stripped of its paper covering and attached to the main spar with a turn or two of black insulating tape. The lamps are most easily fitted by wiring them in the required positions with one of the connecting wires.

A simple example is shown in Fig. 1. Two bulbs are fitted to the cross spar, sufficiently removed from the tips to prevent damage in cases of crash. The connections between the lamps and the cell are made with 24 S.W.G. bare copper wire, soldered at the necessary points. The switch, if it can be so called, is a pin, to the head of which is soldered a flexible wire. When the lamps are required alight, the pin is inserted behind the insulating-tape binding, thus making contact with the zinc case of the cell. The connecting wires should be drawn fairly tight and fixed to the spars wherever possible to prevent them vibrating in the wind, which would result in broken soldered connections. Cotton, thin string, or sealing wax should be used for the purpose. Although this is a very simple arrangement, the effect at height is attractive, especially if the lamps are coloured with the stains which can be purchased for staining glass.

Changing Lights

Steady light soon palls, however, and to get the greatest fun from night-flying kites, some form of switch should be fitted which turns the lights on and off or changes the colours at the will of the operator. Fig. 2 shows a type of switch operated by pulling the kite string. The switch consists of a chassis which may be of iron, brass, or aluminium, formed to the shape shown. The draw-bar, to which the kite string is attached, passes through a hole, drilled in the end of the chassis, to the brass slide, which moves up and down in the two slots cut in the side of the chassis. The slide is returned to its forward position by the spring, which must be strong enough to do this when the kite is flying normally and there is a steady pull on the string. When the string is jerked against the kite, the slide is pulled forward. The pawl is made from a piece of springy brass, soldered to the top of the slide so that when the slide moves backwards or forwards the notched brass-fibre contact wheel is rotated. This wheel is made of brass and cut to the shape shown in Fig. 2, and drilled through the centre to take a spindle which is then soldered to the brass shape. Riveted to the brass shape is a fibre shape of the same dimensions, but in such a position that the tips of the fibre shape are half-way between the tips of the brass shape. This makes an eight-toothed wheel, the alternate segments of which are of metal and insulating material. The wheel is located centrally in the chassis by two small collars slipped on each side of the spindle. Contact to the wheel is made through the combination brass-fibre strip secured to the insulator block, which is in turn secured by two screws to the chassis. The contact also holds the wheel in the position wherever the pawl leaves it. The switch must be located as near the kite as possible to keep the resistance of the leads as low as possible. One of the leads from the switch can be used as the string between the switch and the kite. The second connection is made with thin flexible insulated wire, tied into the kite lead in several places.

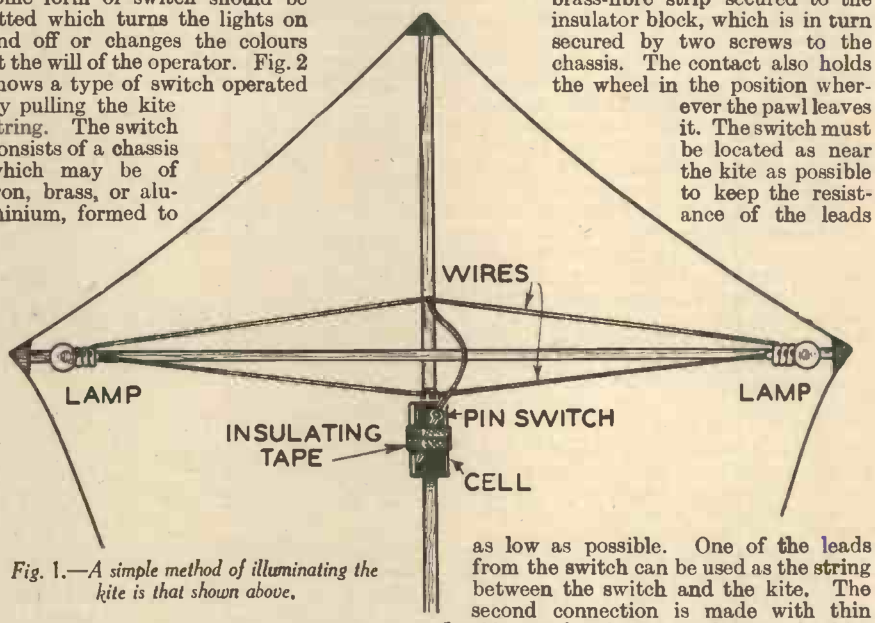


Fig. 1.—A simple method of illuminating the kite is that shown above.

A Rotating Switch

The operating end of a rotating-tvpe switch which is connected to the kite string and switches off or on different lamps is shown in Fig. 3. It has a wider chassis than the single switch, to take a brass barrel which consists of a piece of brass tube, with a core of wood, drilled to take a spindle which is located in two holes in the

(Continued on page 244.)

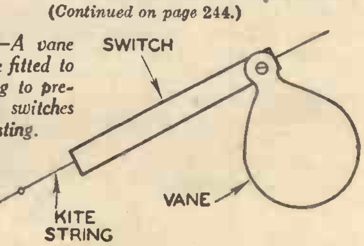


Fig. 4.—A vane should be fitted to the string to prevent the switches from twisting.

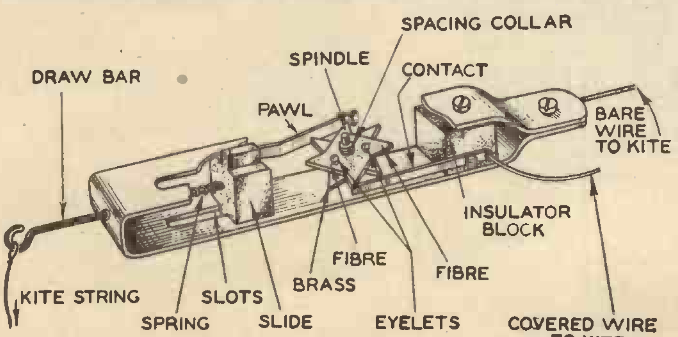


Fig. 2.—This type of switch is operated by pulling the kite string.

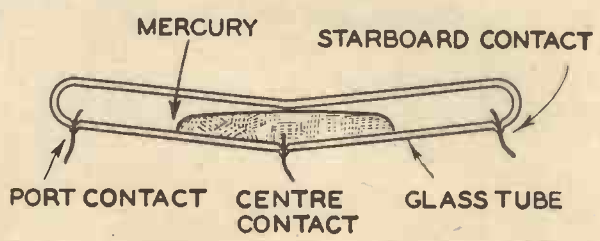


Fig. 5.—A mercury switch for indicating the movements of the kite.

MEASURING CANDLE POWER ELECTRICALLY

A simple device for measuring the brilliance of light sources.

The complete and simple apparatus described. The positions of the wood screws on the wooden arm can clearly be seen.

THE little device shown in the photograph has many uses, and gives interesting and valuable information. It depends for its action upon the use of one of the modern types of "photronic" cells, and while these are somewhat expensive, they give the apparatus a very valuable characteristic not possessed by the simpler kinds of photometers, *i.e.*, they permit of a permanent calibration which dispenses with the continual use of a standard light-source for comparison purposes.

Indeed, if one requires results of only the standard of accuracy demanded in most practical work, for making comparisons, etc., it is quite feasible to omit the initial calibration operation altogether, and work entirely on the basis of the figures given by the makers of the cell for its output when excited by a standard amount of light. These figures are naturally averaged from a number of examples, but can be taken as applying to any individual specimen sufficiently closely to meet ordinary needs.

The Weston Photronic cell gives an average output of 0·14 milliamperes per 100 foot-candles, which, of course, is the light which falls upon the cell when it is placed at a distance of 1 ft. from a light source of 100 candle-power.

The Cell Described

This type of cell has the property of actually generating an electric current when light falls upon it, and so long as that current is drawn off through a suitable external circuit it is proportional to the intensity of the light. Hence, in its simplest form a photometer using a cell of this sort consists only of the cell itself and an electrical measuring instrument of appropriate type, whose readings can be taken as an exact indication of the amount of light falling upon the cell.

In practice it is convenient to mount the cell up in such a way that it is easy to place the lamp whose output is to be measured at a standard distance from the face of the cell, and properly facing the glass "window" of the device. The photograph shows the effective layout which is used, the cell being mounted in a wireless valve holder (American type, not European), its two pins fitting into the "P" and "F" sockets. Tae holder is screwed to the end of a strip of wood a little over 2 ft. long, which enables the bulb to be tested at distances of 6 in., 1 ft. or 2 ft. from the face of the cell.

At a distance of 6 in. from the cell draw a 2-in. diameter circle, and round the circumference of this insert three round-head wood screws equally spaced out. The screws should be fitted as shown, so that the three heads provide a three-point positioning device for the bulb of the lamp to be tested. The operation is then repeated at positions 1 ft. and 2 ft. from the cell respectively.

If each bulb is set down on the heads of the screws the filament will automatically be located over the centre of the circle around which the screws are placed, regardless of the size of the bulb itself, so long as the latter is of the usual spherical shape. This arrangement suffices for most routine tests, but, of course, special measurements must be made when the lamp bulb is of some other shape, or when it is seen that the filament is located some way from the centre of the globe.

Measurements of Light

In making measurements of light it is best to take the 1-ft. position as the standard, since it lends itself so readily to estimation in terms of foot-candles. The point is that since the distance is then unity, the figure for foot-candles is the same as that for actual candle power. Thus a 100 candle power lamp placed on the 1 ft. mark gives an intensity of 100 foot-candles.

The reason for using other distances than 1 ft. is simply to get readings which suitably come on to the scale of the electrical measuring instrument, bearing in mind the wide range of light outputs of the different sizes of lamps on which it may be desired to make tests. It is well, however, to convert all readings obtained at distances ot ıer than 1 ft. into the figures which *would* have been got at the standard distance, in order to simplify the actual calculation of the candle power of the lamp. Thus, when it is necessary to place the bulb at 2 ft. to avoid running off the top end of the meter scale, the figure should be multiplied by four to find the equivalent reading at 1 ft. (It will be realised that the reason for multiplying by four, although the distance has only been doubled, is to be found in the fact that the intensity of a given light varies inversely as the square of the distance.)

In the case of small lamps which have to be set at the 6 in. position in order to get a clear reading, the figure should be *divided* by four to find the equivalent intensity at a foot. This position will be found desirable in most cases (it actually depends upon the nature of the scale of the measuring instrument) for bulbs up to 100 watts, while those over this size and up to about 500 watts should be placed at a foot. Really large lamps will require the 2-ft. distance.

Completing the Apparatus

The electrical instrument which completes the apparatus consists of a low-reading milliammeter, the one employed having a scale reading from 0–1·5 milliamperes. An expensive "dead-beat" instrument is scarcely necessary here, but a clear and fully subdivided scale is important. The connections are extremely simple: one terminal of the meter is joined to one side of the cell, and the other terminal to the remaining point on the cell.

The milliammeter is connected to a flex lead from the cell holder, and this should be joined to the meter whenever the apparatus is to be used.

To make a measurement, one simply places the lamp bulb down upon the three screwheads, with the neck of the bulb pointing horizontally away from the cell, and notes the reading shown by the milliammeter. For all general comparative work it suffices in the case of the Weston cell to convert this into candle power by assuming that a reading of 0·14 milliamperes denotes a light intensity of 100 foot-candles. Thus, suppose that the reading obtained is actually 0·28 milliampere at the 6-in. distance. This is equivalent to 0·07 milliampere at the standard 1-ft. position, and the candle power is therefore $\frac{0{\cdot}07}{0{\cdot}14} \times 100$, which works out to 50 candle-power. The general rule, therefore, is first to convert the current reading into that which would be got at the standard distance of 1 ft., then divide this by 0·14 and multiply by 100. Obviously, if the measurement were actually made at a foot the preliminary conversion would be unnecessary, and one proceeds straight to the next step.

Accurate Readings

The results obtained by these methods are sufficiently accurate for their main purpose of making comparisons, checks on condition after life tests, and so on, but it may be objected that avoidable errors are introduced by the rather primitive method of positioning the bulbs for test. It is true that this does not take account of possible variations in the position of the filament inside the bulb, and while the errors which result may be small in most cases, it may be of use to point out that they can be averaged out when desired for a specially accurate check.

The method is quite simple: first, a measurement is made in the manner previously described, then the bulb is set in an inverted position, with the round globe resting on the screwheads as before, but with the neck and cap upwards, whereupon another reading is taken. Next, the bulb is turned through a quarter of a revolution, still in the same (cap-uppermost) position, and the reading again noted. A further quarter turn is then given, the reading taken, another turn is given, and so on until the bulb has been turned right round. The result will be five sets of figures, one for the normal position with the bulb on its side, and four for the cap-upwards settings. These readings are then averaged, by the usual method of adding them all together and dividing by the total number of readings (five).

MODEL

By

Model submarines of the most interesting to use. providing that proper pre- them once they

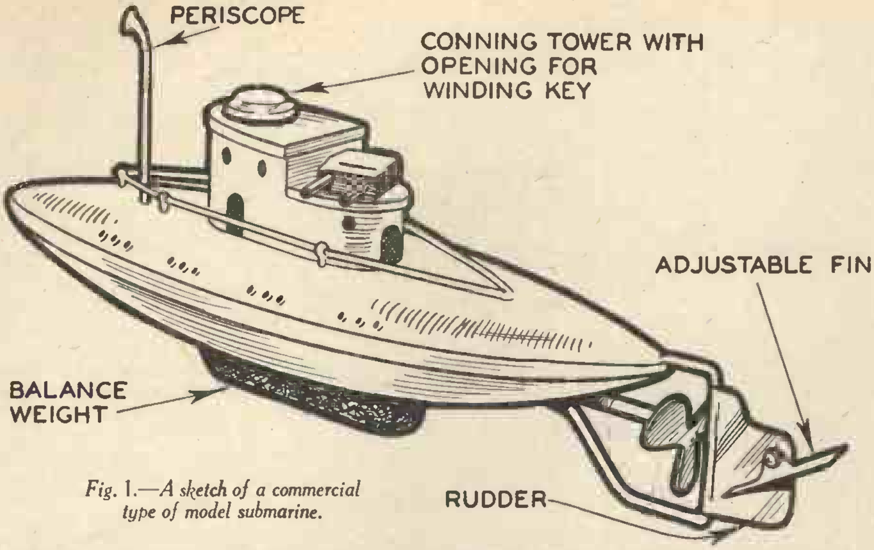


Fig. 1.—A sketch of a commercial type of model submarine.

THE model with which it is proposed to deal is fitted with a solid hull made from any suitable wood, and derives its motive power from an elastic motor. It is similar in principle to the commercial model shown in Fig. 1, but whereas this model travels through the water in a series of short dives (see Fig. 2), the model about to be described will travel a considerable distance under water, only coming to the surface when the rubber motor is spent.

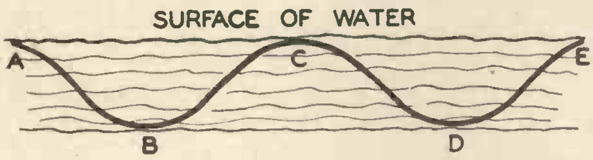


Fig. 2.—A, B, C, D and E shows the path in the water of the model submarine shown in Fig. 1.

The Hull

The hulls of the large and small models shown in the photograph are made of mahogany and deal respectively. The dimensions and shape of the larger model are shown in the scale drawings (Fig. 3).

The upper deck for the large model consists of a piece of wood $10\frac{1}{2}$ in. × 1 in. × $\frac{3}{8}$ in., shaped as shown, but it must have a central groove running right through from end to end on the lower side. This is to enable a piece of copper or brass wire of about 20 gauge to be passed through it.

Conning Tower and Periscope

This is made from a piece of wood $1\frac{7}{8}$ in. × $\frac{1}{4}$ in. × $1\frac{1}{4}$ in. with rounded ends. The periscope for the smaller model is a piece of wire, and in the case of the larger a piece of light tubing. It is an advantage to have a long periscope from the experimenter's point of view, but a round periscope offers considerable resistance when being driven through the water. Therefore a flat or knife-edged periscope fore and aft is a decided advantage. Do not forget that the whole of the model has to be driven through the water, and although rubber, weight for weight, has some six times the energy of a coiled steel spring, you must cut down resistance as much as possible.

The Propulsion Apparatus

This naturally divides itself into two parts: (1) the motive power, (2) the propellers or screws.

The reason for using rubber as a propulsive power in this type of model is because it is unaffected by water. Its drawback, however, is the resistance set up by the untwisting and vibration of the rubber under the water. However its advantages far more than compensate for this, and since the motive power is external, there is no need to build a watertight boat.

It will be noted that both models, even the smaller one, and the torpedo, are all fitted with twin propellers.

It must be remembered that these models travel at quite a good speed, and therefore the elastic will run out very quickly. To avoid the irksome task of continually winding the motor by hand, a winder similar to that used for model aeroplanes should be constructed. This can easily be made from an egg beater.

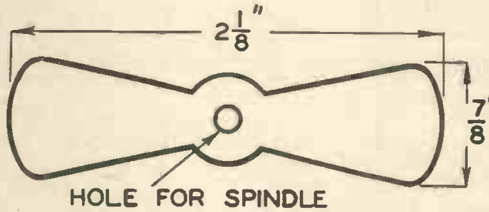


Fig. 4.—Details of the propeller.

For the small model only one skein of $\frac{3}{16}$ in. strip rubber is used, but the larger model requires three strands. When fully wound the large model travels at least 30 to 40 yd., and the smaller model 15 to 20 ft.

Before joining the two ends of the elastic, a small brass ring should be slipped over the

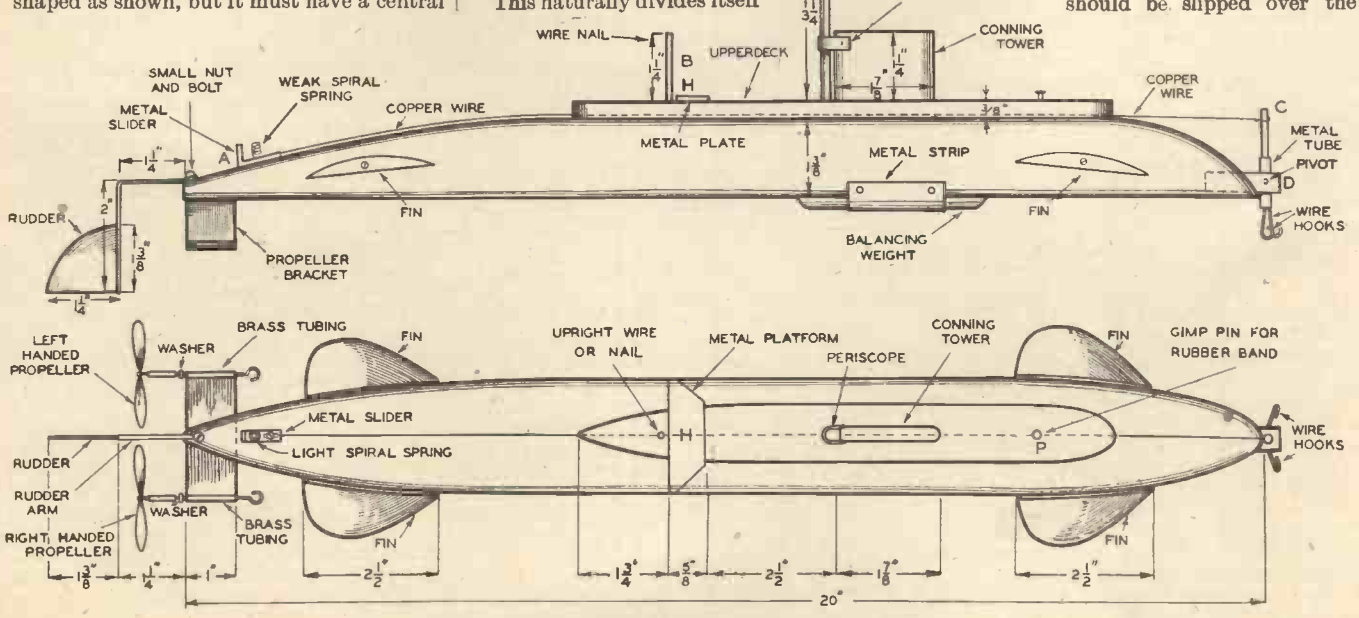
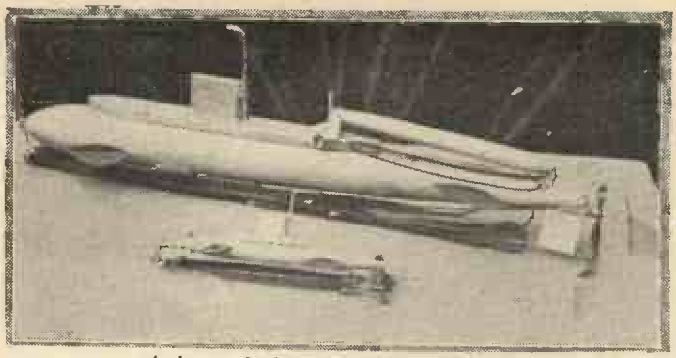


Fig. 3.—A side and plan view of the model submarine described.

SUBMARINES

V. E. JOHNSON, M.A.

type shown are both easy to construct and Their working parts are of the simplest and, cautions be taken, there is no danger of losing are in the water.



A photograph of the models described in the text.

rubber, which is in turn fitted over the steel wire hooks attached to the prow. When winding, these rings are slipped over the hooks of the winder. It is an advantage to slip a small piece of cycle valve tubing over each steel wire hook to prevent the rubber wearing.

The Propeller Bracket and Propeller

Obtain some lengths of 22 gauge bore brass tubing (copper will do), and solder these pieces of tubing to the ends of a strip of brass or tin (*i.e.*, sheet iron tinned) bent as shown in Fig. 6. The angles at B and C should be such that the tips of the propellers will just clear them.

The propellers can have two, three or four blades, but the two-bladed will be found the simplest to construct. Cut out two pieces of thin sheet brass or tinned sheet iron to the shape and dimensions shown in Fig. 4. Drill a hole as shown and solder the propeller blank to the tube; the length of the tubing being sufficient to allow the blades (when twisted) to clear the bracket. Next solder to the brass tubing a piece of steel piano wire long enough to form the axle and hooks for the rubber. The propeller blanks must now be turned into "screws" and given their proper "pitch." They must, of course, have opposite "pitches," and should be twisted with the fingers. In every case the blades should be given a considerable twist until they are at an angle of 70 degrees to one another. This avoids too much "slipping" when the motor starts at maximum power.

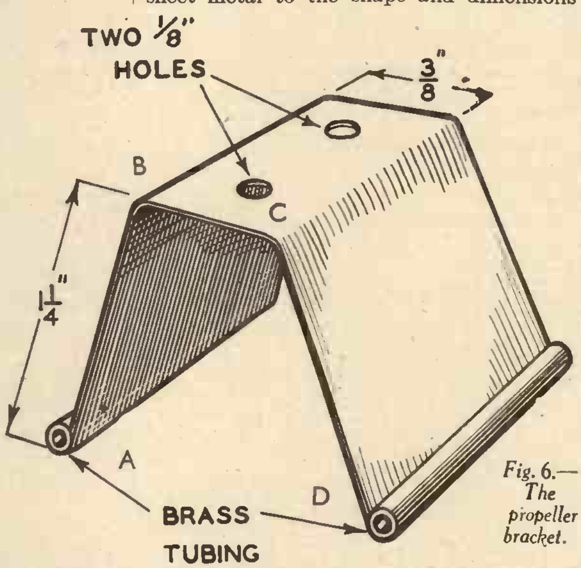


Fig. 6.—The propeller bracket.

The Vanes or Diving Fins

As already stated, these and the balancing weight, constitute the controlling part of the mechanism. Cut out a piece of thin sheet metal to the shape and dimensions shown in Fig. 5. Next drill a ⅛ in. hole as shown, turn up at right angles the upper part A.C.B. along the line A.B.

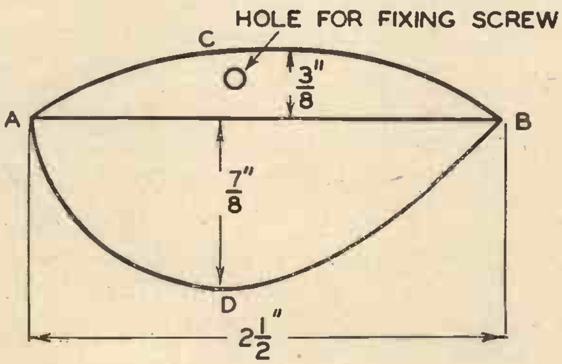


Fig. 5.—How the fins are made.

Four fins are required, and these are fastened to the wooden hull with an ordinary screw. Their positions can be easily altered, but wherever fixed, each pair must be symmetrically placed.

The balancing weight consists of a piece of half-round iron (see Fig. 7). The ends should be filed off at a sloping angle so as to lessen resistance. When fitted, the flat side of the weight is against the bottom of the model and it is held in place by metal bands. Its size and weight must be such that the model just floats, the larger model however, must sink up to the upper deck, the stern being lower than the prow.

Adjust the weight and balance of the model so that when the propellers revolve and drive it through the water it will dive, steeply or gradually, without the propellers and rudder coming out of the water.

The rudder bracket consists merely of a piece of bicycle spoke bent at right angles, one end of which has been heated, softened and beaten out flat. Through this a hole is drilled and the bracket is fastened to the hull by means of a small nut and bolt. The rudder is bent round and soldered to the vertical portion of the bracket.

Dimensions of Smaller Model

Length, 7½ in.; maximum breadth, ¾ in.; maximum height or depth, ¾ in.; the maximum breadth is about quarter distance from prow to stern. Depth of upper deck ¼ in.; length, 2⅞ in.; breadth ½ in. Conning tower depth, 2 in.; length, ¾ in.; breadth, ¼ in. Periscope height, 1½ in. Diameter of propellers nearly 1 in. Length of fins 1¼ in.; maximum breadth (horizontal portion), ⅝ in. Dimensions of propeller bracket, ¾, ¼, ¾ in., total 1¾ in.; breadth fore and aft, ¾ in.

The actual length of the model shown in the photograph is 6½ in., but another inch is added so that the wire hooks for the motor need not project in front.

How the Torpedo is Held and Released

Referring to the elevation drawing

(*Continued on page 244.*)

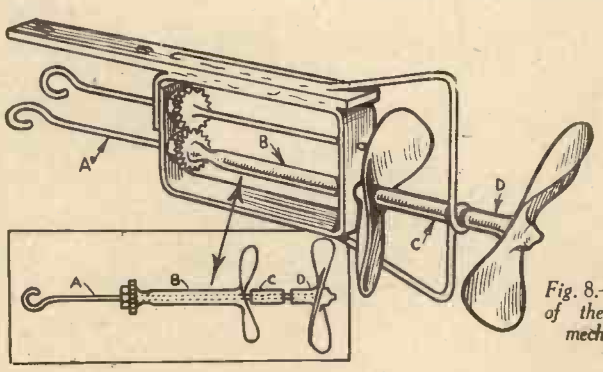


Fig. 8.—Details of the driving mechanism.

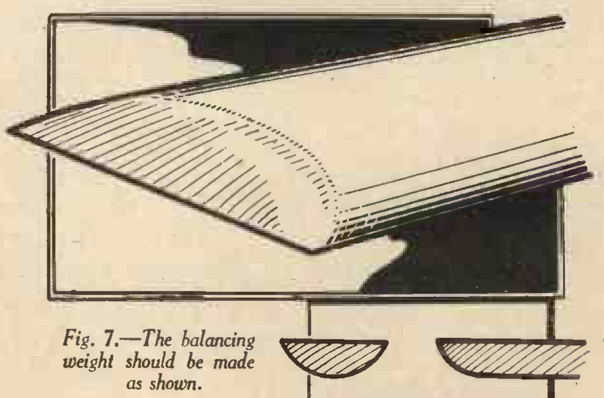
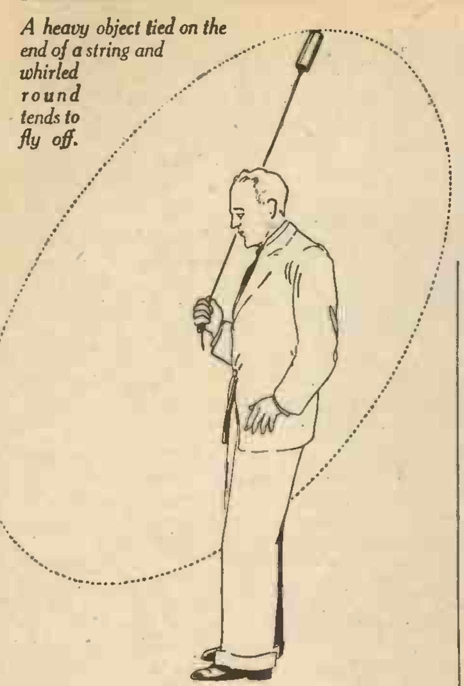


Fig. 7.—The balancing weight should be made as shown.

THE WONDERS OF GRAVITY

The great mystery which, however much its effects have been made clear, no modern invention or discovery has done anything to solve.



A heavy object tied on the end of a string and whirled round tends to fly off.

EVERYONE knows that a heavy object tied to the end of a string and whirled round tends to fly off, and if suddenly released will do so. Suppose the string to be 3 ft. long whirled round five times per second. The linear velocity of the weight is then slightly over 93 ft. a second at any instant. The linear velocity of an object on the earth's surface relative to the earth's axis differs at different latitudes between zero at the poles to some 1,400 ft. per second at the equator, yet an object at the equator shows no tendency to fly off. The rate of change of direction of any moving part of the earth's circumference, relative to the earth's axis, is only 360 degrees in twenty-four hours, while the rate of change of direction of our object on the end of the string is as high as 360 degrees in one-fifth of a second. It is rate of change of direction, not linear velocity, that counts, but still it might be expected that objects on the earth's surface, except at the poles, would show some tendency to leave it, rather than to seek contact with it if removed.

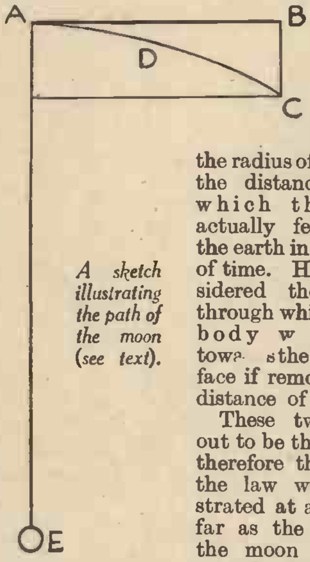
Early Research

One of the first facts that we become acquainted with in life—often very unpleasantly—is that all bodies, if unsupported, fall to the ground. We do not, perhaps, wonder at it, because it is so universal. But we should wonder if it ceased to be so, or rather we should not wonder at it at all, because no opportunity would be given us of so doing. If gravity ceased to act for the twinkling of an eye, it would involve the end of all life so far as this earth is concerned, and no one would live to tell the tale.

As we study the stars we find that their courses are regulated and governed by this same law of gravity. What is this law? It is as follows: *Every particle in the universe attracts every other particle with a force varying directly as the product of their masses, and inversely as the squares of the distance between them.*

Mechanical Deductions

It is often stated that Sir Isaac Newton discovered gravitation, but such a statement is absurd. What he did was to prove mathematically that the mechanical deductions from this law did really explain observed phenomena. He first established it in the case of the moon; the manner in which he did so being as follows. He considered the moon as a body falling in one sense towards the earth. Let us make this a little clearer. Suppose the arc ADC represents the path of the moon relative to E, which is the earth. Were it not for the attraction of the earth, the moon would proceed along the straight line AB and traverse AB in the same time that it would have taken to go from A to C along the curved line ADC under the earth's attraction. Suppose ADC be the distance the moon goes in one second of time, BC is the distance, so to speak, through which it has fallen in that period, due to the earth's attraction. Newton first computed from the known velocity of the moon in its orbit and from the radius of that orbit, the distance through which the moon actually fell towards the earth in one second of time. He next considered the distance through which a heavy body would fall towards the earth's surface if removed to the distance of the moon. These two worked out to be the same and therefore the truth of the law was demonstrated at any rate so far as the earth and the moon were concerned. He afterwards demonstrated it for the whole solar system, and thence was led to infer his grand theory of universal gravitation stated above.



A sketch illustrating the path of the moon (see text).

Powers of the Law of Gravity

Modern science has fully confirmed this inference, and in so doing has infinitely increased our ideas of the wonders and powers of this law. It annihilates both time and space and may be said to be the greatest of all wonders, the mightiest of all marvels, either ancient or modern.

There are various theories to explain the various phenomena but not one to which exception cannot be taken. Le Sage imagined interplanetary space to be filled with very tiny corpuscles, travelling in all directions at very high velocities. An isolated body in space will not be affected apparently by collisions with these corpuscles, since the collisions are distributed equally in all directions. But if two bodies, A and B, are in proximity, the body, B, will act as a screen and intercept a portion of the bombarding corpuscles, which but for it would have struck A. Then the collisions received by A from the side away from B will have no counterpart or be only imperfectly compensated, and will drive A towards B. Now these bombarding bodies must be either inelastic, partially elastic or perfectly elastic. If they are the last named the effect is *nil*, because the corpuscles intercepted by the body, B, would be replaced by others which had rebounded from B, and it can be proved that the compensation would be perfect. If they are not perfectly elastic, heat must be generated, and according to Poincaré the temperature of the earth would be raised 10^{26}, that is:

1,000,000,000,000,000,000,000,000,000

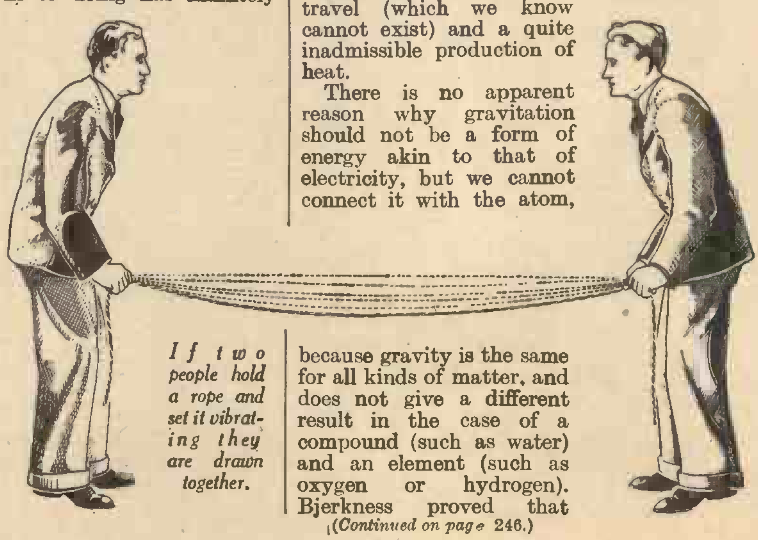
degrees a second or, in other words, would receive 10^{20} times as much heat as the sun emits in all directions!

Much the same results follow if we imagine the ether traversed by waves coming from all directions in space. We know that when a material object (like the earth) receives a luminous wave, this wave exerts on it a mechanical action due to the Maxwell-Batholi pressure, just as if it had received a blow from a material projectile, but this is not borne out by comparing the velocity of light, 186,000 miles per second, with the even far greater rate at which the force of gravity *begins* to take effect.

Two Possibilities

If we replace the ordinary laws of mechanics by what is often termed the "New mechanics" and the principle of relativity, we arrive at no more satisfactory a result. For two impossibilities must be pre-supposed—a very appreciable resistance of the medium through which the solar system and other heavenly bodies travel (which we know cannot exist) and a quite inadmissible production of heat.

There is no apparent reason why gravitation should not be a form of energy akin to that of electricity, but we cannot connect it with the atom, because gravity is the same for all kinds of matter, and does not give a different result in the case of a compound (such as water) and an element (such as oxygen or hydrogen). Bjerkness proved that



If two people hold a rope and set it vibrating they are drawn together.

(Continued on page 246.)

ALL RADIO QUESTIONS ANSWERED FREE.

The PRACTICAL MECHANICS Wireless Experimenter

Every Question must be accompanied by the Coupon on page iii of Cover

THE TWO-GUINEA THREE-VALVER

An efficient low-priced three-valve receiver of modern design

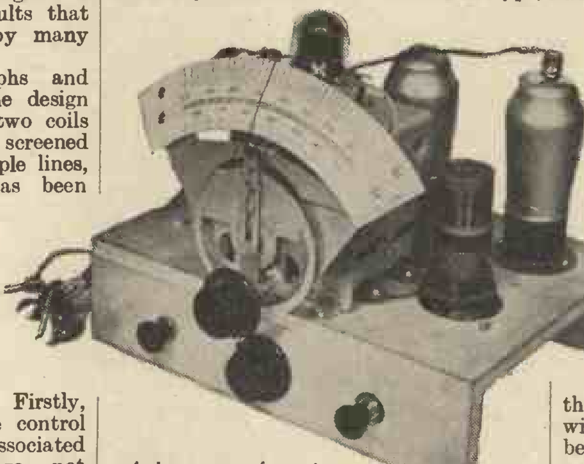
COST is one of the chief considerations of every receiver, but it must always be borne in mind that cost must be considered as a collateral part of performance. It is possible to build a three-valve set for a few shillings, but obviously it cannot be expected to produce the results that would be obtained with a similar circuit constructed from parts bearing well-known trade-marks. In the "Two-Guinea Three-Valver," however, a low-priced receiver has been produced incorporating high-class components which will give results that greatly exceed those obtained by many receivers costing several pounds.

The accompanying photographs and wiring plan will reveal that the design follows certain new lines. The two coils which are employed are not of the screened variety, but are built up on simple lines, although the method which has been adopted in arranging the windings renders them extremely efficient.

The Circuit

Three valves are employed in the well-tried combination, S.G., detector, and output stage. The H.F. valve is not of the variable-mu type, and this enables cost to be reduced quite considerably. Firstly, there is the saving of a volume control potentiometer; secondly, the associated voltage-dropping resistances are not required, and the extra decoupling required for variable-mu working are not necessary.

The aerial circuit is of the H.F.-transformer type, giving high selectivity with good signal strength, and the coil which is used to couple the H.F. to the detector valve is of a similar type, thus avoiding the expense of an H.F. choke and coupling condenser. Coupling between the detector and output valves is by means of a directly-fed L.F. transformer, and it will also be seen that expense has been saved in this stage by dispensing with the customary H.F. choke used for reaction. The primary of the particular L.F. transformer which has been employed provides ample choking effect, and smooth reaction is obtainable throughout the tuning range. Decoupling has been incorporated in this stage, and the necessary condenser is of the tubular type, which is very much cheaper than the usual type of condenser, and it is connected directly to the appropriate points by means of the wire ends.



A three-quarter front view of the receiver.

The Controls

Although their are four controls on the front panel, there are only two which are of prime importance, namely, the main tuning control (upper centre) and the reaction control immediately below it. The remaining two knobs control the wave-change and the filament switching, and are therefore only subsidiary. With regard to the main tuning control, this operates on the two-gang condenser, and it will be seen from the illustrations that a special slow-motion tuning dial is fitted to the condenser. An Amplion loud-speaker has been specified and this efficient unit enables advantage to be taken of the quality reproduction. This loud-speaker in conjunction with the particular output valve which has been specified will enable really high-class reproduction to be obtained, and there will be no suggestion, when the receiver is working, that it cost such a small sum.

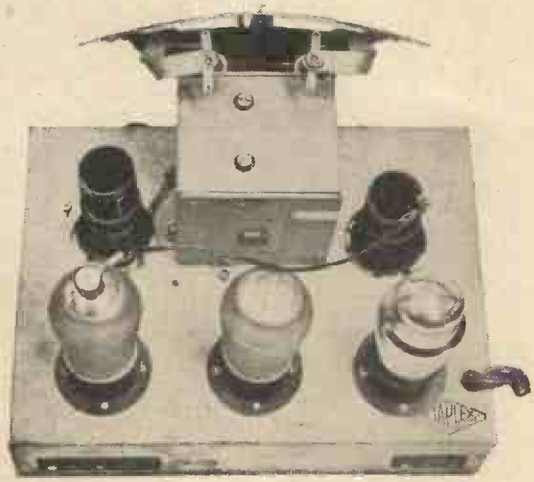
A three-quarter rear view of the set.

The Wiring

With such a limited number of components, construction is naturally greatly simplified, and it reduces itself to the mounting of the ganged condensers, the coils, the valveholders, and the connecting of the separate contacts, in some cases by means of ordinary wire, and in others by means of the wire ends of resistances or condensers. To accommodate the valve-holders you must drill 1¼ in. holes, and for each of the coils the holes must be 1½ in. On the rear of the chassis, drill small holes to accommodate the socket strips, and on the front of the chassis clearance holes for the three controls. Assemble the valveholders, the socket strips, the two switches, and the reaction condenser, and carry out as much of the wiring as possible with these parts only in position. The advantage of this method of construction is to be found in the ease with which the chassis may be handled and turned about. If you mount the coils and the ganged condenser, not only is the complete chassis more weighty, but you have to exercise some care to avoid damage to the coils. When you have affixed all those wires that are possible, add the L.F. transformer and complete the wiring to this. Now place the coil clips beneath the chassis and lock them in position. Attach the gang condenser, and the chassis may then be inverted, as the condenser is higher than the coils and will prevent them from being damaged. Complete the wiring and the receiver is ready for a test.

Testing Out

When the aerial and earth are connected, plug in the H.T. leads to the H.T. battery, inserting H.T. + 1 into the 60-volt socket and the H.T. + 2 plug into the 120-volt socket. It may be found desirable at a later stage to vary the voltage at H.T. + 1, but for the preliminary tests 60 volts will



A plan view showing the neat layout at the top of the baseboard.

be found quite satisfactory. The G.B. plug should be inserted into the 6-volt socket, and the positive plug into the socket so marked on the battery. Now switch on the receiver with the right-hand switch, set the reaction control to zero and slowly turn the tuning control. The local station should be heard at some point, and it should be tuned in to its maximum strength, without using the reaction if possible. Should no station be heard, use may be made of the reaction control in order that some kind of signal may be obtained for trimming purposes. Now with a non-metallic screwdriver adjust the trimmers on top of the ganged condenser, slowly swinging the main tuning knob whilst so doing in order to keep the signal at the correct point. It should now be possible to turn the tuning knob throughout the entire tuning range and find many stations without the use of the reaction control. To build up signal strength the latter should be used, but in the interests of quality, keep the reaction always at minimum. The change to long waves is carried out by rotating the left-hand knob, and a number of long-wave stations should be heard, Droitwich occupying only a small space on the dial and enabling Radio-Paris to be heard quite clearly without overlap. When the receiver is functioning correctly, experiments may be carried out with the H.T. + 1 plug in order to find the most suitable tapping point for your particular valve and aerial system, but when once this has been found it may be ignored until the battery has run down.

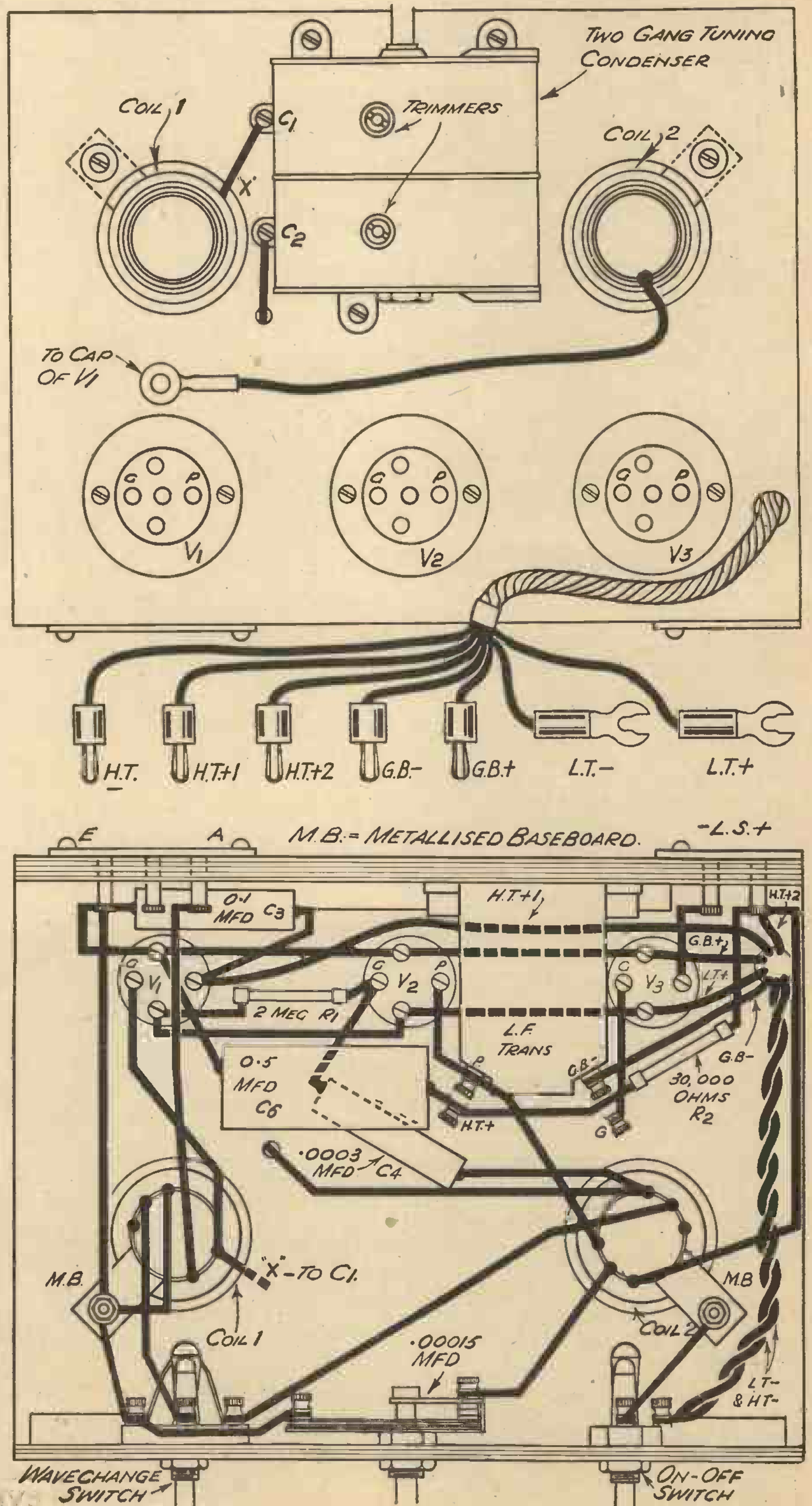
The Coloured Leads

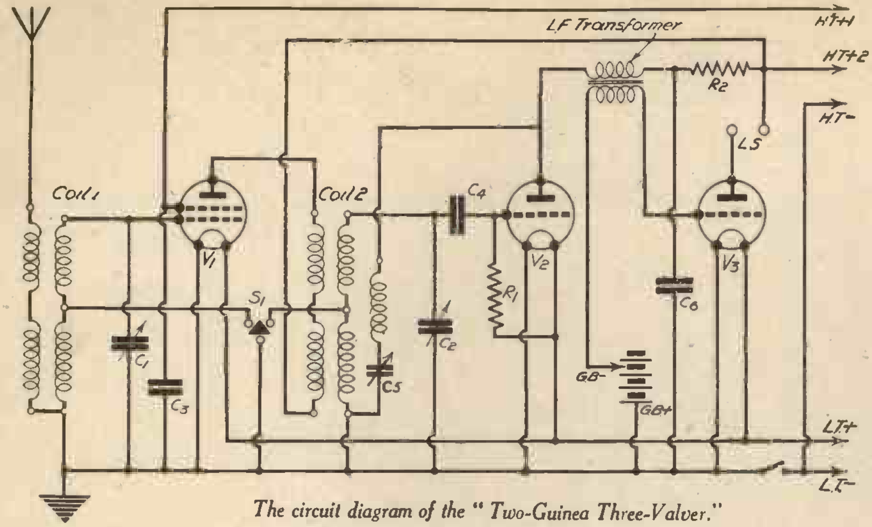
When the coils are purchased they will be found to have lengths of coloured wire, approximately 9 in. long, attached to all points, with the exception of one. The latter is the connection on top of the H.F. transformer to which the anode of the S.G. valve is joined. The other ends of the coils

LIST OF COMPONENTS FOR THE TWO-GUINEA THREE-VALVER

- Two Hall-Mark Coils (B.T.S.).
- One Midget 2-gang Condenser (Polar).
- One Micro-drive Arcuate Drive (Polar).
- One ·0003 mfd. Reaction Condenser (Polar).
- One 3-point Wave-change Switch (Ward & Goldstone).
- One 2-point On-off Switch (Ward & Goldstone).
- One L.F. Transformer, 5/1 (Niclet) (Varley).
- One Tubular ·5 mfd. Condenser (T.M.C.).
- One Tubular ·1 mfd. Condenser (T.M.C.).
- One Tubular ·0003 mfd. Condenser (T.M.C.).
- One 2 meg. Grid Leak Type G1 (Ferranti).
- One 30,000 Resistance Type G5 (Ferranti).
- Three Four-pin Valveholders (Clix).
- Two Terminal Strips A.E. and L.S. (Clix.)
- Five Wander Plugs (H.T. –, H.T. + 1, H.T. + 2, G.B. +, and G.B. –) (Clix).
- Two Spade Terminals (L.T. + and L.T. –) (Clix).
- One Battery Lead (Ward & Goldstone).
- One Metaplex Chassis, 8½ × 6½, with 2 in. Runners (Peto Scott).
- Three Valves, V.P.215, (four-pin) D210, PP.220 (Hivac).
- Two Batteries, 120 volt H.T., 9 volt G.B. (Exide).
- One "Lion" Loudspeaker (Amplion).

THE ABOVE—AND UNDERNEATH—CHASSIS WIRING PLAN OF OUR TWO-GUINEA THREE-VALVER





The circuit diagram of the "Two-Guinea Three-Valver."

will have to be joined so that the coloured wires are connected as follows :—

Coil No. 1 (aerial coil).
Aerial lead : Pale blue.
Earth lead : Black.
Wave-change switch : Yellow.
Grid and tuning condenser : Two white leads.

Coil No. 2 (H.F. transformer).
Grid and tuning condenser : Two white leads.
Detector anode : Dark blue.
H.T. plus : Red.

Receiver Design

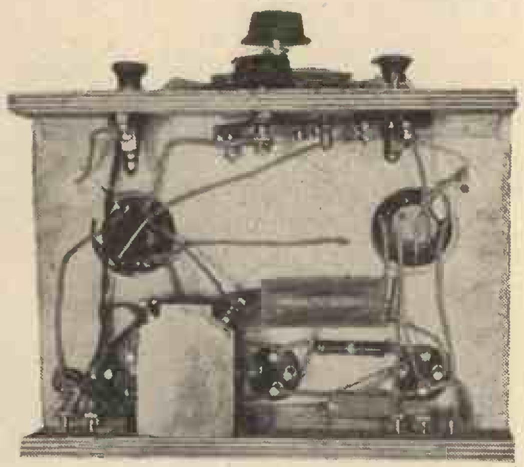
It is interesting to compare this receiver with other models which have been published by us from time to time, and the general overall dimensions will be one of the first points which will strike the eye of the older experimenter. This is in no small measure due to the neatness of the particular gang condenser which is specified, and this represents a marked advance on the designs of even last year. A single tuning condenser would have occupied at least as much room a year ago, and yet to-day two sections, each of ·0005 mfd., have been accommodated in an all-metal casing, complete with a dust cover and trimming condensers, with overall dimensions of approximately the same size.

Using a Pick-up

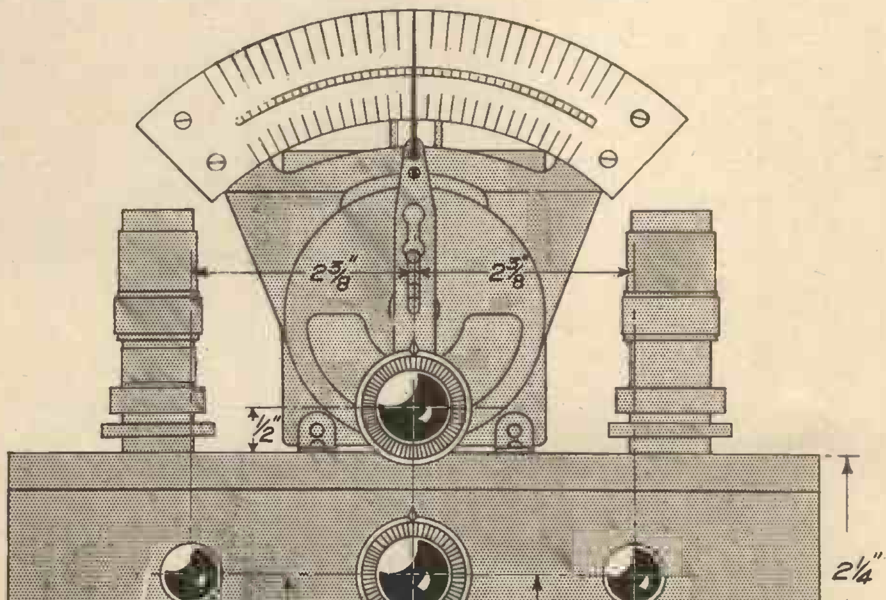
A gramophone pick-up may be used with the receiver, by joining it between the grid of V2 and a tapping on the grid-bias battery. Condenser C4 is joined to the grid of V2 as well as to one side of the grid-leak R1. Disconnect these two points from the grid, but leave them joined together, and connect them to one side of a single-pole change-over switch. This may be of the push-pull type, the Q.M.B. type, or any other suitable variety, and may be mounted on the front or rear chassis strip as desired. The arm of the switch should then be joined to the grid of V2, whilst the other contact should be joined to one of the pick-up leads. The other lead must now be provided with a wander-plug and inserted into the 1·5 volt tapping on the grid-bias battery. The switch will enable the receiver to be adapted for records or radio at will, and this is more convenient than joining the pick-up direct to the grid and setting the tuning control at 0 when records are being reproduced. If it is desired to provide the pick-up as part of the actual make-up of the receiver, the terminal strip on the rear—at present used for the loud speaker—may be replaced by one having also pick-up sockets, and thus the receiver will have greater adaptability. Obviously these improvements mean extra expense, and for that reason they were not originally specified. They are, however, permissible refinements which will in no way mar the performance of the receiver, but which will make it even more valuable than its original form.

Results

It will have been noticed on other occasions that we do not give a list of the stations which can be heard on any of our receivers. This is, of course, a rather dangerous practice, as conditions vary so much in various parts of the country. Thus, the Londoner may expect to hear stations which probably are inaudible to the listener in Cornwall or Devon, and so on throughout the country. This particular receiver, however, may be relied upon to give really good reception of dozens of stations, naturally at different strengths. Entertainment value is the point which counts when receiving a station, and it is of little use tuning into a station with reaction adjusted to the oscillating point, and with the receiver in such a condition that an atmospheric or some other disturbance sets the receiver into oscillation. Consequently we do not claim 100 stations on this receiver, but in most parts of the country it should be possible to hear all the English and majority of the Continental high-powered stations at comfortable volume, with a judicious use of the reaction control.



An underneath view of the receiver.



Dimensions for the knob layout.

WHAT IS THE

The Interesting Story of a Lowly Organism and a

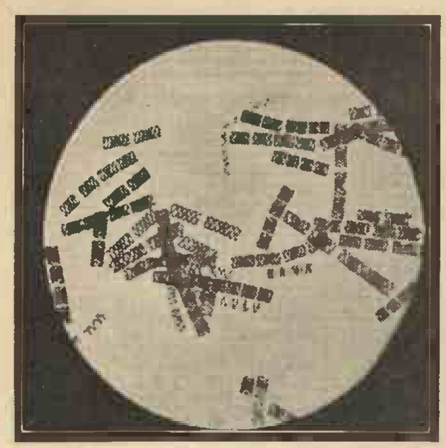


Fig. 1.—The dormant or resting stage of the spirogyra during the winter. It is termed the "single-cell" stage of the plant.

DURING the spring and summer months of the year any pond, ditch, brook or slowly-running stream will almost certainly be found to contain, either at the bottom of the water or floating upon the surface, a bright green mass of material of a fibrous or hair-like nature. If the brook is a slowly-running one, the vivid green mass may often be seen attached to some submerged twig from which it will throw out waving streamers in the direction of the current of water. More frequently, however, particularly if the water be more or less stagnant, the green mass will appear on the surface and, being entangled with various other materials, will assume a gelatinous nature. In this state it is often referred to as "green slime," and, indeed, the description is an accurate enough one, for if the mass of green matter be taken up in the palm of the hand it will pass through the fingers in a slimy and not very pleasant manner.

If a small quantity of this green slime be placed on a piece of white paper and examined even under a low-powered hand lens, it will at once be observed that the mass is made up of an enormous number of bright green filaments which have all become matted up together. A higher-powered lens will disclose the fact that these filaments are jointed and that they carry peculiar markings.

Such is the *Spirogyra*, one of the commonest of the lowly plant organisms which flourish in ponds, ditches, pools, and, in fact, in any patch of fresh water in which the current flow is not too swift. Although one of the commonest of microscopic aquatic plants, the spirogyra is one of the most remarkable subjects known to botanical and biological science. The life-cycle of the spirogyra never fails to fascinate the beginner in botanical and microscopical science, and even the "old hand" at the game finds fresh interest in the observation of the spirogyra every time he redirects his attention to the subject.

The "Single-cell" Stage

Let us commence our acquaintance with the spirogyra by observing it in the state in which it is shown in the photomicrograph (Fig. 1). This is the "single-cell" stage of this minute plant growth. It is the condition in which the plant usually exists during the cold winter months on the bottom of the pond. As will be seen from a glance at the illustration, the plant, in this state, consists of single oblong cells. Perhaps two or three of them may be linked up together, but never more than this number. It requires but a medium-powered microscope to disclose the fact that each plant cell has a very brilliant green spiral band running round its interior walls. This spiral band is characteristic of the spirogyra. Indeed, the organism takes its name from this characteristic formation, the word being derived from the Greek, *speira*, a coil, and *gyros*, a ring.

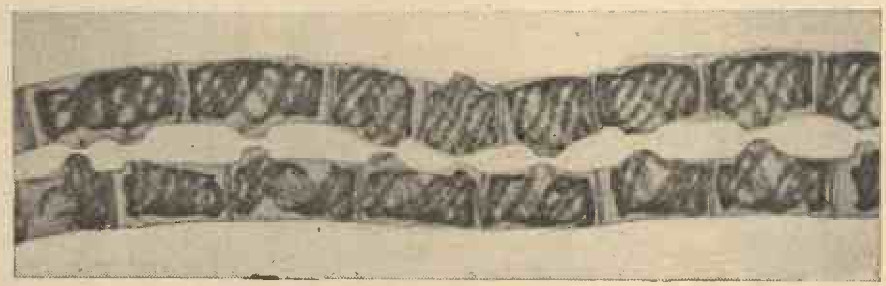


Fig. 3.—The spirogyra reproduces itself. First stage. Two adjacent filaments begin to put out small projections, each directed to the opposite cell of the adjacent filament. Note the characteristic spiral band formation of the cells from which the plant organism derives its name. Each separate cell is actually no more than one hundredth of an inch in length.

The average length of the single cells of the spirogyra is not more than a hundredth of an inch. After the turn of the year, and particularly when the frosts have departed, the spirogyra casts off its dormant single-celled state. Each spiral-lined cell begins to grow rapidly in both directions. At each end it adds on cell after cell, all the added cells being exactly of the same pattern, until, eventually, it develops into a filament a yard or more in length. These are the green filaments which are seen waving gently below the surface of the water. If, on the other hand, the filaments float loosely on the water's surface, they generally become matted together and entangled with dirt and foreign matter, thus forming the well-known green slime.

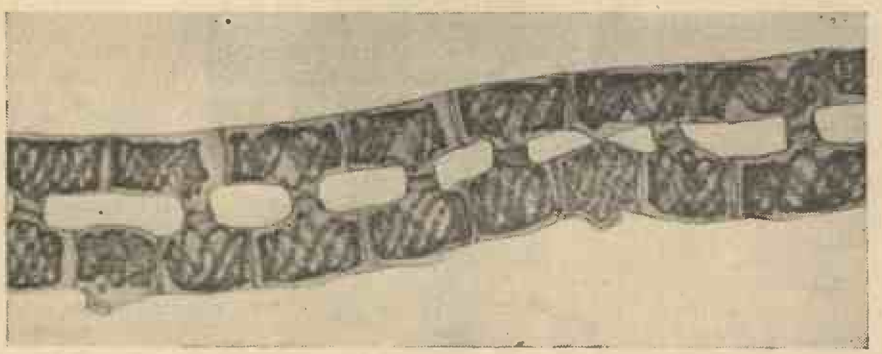


Fig. 4.—Second stage of the spirogyra's reproduction progress. The extended projections have now grown firmly together, uniting the adjacent filaments in ladder-like formation.

A Remarkable Change

During the early summer a remarkable change comes over the spirogyra plant. After its growing energy has become exhausted it begins to think of reproducing itself. And the high-power microscope photographs which you see on this page illustrate very clearly the manner in which this extraordinary plant provides for its next generation.

The tangled and matted filaments of the plant first of all break away from their

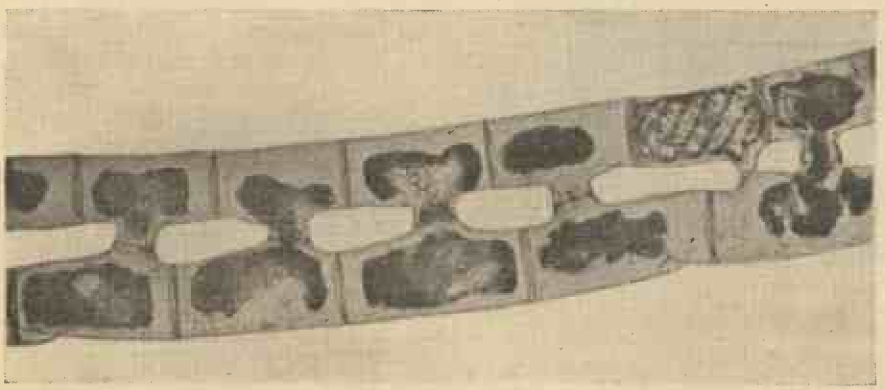


Fig. 5.—Third stage of the reproduction. The spiral pattern of the cells is lost. The contents become disorganised and flow in a jelly-like mass from one cell to the opposite one through the newly-formed "bridges."

SPIROGYRA?

Fascinating Subject for Study under the Microscope

points of attachment if they are anchored to any submerged object, and they drift to some area of the pond or brook in which a minimum of water is present. Then two or more of the green filaments which happen to be closely adjacent begin to grow tiny gelatinous " processes " or projections, each projection being directed towards the opposite filament. In time these projections meet one another and unite firmly together, forming a sort of ladder-like arrangement with the two adjacent filaments. The spirogyra filaments are now said to be " in conjugation."

Soon after arriving at this stage the filaments lose their interior spiral pattern. Their characteristic colour goes too. They turn brown, and the contents of their cells changes to a brown-green jelly which

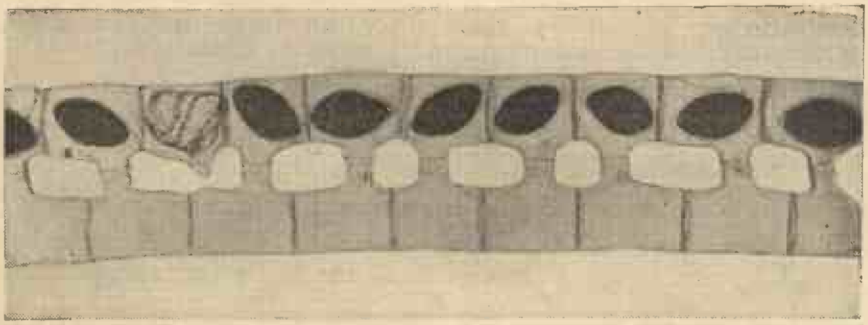


Fig. 6.—The completion of the process. Seeds or " zygospores " have now been formed in the spirogyra's cells. These will give rise to new plants during the following spring.

passes freely from the cell of one filament across the newly-grown bridge and into the immediately opposite cell of the adjacent filament.

A week or two elapses, and then another remarkable change takes place. The jelly-like mass in the cells of the filaments gradually assumes an oval shape. It has, in fact, formed itself into spores or seeds, and very extraordinary seeds they are, too, for they are covered with no less than three protective coats which serve to preserve them from injury until the following year's germination time comes round again. These seeds or spores are termed " zygospores " (from the Greek, *zygos*, a yolk) and, having been formed in each of the cells of the spirogyra filament, the latter sinks to the bottom of the pond towards the end of the summer. There, during the winter-time, the cellular material which composes the filaments gradually rots away, thus liberating the zygospores, each of which forms a new filament in the following spring.

Very often conjugation takes place not only between spirogyra filaments which exist side by side, but also between those which lie at right angles to each other. Such is the " lateral conjugation " of this tiny plant organism, and its effect is to increase the entangling and matting of the filaments together.

During the warm months of the year the spirogyra is able to reproduce itself without going through the zygospores stage. If a small portion of a single filament be taken and placed in suitable water it will quickly extend itself at both ends by the simple process of adding on new cells. Indeed, this is what the spirogyra is continually doing all through the summer months. It thus makes up for losses or injuries received by it when a pond is cleared, when cattle happen to wade through the pond, or when fishes and other aquatic creatures, some of which are very partial to the bright green filaments of the plant, devour portions of it.

A Super Oxygenator

And now, having perused this article and examined the photomicrographs, you will be wondering in your own mind what is the exact use and purpose of this unique plant organism. Nothing, it is often asserted, is without its due uses in the natural creation. The spirogyra certainly has a very important use. It is an oxygenator of water. Sometimes it often works as a super-oxygenator. In bright sunshine the spirogyra filaments absorb the carbon dioxide which is produced by the decomposing vegetation and other matter in the water and, in return, give out pure oxygen. Indeed, when the spirogyra is present in ponds, the water frequently becomes oxygenated beyond saturation. That is why, when the green slime on the surface of pond-water is examined it very often will be observed to entangle countless small bubbles among it. They are all bubbles of the purest oxygen.

Fig. 2.—Here the single cells of the plant have linked themselves up together. Growing freely at both ends and intertwining, they quickly become a matted mass of green slimy material.

Thus, by the operation of the spirogyra and other similar oxygen-evolving plants, Dame Nature keeps a constant and kindly balance. She endeavours to prevent waters from becoming foul and putrefactive, sour and offensive. A natural area of water, if left to itself, will never remain evil-smelling for long. Nature will sooner or later provide the cleaning-up agent, and one of the efficient scavengers which she uses for this purpose is the tiny bright-green filamentous plant, the remarkable life-story of which has formed the theme of this article.

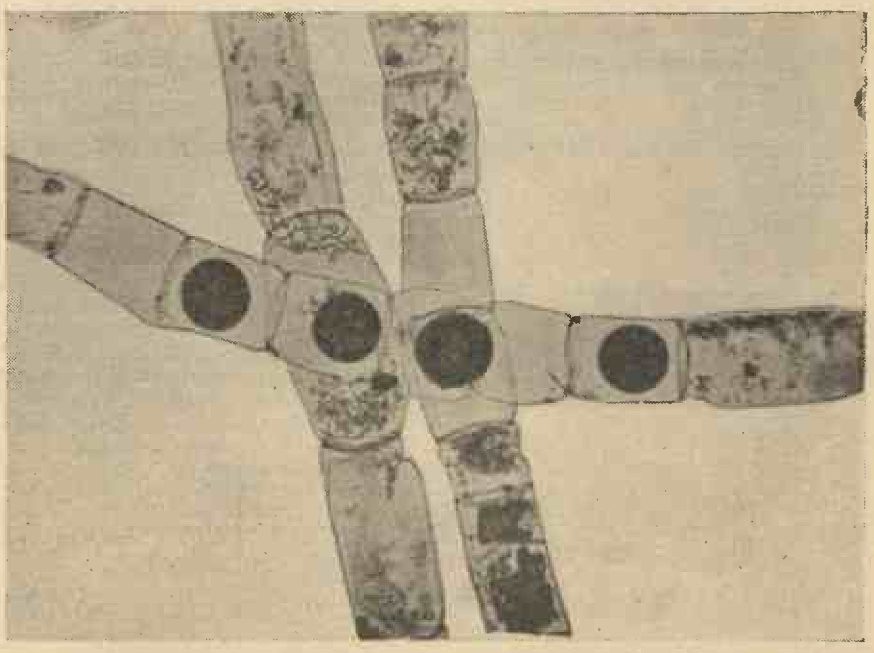


Fig. 7.—Spirogyra filaments in " lateral conjunction." One filament, passing at right angles, has united to them. In this manner the filaments become matted and entangled together.

REMARKABLE MODERN MACHINERY

British-made machine tools have long been recognised as the finest in the world, and the examples illustrated in this article are no exception to the rule.

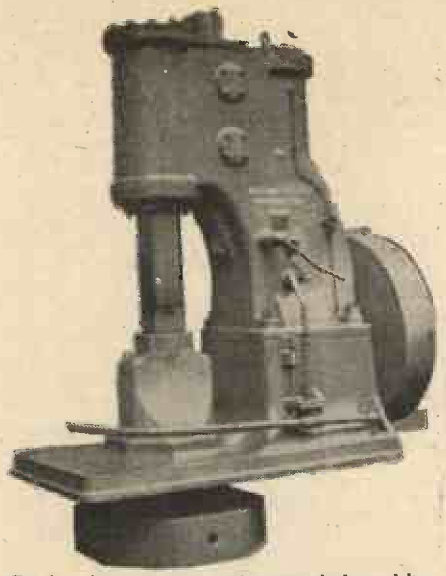


Fig. 1.—A pneumatic power hammer which can deliver up to 200 blows per minute.

AT the recent Machine Tool and Engineering Exhibition at Olympia a wonderful display of machine tools and other appliances was seen. The Great Hall of Olympia was transformed into a huge engineering workshop, and resounded with the familiar hum of machinery in motion, huge power hammers at work, and heavy duty metal saws cutting their way through thick iron bars.

Some of the machines were no larger than a small bench lathe, while others were over 15 ft. long and weighed over 20 tons. Precision machinery was seen working to very fine limits, and there were small band-saws cutting through mild steel plate ½ in. thick with the ease of a fretsaw cutting through a piece of plywood.

Automatic Machines

Automatic multiple gear-cutting machines, which have done so much towards cheapening motor-car chassis construction, were much in evidence, together with multi-spindle drilling machines. One of these machines, designed for valve hole drilling and reamering on motor-car engines, is 11 ft. 9 in. in height and weighs approximately 4 tons. It has eight drilling spindles in a row, which are driven, through reducing gears, by an electric motor mounted on top of the supporting framework.

Several heavy-duty lathes were at work, and some were turning thick shavings from mild steel with the ease of a knife cutting cheese. One of these huge machines admits 15 ft. between centres, and will turn work up to 3 ft. diameter. It is powerful enough for the heaviest roughing cuts, and yet can turn work with the accuracy of a fine finishing tool. The faceplate is driven by a 50 h.p. motor through the medium of suitable gears.

A Mammoth Lathe

Another remarkable lathe was one for turning railway wheels up to 3 ft. 9 in. diameter. This machine is so arranged that the wheel sets (two wheels and an axle) may be rolled in from a track on one side, and after being turned may be rolled out to a track on the other side. In the centre of the lathe bed an electric hoist lifts and lowers the wheels from and to the rails. This lathe is driven by a two-speed 20/40-h.p. A.C. motor, and in a convenient position for the operator is a board carrying push-buttons for controlling all electrical movements.

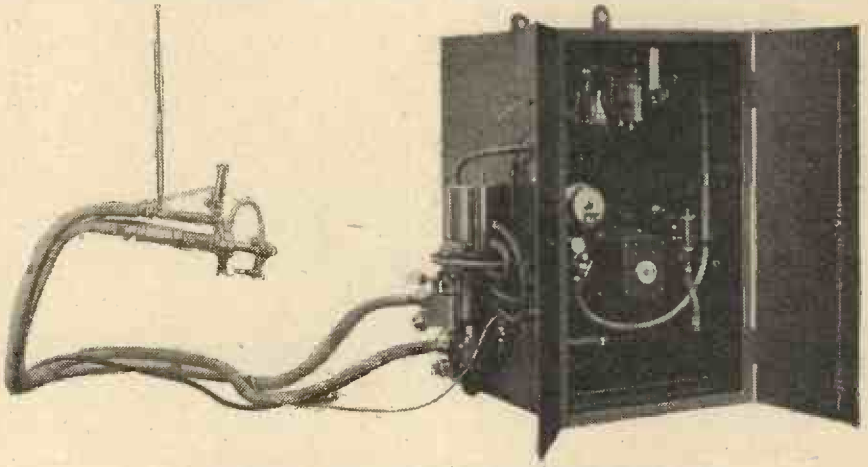


Fig. 2.—The Sciaky portable electric spot-welding machine largely used for motor chassis and body construction.

Another remarkable appliance which created a good deal of interest was a gas-jet cutting machine which, by means of oxygen and acetylene or coal-gas, and a suitable torch, will cut through mild steel or wrought iron plate at an astonishing rate. For instance, a piece of mild steel plate, 1 in. thick, can be cut through at the rate of 12 in. per minute. The machine has two compound slides, and will cut square or oblong holes; it has also a circular motion which enables holes from 1½ in. to 36 in. diameter to be cut. For cutting irregular-shaped holes a template is used for guiding the path of the torch.

A very interesting machine was a self-contained pneumatic power hammer made by B. and S. Massey Ltd., of Manchester. The accompanying illustration of this machine, (Fig. 1) shows the power cylinder, and behind this the pump cylinder, the piston in which is actuated by a crankshaft and connecting rod inside the casing. The crankshaft is rotated by a heavy flywheel, which in turn is driven by an electric motor mounted on the bedplate. By manipulating the controlling lever, the hammer will strike either single strokes or a series of blows, as required. Another movement of the lever allows the ram slowly to descend and grip the work on the anvil as in a vice. This type of hammer will deliver from 100 to 200 blows per minute.

Welding by Electricity

Another remarkable appliance was the Sciaky electric spot-welding machine

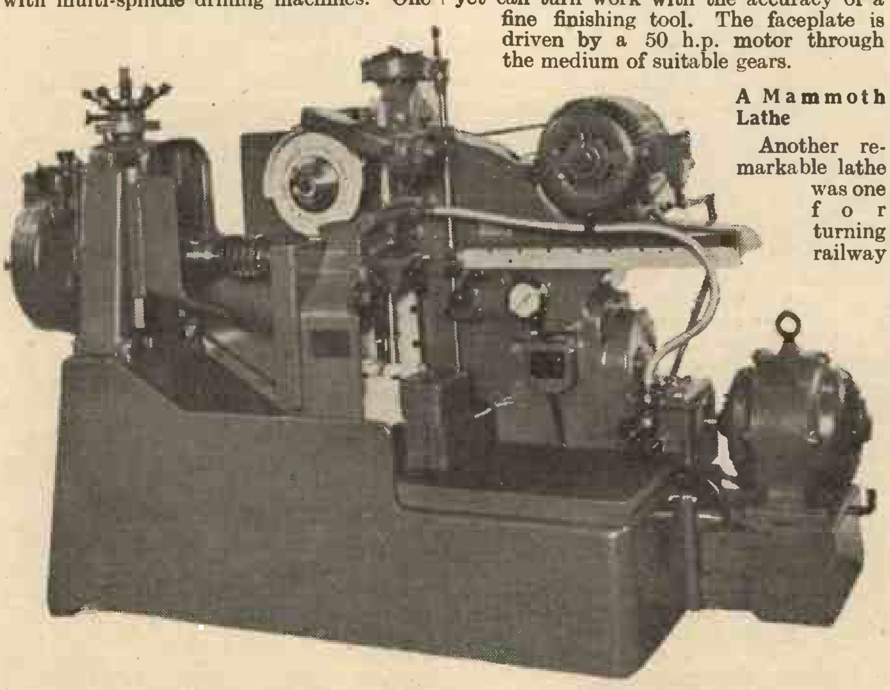


Fig. 3.—A general view of the Orcutt hydraulic gear-tooth grinder, used for the precision grinding of gear wheels for all kinds of machinery.

designed for welding together all kinds of metals, including aluminium, brass and steel. In the illustration (Fig. 2) a portable welder is shown, comprising a transformer with its associated control apparatus mounted in a steel casing. Water-cooled flexible cables are taken from the transformer secondary terminals to the welding pincer which grips the work during the welding operation. The moving electrode of the pincer is operated by a piston working in a cylinder under hydraulic pressure up to 1,500 lbs. per square inch. This hydraulic pressure is provided by compressed air under the control of a hydro-pneumatic relay fixed on the transformer case. The machine is put into operation by means of a small pneumatic push-button on the welding pincer. These welding machines, which are now largely used for motor chassis and body construction, are capable of welding up to 4,000 spots per hour, each welded spot taking the place of a rivet. It is claimed that spot welding is cheaper, and gives more lasting results than ordinary riveting.

A Mechanical Wood-carver

An ingenious machine which created a good deal of attention was a semi-automatic pattern-milling machine made by Wadkin & Co., of Leicester. This machine, which is illustrated in Fig. 4, carves out of wood coreboxes and patterns for castings. The block of wood to be machined is clamped to a table, which can be moved in any direction like the slide-rest of a lathe. Immediately above the work on the table is the revolving cutter spindle, which is driven by an electric motor through the medium of belt-driven shafting and spiral gears. The overhanging arm carrying the spindle head is mounted on sliding ways on the main frame, and can be raised and lowered either by power or hand feed. There are many different shapes and sizes of cutters which fit into the end of the cutter spindle for cutting the different kinds of grooves, channels and profiles met with in pattern work. On one of these machines it is possible to make the two halves of a complicated corebox, each measuring 3 ft. × 2 ft., out of solid blocks of wood in approximately three hours. The time taken to do the same job, without the aid of the machine, would be about three days. This will give an idea of the amazing speed and accuracy with which the machine works, and incidentally, it also shows what a high standard of workmanship is displayed in British-made machine tools.

An Ingenious Gear-tooth Grinder

Another wonderful machine was the Orcutt Hydraulic Gear-tooth Grinder, shown in Fig. 3, which is used for accurately grinding the gear wheels used for motor-cars, aeroplane engines, electric motors, and many other kinds of machinery. The gear blanks to be cut are mounted on a horizontally reciprocating ram arranged immediately below a special grinding wheel, the edge of which is shaped to conform to the contour of the teeth. The grinding wheel is driven by the electric motor seen at the top right-hand corner of the machine, the motor at the bottom right-hand corner drives the main oil pump and suds pump. A jet of suds is played on the work, during grinding, for cooling and lubricating purposes. The casing seen on the left-hand side of the machine houses the index mechanism, which is locked while the grinding wheel is making its cutting stroke, but allows the gear wheel to be rotated one tooth at a time as the grinding proceeds.

It is interesting to note that in some of the world's speed-record flights the engine reduction gearing used played an important part. Without the accuracy of form, pitch and quality of surface which modern gear grinding alone can give, the life of the gearing, under the enormous stresses to which it is subjected, would have been of very short duration.

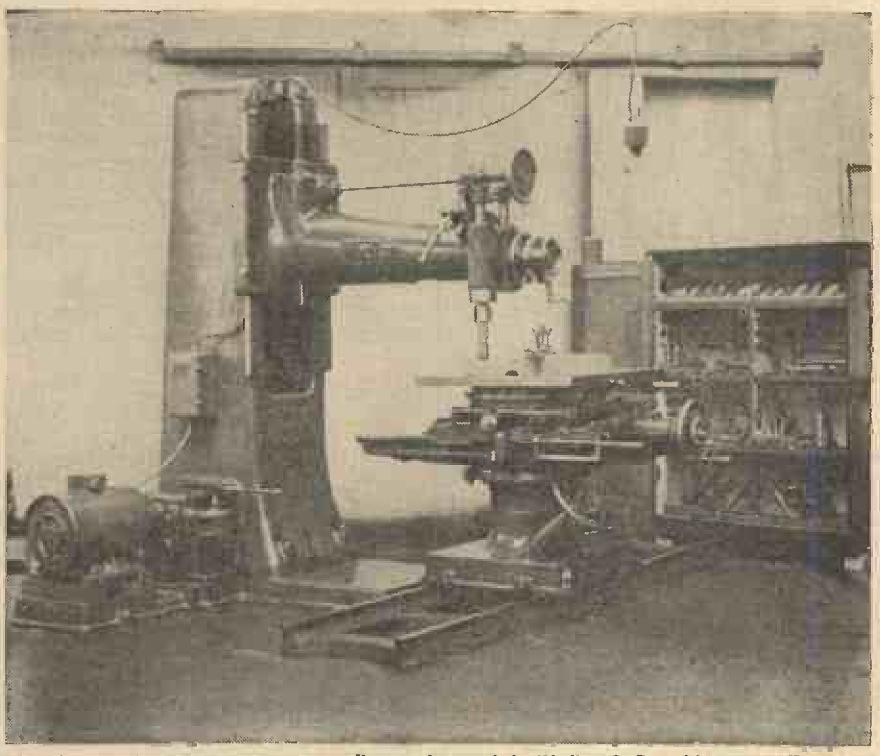


Fig. 4.—A semi-automatic pattern-milling machine made by Wadkin & Co., of Leicester. This machine rapidly carves intricate patterns and coreboxes out of blocks of wood.

MAKING AMORCES OR TOY CAPS

A. ST. HILL BROCK

AMORCES—or toy caps—consist of a fulminating mixture enclosed between two pieces of thin paper. The mixture generally used in this country, at any rate, is potassium chlorate and amorphous phosphorus in the proportions of five of the former to one of the latter. Caps of foreign manufacture formerly contained in addition potassium nitrate, antimony sulphide and powdered sulphur. Mixtures of sulphur and any chlorate in fireworks were, however, made illegal in 1895, on account of their sensitive nature.

Methods of Manufacture

The potassium chlorate is placed in a bowl and thoroughly wetted, a weak solution of gum is then stirred in and the phosphorus added and stirred. The result is a solution of about the consistency of thin treacle. A portion of the mixture is then spread evenly on a slate slab, and a tool known as a "dotter" is then used to transfer dots of composition to the paper sheets. This implement consists of a square of wood in which are fixed rows of metal pegs like bristles in a brush, but farther apart. The dotter is pressed on to the composition, then on to the paper, leaving rows of dots corresponding with the pegs. The sheets are next dried and blank sheets of paper are pasted over them, covering the dots. The double sheets are pinned between damp pieces of felt to ensure complete cohesion between the two layers of paper.

After being completely dried, the sheets are cut or stamped out into individual amorces and packed in boxes.

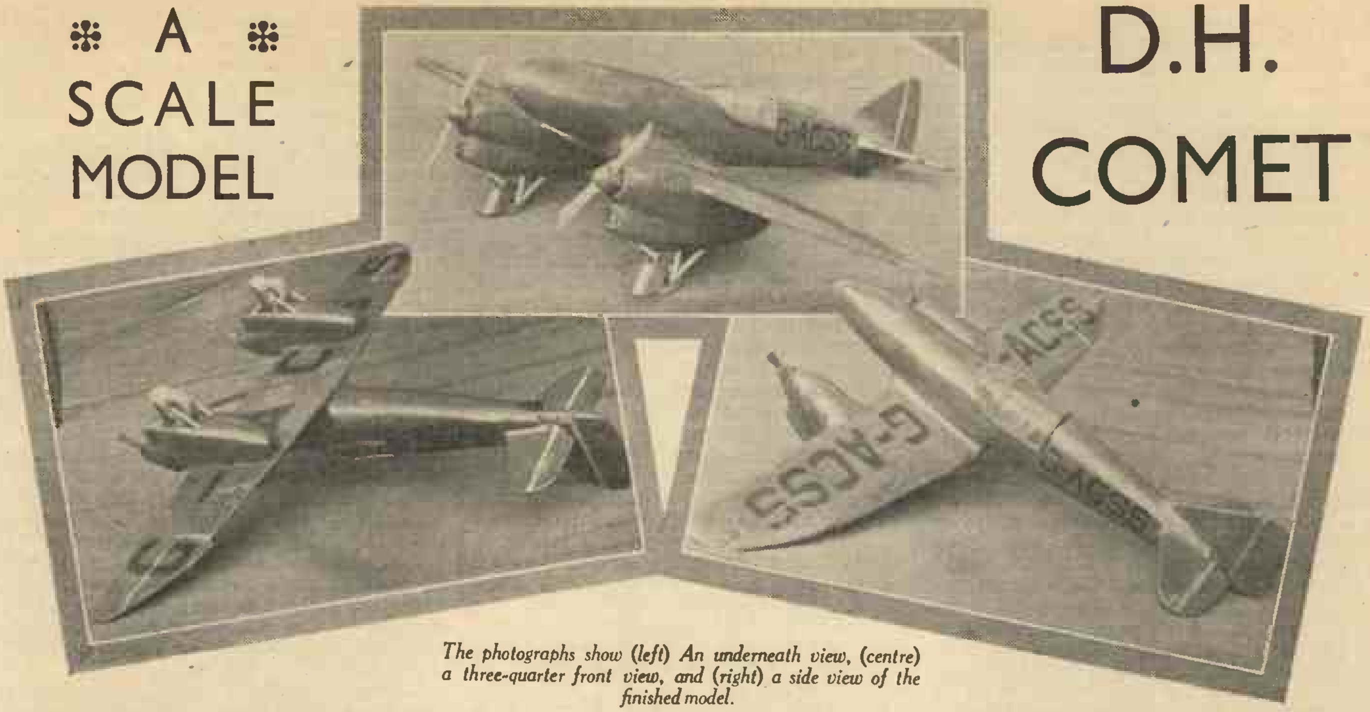
Serious Accidents

Although individually these toy caps are harmless, in bulk they are capable of exploding with extreme violence. The same may also be said of the composition used. Several serious accidents are attributable to them: of these the earliest on record is that which occurred in New York in 1864, when one person was killed and another blinded and otherwise injured. At Vincennes, in 1873, approximately a million and a quarter caps exploded as the sheets were being cut up, with the result that seven women were killed and three injured. In 1878 at Vannes, France, a boy of twelve, in order to frighten his sister, fired an amorce between the blades of his mother's scissors. Two packets of 600 caps were detonated by the initial explosion, killing and terribly mutilating the boy and injuring his sister. In May of the same year the most disastrous explosion of the kind occurred at an amorce factory in Paris. Fourteen women were killed and sixteen more or less severely injured, the building being practically destroyed. In this country three girls were killed and one severely injured when an explosion took place at a toy cap factory at Wandsworth in August, 1888. The small building in which the girls worked being blown literally to fragments.

"Toy Firework Factories"

Amorces, of course, may not be made except in a licensed factory, and it is interesting that although classified as fireworks, they cannot be made in a small firework factory as the composition is classed as a fulminate. They are manufactured in "toy firework factories," which are specially licensed to deal with small quantities of fulminating composition.

A SCALE MODEL D.H. COMET



The photographs show (left) An underneath view, (centre) a three-quarter front view, and (right) a side view of the finished model.

The first article of a series dealing with the construction of scale-models of most of the present-day aeroplanes.

IN the making of scale-model, non-flying aircraft, some suitable scale should first be decided upon, because one model having been built, it is extremely likely that, finding a really life-like model resulted with just a few hours of interesting work, one is tempted to build others until a collection of well-known aircraft is built up. If the scale is large, the resulting model may be all right for a solo exhibit, but when one becomes the owner of four or five large machines their effective display becomes rather a problem. If, on the other hand, a very small scale, say 100 to 1 is used, the model becomes so small that minute accuracy is required to get even a passable similarity, and, such being the case, the work becomes tedious and difficult for the ordinary worker. Let it therefore be decided to employ a scale of approximately 50 to 1, which brings the size of most general aircraft down to the 6-in. length mark, a reasonable size for a model. No exceptionally intricate detail is needed to get a correct effect, and the separate parts are easy to handle and capable of easy assembly and finishing.

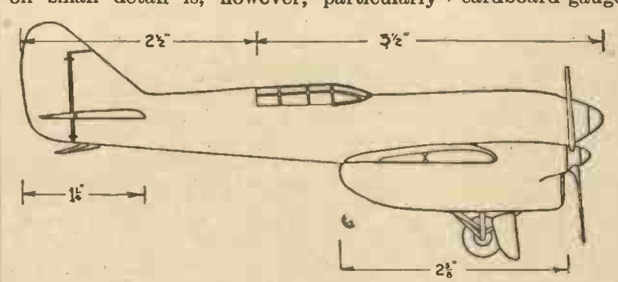
Tools and Materials

Good-looking scale-model aircraft can be built from the simplest of materials and with a small kit of tools. A couple of chisels (say, a $\frac{1}{2}$-in. and an $\frac{1}{8}$-in.), a sharp knife, a safety-razor blade, a brass-backed saw, a few household pins of different lengths, a tube of fish-glue, a brush or two, paint, sand-paper and some putty or plastic wood, are the main essentials. Practically any wood can be used. Most of the wood in the model which appears in the photographs was once actually doing duty as a garden fence! However, satin walnut is a very suitable wood, easily worked, usually straight-grained, reasonably hard, and taking a good finish. The quantities required for each model are so small that the cost becomes negligible. Three grades of sand-paper are usually required—rough for taking off radii and rounding curved bodies, medium for general finishing, and fine for rubbing down paint.

Colouring of the models can be carried out with three types of paint, Japanese lacquer being particularly good, covering well and having a clean bright surface. It takes a day or two to dry, which may be considered a disadvantage by some. The second material is cellulose, which also gives a good clean, bright surface, and can be brushed or sprayed on, and the third method is to use good-quality poster colour, which dries quickly and with a perfectly flat surface. Disadvantages of the last-named are that it cannot be used at all well on metal, and that it picks up dirt and finger-marks easily. The appearance of the dull surface on small detail is, however, particularly good, and if models are made purely for exhibition purposes its use is advised.

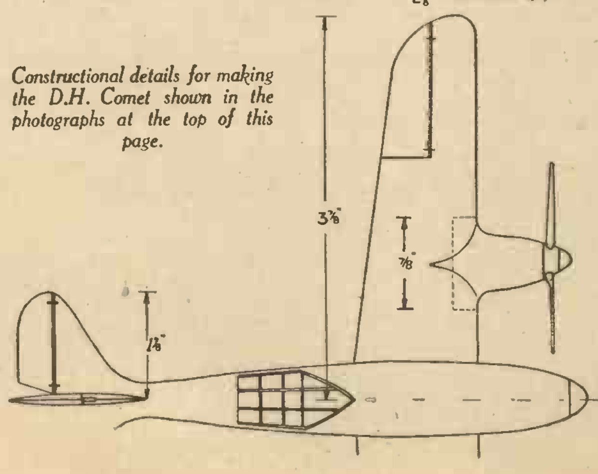
The Fuselage

The D.H. Comet shown in the photographs and in the drawings reproduced below has a span of $7\frac{3}{4}$ in. and a length of 6 in. The main dimensions are given, whilst the others can be easily gauged where necessary. Commence with the fuselage. This requires a piece of wood $\frac{7}{8}$ in. × $\frac{3}{4}$ in. and $5\frac{1}{2}$ in. long. Actually, $\frac{1}{8}$ in. over at both ends is advisable, the front end being more easily rounded off to shape if there is an ample length. The squared-up block of wood is marked out from the elevation given and the unwanted wood cut away. In order to make sure of the correct shape of the fuselage at various points cardboard gauges can be cut and tried over. The chisel marks are then sand-papered away and the whole job smoothed over. The fuselage can then be given its first coat of paint and put aside whilst other parts are being made.

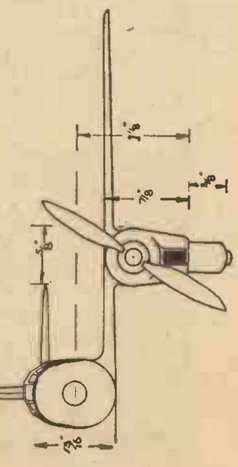


The Wings

The wings, which are made in one piece, require a piece of wood $7\frac{3}{4}$ in. long,



Constructional details for making the D.H. Comet shown in the photographs at the top of this page.



$1\frac{3}{8}$ in. wide and $\frac{1}{4}$ in. thick. First put the dihedral on the underside of the wings. The angle is taken from the centre of the wood to a depth of $\frac{1}{16}$ in. at the ends and is the same at the leading and trailing edges. Then mark out a space 1 in. wide in the centre of the top and lay out the upper surfaces of the wings from the front elevation. These are in line and with the taper already cut become $\frac{1}{8}$ in. thick in the centre and $\frac{1}{16}$ in. at the ends. The unwanted wood is then removed, with the exception of the 1-in. centre piece, which must be left to form the fairing between the wing and the fuselage. The fairing can be partially formed, but it is safer to leave the major portion until the wings are fitted to the fuselage.

Then mark out the wing plan. The leading edge is straight and the taper is found by marking a point $\frac{3}{4}$ in. from the leading edge at the extreme ends. A straight line drawn from that point to the fairing block will give the correct slope. The curved ends should also be marked out and cut with a fretsaw. Do not cut the ailerons at this stage. Then with a wide chisel cut the camber, the thickest part being about $\frac{3}{16}$ in. from the leading edge. The ends of the wings are rounded off to meet the flat surface of the underside. Finish off with sand-paper.

The ailerons can then be cut out or the positions merely marked with a deep score. If they are intended to move, the new trailing edge of the wing should be cut back at the top and underside edges to a flat "Vee" and the leading edge of the aileron to a half round. The hinges to the ailerons are made of tin, one end being buried flush into the wing section in a fretsaw slot and the other end protruding into a slot cut in the aileron. A pin passes through the end of the aileron and through a hole in the tin. The inside pin has its head cut off and is fitted into the aileron before the hinge is pressed into the slot in the wing. The hinges should not be fitted until all the painting is finished. The hinges which are similar to those fitted to the rudder and the elevator are secured in the slots with glue, which will prove satisfactory providing that too much strain is not placed on them.

Engine Nacelles

Now cut two square openings in the leading edges of the wings, as shown in the plan, to take a piece of wood which will make the fairing of the tops of the nacelles and the wing. The centre of these openings is $1\frac{3}{8}$ in. from the centre line of the fuselage. The engine nacelles can now be made, and will be similar in shape whether the under-carriages are incorporated or not. In the real machine the under-carriage is retractable, and is drawn up whilst the machine is flying into the nacelle behind the engine (which is a 224-h.p. Gipsy VI.), the wheel fairing, which reduces head resistance of the wheels whilst taking off, acting as a cover to the aperture.

The nacelles require pieces of wood $\frac{7}{8}$ in. × $\frac{9}{16}$ in. and $2\frac{3}{8}$ in. long and should be made identically the same and, of course, to pattern. The fairing piece, for which the openings in the leading edges of the wings have already been cut, is fitted to the top of the nacelle, being pinned and glued there. The propeller bearings and the spinners are made separately, but if made first act as a good guide for the shaping of the nose. The rear top portion of the nacelles are flat and fit flush on the underside of the wings. When these have been fully sand-papered, they can be pinned and glued into the wings and the glue allowed to set hard before shaping away the fairings.

The fin, the rudder, and the tail plane and elevators can now be shaped and fitted, the rear part of the fuselage being filed flat in the required spots to accommodate these parts which are glued and pinned to the fuselage. The manner in which the blind pins are fitted should be noted. Insert a pin into the required spot in the fuselage, withdraw it, cut off the head and push it back again into the hole backwards. This leaves the point of the pin protruding, and the piece can then be pushed on to it. The fixing of the pin and the rear plane to the fuselage can be carried out with strips of wood glued into the angle, or with plastic wood or by making the plane and fin of thick wood and cutting away as in the case of the main planes.

Fitting the Wings

Now fit the wings to the fuselage. Cut a slot across the underside to sink flush with the 1-in. wide platform on the centre of the wings, and pin and glue in position. Then with a round file and sand-paper go over all the fairings. Those parts of the plane which have so far remained unpainted can now be touched up, any holes, accidental or otherwise, being filled with putty or plastic wood.

The under-carriages are constructed from thinned-down match sticks, and are fitted and glued into holes drilled in the underside of each nacelle. The wheels, which are cut with a fretsaw and finished off with sand-paper in a hand brace, are secured to the carriages with a pin passed through the vertical stay and the centre of the wheel, the ends being cut off flush after insertion.

The cock-pit hood is made of three pieces of celluloid formed to shape in hot water and glued into position, a thin piece of cane forming a head to hold them in position additionally. The bars are pieces of paper glued to the joints.

The propeller blades are cut from sheet aluminium and have their inside ends rolled into a tube. They are glued into small holes drilled in the prop boss. The spinners are secured with a pin, which passes through the centre of the prop boss and allows it to rotate.

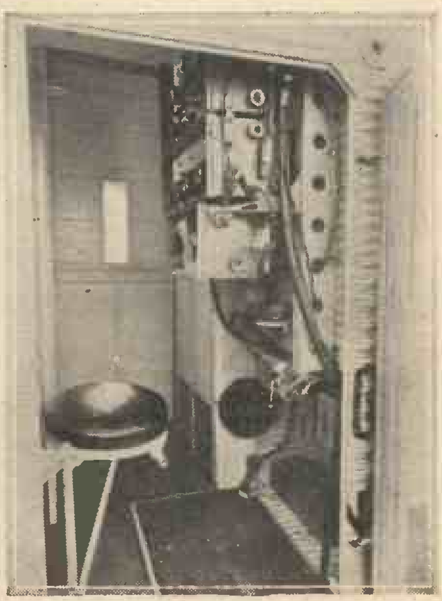
The finishing coat of paint can now be given and the lettering added. The letters on the model shown in the photographs are those of the winning Australian Air Race Machine (G–ACSS), and the name which is painted on either side of the nose is "Grosvenor House." A race number—34—can be painted black on a white oval at the top of the fin if so desired.

The nose of the machine can be painted white or capped with a celluloid cover to imitate the cover of the landing light which is installed in this machine.

WIRELESS IN AFRICA

THE Marconi Company have installed special radio equipment in the Junkers' aircraft recently delivered to South African Airways. Three of the larger aircraft are fitted with transmitting and receiving equipment, Type A.D. 37/38, suitable for telephony and telegraphy on both medium and short wavelengths, and will link up with the present London–Cape Town air route, while a number of smaller aircraft, operating internal routes, are fitted with the new-type Marconi medium-wave sets, Type A.D. 41/42. All are to carry Marconi directional receivers as an aid to navigation. The Marconi Company provided an experienced engineer and two expert operators to accompany the aircraft on their delivery flight from Europe to South Africa, during which excellent wireless working was attained on all machines.

On the medium waves, they gave a practically uniform performance of two-way communication over 600 miles on continuous wave telegraphy, while on short waves (with the A.D. 37/38 equipments), good telegraph working was carried out with Victoria West over 1,200 miles and two-way telephony over 1,000 miles. Ranges between the machines in flight were up to 130 miles by telephony and 200 miles by telegraphy. "Homing" was also successfully used on most stages of the flight.



(Left) Junkers' aircraft for South African Airways photographed in flight. The photograph above shows the medium- and short-wave transmitting and receiving equipment.

PHOTOGRAPHIC LENSES

Although the study of photographic lenses can lead into a maze of mathematics, the general principles can be explained in a reasonably simple manner.

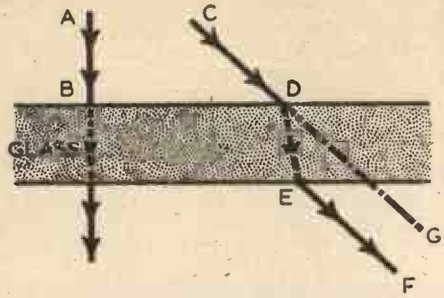


Fig. 1.—The effect of light striking a piece of glass at different angles. Refraction occurs at D and E.

LIGHT, when passing through a homogeneous medium, travels in straight lines, but when passing from one medium to another it may bend to a greater or less degree, depending upon the materials concerned and the angle at which the light rays are inclined. Turning to Fig. 1, which shows the effect of light on a piece of glass striking it at various angles; AB represents a ray of light vertical to the surface of the glass. In this case the light passes straight through the glass without being bent at all and passes out at the other side as a continuation of the same straight line along which it entered. If, however, the original ray of light strikes the surface of the glass at an angle as shown by CD, on entering the glass it will be bent towards the vertical as indicated by the short dotted line DE; but on leaving the glass (if the two surfaces are parallel) the ray of light will be bent back again away from the vertical to its original direction, as shown by EF. The emerging ray is not then in line with the original ray, which, if it remained unbent, would take the course CG. This phenomenon of bending is termed "refraction," and it is entirely owing to this that the lens is able to perform its duty.

Suppose, however, that the two surfaces of the glass are not parallel, but are inclined to a wedge shape, as shown in Fig. 2. The entering ray, or "incident" ray, will be bent towards the vertical on entering the glass; it will then pass through the glass and on emerging will bend away from the vertical (*i.e.*, the vertical of the second surface) with the result that instead of emerging parallel to the incident ray it will be bent to a different direction altogether. The angle of the wedge and the angle of the incident light must, of course, be suitably chosen to give the result shown in Fig. 2.

Diverging Rays of Light

A glance at Fig. 3, which is really a combination of Figs. 1 and 2, will show that three rays of light diverging from the point A are all brought together again on the other side of the glass at the point B. The central ray is vertical to both surfaces of the glass and so passes straight through, while the outer rays each pass through a wedge or prism which bends them, as previously explained, so that they converge to B. The three pieces of glass may become one piece without altering the effect, while if the shape be altered to that shown in Fig. 4, so that the surfaces form a smooth curve, all rays reaching the glass from A, will be bent back to the same point B. Furthermore, if the glass has the same shape on all sections through the axis AB, it will be circular in shape when viewed from A and the whole cone of light between A and the glass will be brought back to the point B and the glass is then a simple lens.

Spherical Aberration

The difficulties of making a piece of glass to the exact curvature required are insurmountable, and in practice the surface of the lens forms part of a sphere, because the glass can conveniently be ground to such a shape. The spherical form approximates very closely to the theoretically correct shape when the diameter of the lens is small compared with its radius of curvature, but there remains a slight difference which causes the rays to converge to a small disc instead of coming exactly to a point. This shortcoming is termed "spherical aberration" and is always present to a greater or less degree, though it can be eliminated for all practical purposes by careful design in compound lenses.

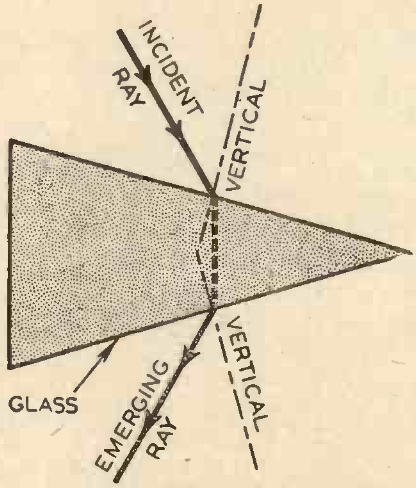


Fig. 2.—A ray of light takes a new path when the surfaces of the glass are inclined.

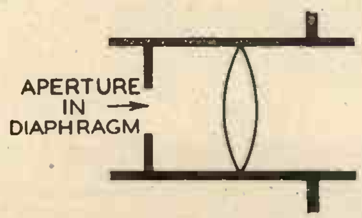


Fig. 5.—A single lens with diaphragm in front.

Another failing of the simple lens is due to the fact that ordinary daylight is composed of a mixture of light of all colours, and the various colours are bent to different extents by the glass, so that instead of a point of light at B, small rings of colour appear. This is called "chromatic aberration," and this also can be corrected, by the selection of glasses with suitable properties for each part in a compound lens.

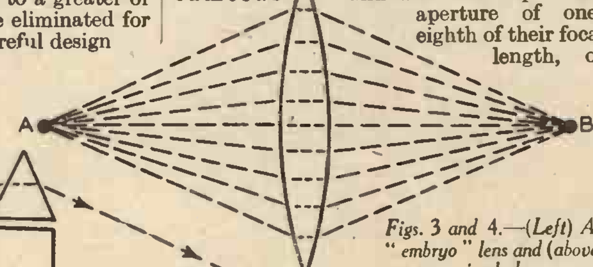
We are only considering one point of light at B, but the image is made up of an infinite number of such points, and if the point B is "fuzzy" the whole image will also be fuzzy, *i.e.*, it will lack sharpness.

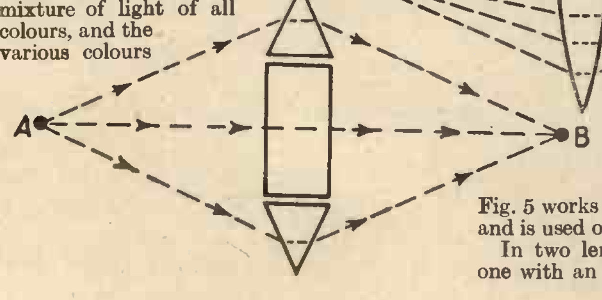
The Diaphragm

The sharpness, or "definition" as it is usually called, can be improved by arranging a diaphragm in front of the lens with a relatively small hole as shown in Fig. 5. This, however, will reduce the amount of light passing through the lens, and so necessitate longer exposures, *i.e.*, the lens is slower but gives a sharper picture. A small aperture also gives a greater "depth of focus," and this is the reason why modern rapid lenses have to be focussed very accurately, *i.e.*, objects a very little nearer or further from the camera than a certain distance will not be sharply defined. In many cases this is an advantage, but this effect cannot be altered by design and a large aperture will necessarily give less depth of focus.

Distortion

The diaphragm or "stop," as it is commonly called, introduces a form of distortion when used with a single lens which results in a square becoming somewhat barrel-shaped as shown in Fig. 6A. If, however, the stop is arranged behind the lens the distortion will be opposite in effect and the square will appear as in Fig. 6B. We can, however, eliminate this type of distortion completely if we use a double lens and arrange the stop between the two components as illustrated in Fig. 7. Such a lens is known as a "rapid rectilinear" and it would usually be corrected for chromatic aberration, in which case each component of Fig. 7 would consist of two pieces of glass permanently cemented together. Such lenses are very popular on cheap cameras and work well up to an aperture of one-eighth of their focal length, or as is usually expressed, they work at an aperture of F/8. The single lens in Fig. 5 works satisfactorily at about F/16, and is used on cheapest hand cameras.





Figs. 3 and 4.—(Left) An "embryo" lens and (above) a simple lens.

In two lenses of similar focal length, one with an aperture of F/8 will be four times as fast as another at F/16, because the F/8 stop is twice the diameter of the F/16 and is therefore of four times the area and admits four times as much light. The exposure is therefore one-fourth and the F/8 lens is said to be "four times the speed" of the other.

In lenses of greater apertures than F/8

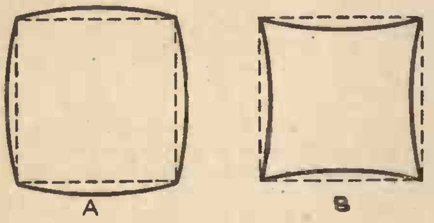


Fig. 6.—Showing two forms of distortion.

astigmatism becomes objectionable. This defect accounts for lack of sharpness because radial lines in the image come to a focus at a different point to tangential lines; therefore both cannot be focussed sharply at one setting and a compromise must be sought between the two. Astigmatism is almost completely overcome in modern "anastigmat" lenses by the choice of suitable kinds of special glass and the clever balancing of multiple lenses, with the result that

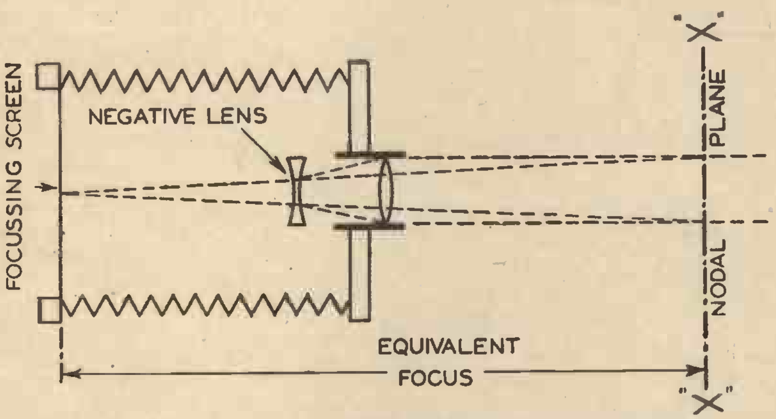


Fig. 8.—The telephoto lens system, showing how the radial plane is displaced.

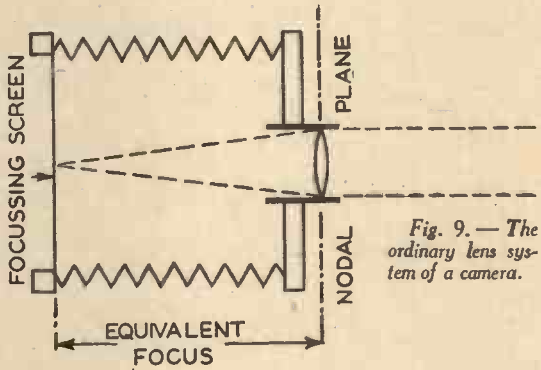


Fig. 9.—The ordinary lens system of a camera.

lenses with apertures of F/2 or thereabouts are now obtainable; in fact, in small lenses for cinema work, even greater apertures can be obtained.

Conjugate Foci

It is sometimes useful, especially when making enlargements, to know the distance the lens must be from the image, or the bromide paper in the case of an enlargement. The focus of a lens is generally stated on the assumption that objects being photographed are a long distance from the camera, so that all rays approaching the lens from any one point are, practically speaking, parallel. Any lens, however, has a multitude of foci, for if the object be brought closer to the lens the image will be brought to a focus further away on the other side. For instance, if a lens is nominally of 8-in. focus, an object 50 ft. in front of the lens will give a small image 8 in. behind the lens. If, however, the object is moved closer to the lens the image will be brought to a focus further away than 8 in., until, when it is only 16 in. in front of the lens, the image will then be 16 in. behind the lens and will be the same size as the object. Every distance in front of the lens has its corresponding focus behind the lens and the two distances are spoken of as "conjugate foci," and the ratio of enlargement or reduction will be the same as the ratio between the pair of conjugate foci in use at the moment. For instance, if a four-times enlargement is required the distance from the bromide paper to the lens must be four times as great as from the lens to the negative.

The actual distances may be found from the following formula, where F = the focus of the lens and L the ratio of enlargement.

$$F + \frac{F}{L} = \text{the shorter distance.}$$

$$L\left(F + \frac{F}{L}\right) = \text{the longer distance.}$$

A four-times enlargement with a lens of 6-in. focus it will be seen, for example, requires a distance of 7½ in. from negative to lens and 30 in. from lens to bromide paper.

There is no fundamental difference between a wide angle lens and an ordinary one. The wide angle lens is useful indoors and in restricted situations where the camera cannot be moved far enough away from the object. It consists of a lens of shorter focus than usual for the size of plate covered, and is made to give a sharp picture over a large area by using a small stop.

The Telephoto Lens

A wide angle lens gives a small image but gets a lot of the subject on the plate, but a telephoto lens does the reverse, it picks out a small part of, let us say, a distant view, and spreads it out to form a relatively large image. This is merely an effect of altering the focal length, the wide angle lens having a short focus and the telephoto lens a long one.

A lens of 6-in. focus will give an image of a distant church tower, for instance, 1 in. high, but if we use a lens of 12-in. focus the church tower will appear on the focussing screen 2 in. high. Now suppose we require an image 6 in. high! We can get this with a lens of 36-in. focal length, but with an ordinary lens this would necessitate a camera extension of 36 in., a most unwieldy piece of apparatus. There is, however, another method of dealing with the problem.

Nodal Planes

The focal length of a lens is measured from what is called a "nodal plane," and the situation of this is such that if the lens were given a pivotal motion about the point where the nodal plane meets the axis of the lens there would be no movement of the image on the focussing screen. Now in an ordinary single lens the nodal plane would be in the glass itself, but in the case of a compound lens it does not necessarily come within the lens mount. It may be a considerable distance from it, and this property is made use of in the telephoto lens.

(It should perhaps be mentioned that there are two nodal planes in a compound lens, but the second one does not concern us here because it need only be considered when the lens is reversed in its mount.)

If, then, we can obtain a lens of 36-in. focal length which has its nodal plane 24 in. in front of the lens itself, then we can get a six-times magnification (*i.e.*, the church tower will be 6 in. high) with a camera extension of only 12 in. This is precisely what the telephoto lens does, and the principle is illustrated in Fig. 8.

Fig. 9 shows an ordinary lens; the rays approaching the lens from any point are coming from the right and are brought to a focus at a point on the focussing screen at the left. In Fig. 8 the rays approach the lens as before, but after they have passed through it they encounter a negative lens (which has the property of bending light rays in the opposite manner to a positive lens, the positive being the only type we have considered up to now). This makes the bundle of rays come to a focus further back so that they reach the plate at a different angle just as if they had originally been bent at the plane marked "X," which is the nodal plane previously referred to. We therefore get a much larger image with only a slightly increased camera extension. The distance from the nodal plane to the focussing screen is called the "equivalent focus" because the whole lens system is the equivalent of a single positive lens situated in that plane.

A feature of the telephoto lens is that the magnification can be varied by altering the separation between the negative and positive elements, bringing them closer together increases the magnification and *vice versâ.*

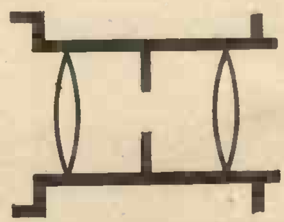


Fig. 7.—A "rapid rectilinear" lens.

HOW A SYPHON WORKS

A syphon may be described as a device for causing a fluid to flow upwards, but such a remark is of course only a half-truth because it implies that the force of gravity is overcome, so to speak. Such a state of affairs is of course absurd, but the fact that water can actually be made to lift itself by the combined action of atmospheric pressure and the force of gravity, has led many ill-informed would-be inventors to see in the syphon a source of perpetual motion. This again is, of course, an impossibility, but below is described where the fallacy lies.

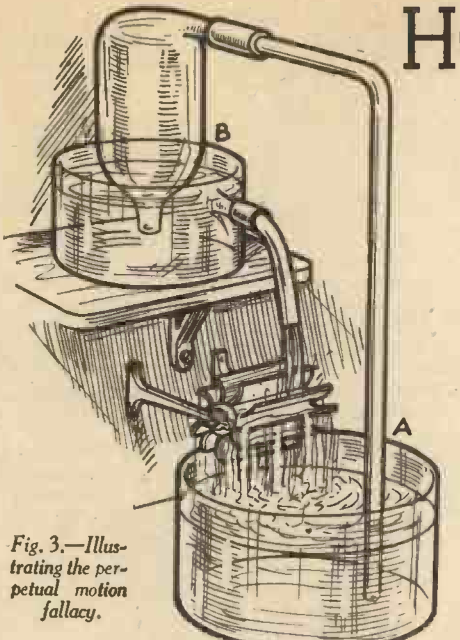


Fig. 3.—Illustrating the perpetual motion fallacy.

A SYPHON is merely a bent tube; it is sometimes supposed that one limb must necessarily be longer than the other but this has really only an indirect bearing on the matter, for the syphon will still work under suitable circumstances with limbs of equal length (see Fig. 2).

Fig. 1 shows a syphon arranged to empty a tank of water. If the bent tube (open at both ends, of course) is merely put into the tank as shown, nothing will happen except that the water will find its own level in the part of the tube which is immersed. But if the tube is filled with water and then placed in the tank as before, water will flow out of the bottom end and continue to do so until the tank is empty, or at any rate until the water level gets down to the end of the tube inside the tank.

What happens is that the water in each leg of the syphon tends to flow downwards at once, but it will easily be understood that both columns of water cannot flow away without leaving a vacuum in the region of the bend in the tube. There is a kind of tug-of-war at the bend between the two columns of water, in which the taller column pulls hardest and flows away. The water in the shorter column is not able to "leave go" without forming a vacuum, so it runs *up* the tube to replace the water that flows away down the other side, and a continuous flow results.

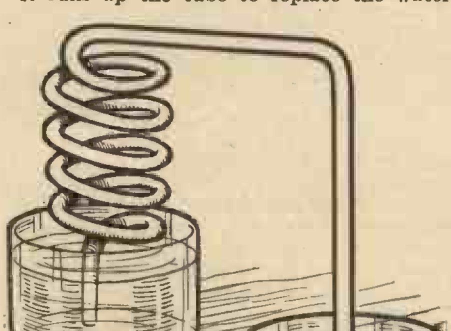


Fig. 4.—Another variation of the scheme shown in Fig. 3.

Limbs of Equal Length

Now in Fig. 2, both limbs of the actual tube itself are of equal length, but water will still flow from A to B until the water in A has fallen to the level of the rising water in B. The flow will then cease, because although there is stil' a tug-of-war at the bend, the pull on each side is exactly equal. It will be seen then that the actual length of the tube does not enter into the question; what really matters is that the column of water must be of greater *height* on the side towards which the water is to flow. So although the water flows uphill for part of the way, the final result is that the syphon will not work unless the water flows to a lower level than that from which it started.

The maximum height to which the syphon action can be carried is strictly limited to about 33 ft. in the case of water, for if the rising column of water exceeds this figure a vacuum will be formed at the bend of the pipe. Continuing our tug-of-war analogy, we might say that the "rope" breaks when the pull becomes too great. If we were to use mercury in the syphon instead of water, however, we should find that the height to which it would rise before the vacuum appeared would be about 29 in., more or less, depending upon the atmospheric pressure at the moment. It will be seen that this is about the height of a mercury barometer; in fact, the whole arrangement of a mercury syphon, more than 30 in. or so high, would be equivalent to two mercury barometers joined at the top. The height of the two columns would be equal when measured above the level of the mercury exposed to the atmosphere and both columns would rise and fall with change of weather.

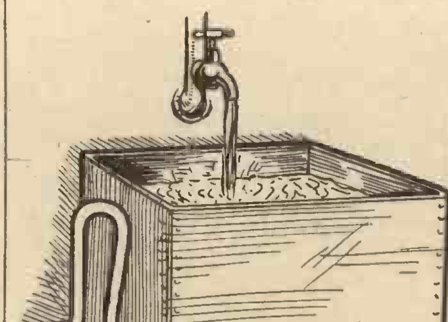


Fig. 5.—A photo washing tank with syphon outlet.

Perpetual Motion

Now to return to the perpetual-motion fallacy. The misguided inventor might argue thus: "If we make a syphon with a big bulge in the shorter limb like Fig. 3, this side of the syphon will hold much more water than the other, therefore it will be heavier and win the tug-of-war and water will flow from A to B. Then all that is wanted is a water wheel worked by the water running back from B to A." But, alas! It would not work. The fallacy is that it is not volume, or even weight of water that matters—it is the height of the column on each side. As a matter of fact, water would actually flow from B to A! Another fallacious variation of the above scheme is to coil up the longer leg of the syphon as shown in Fig. 4, the argument being that there is a longer column of water on the coiled side, but here again it is not the length of tube that matters, but the height of the water column, therefore the water would flow, as always, from the higher to the lower level.

An Application of the Syphon

An interesting application of the syphon is that made use of by the photographic washing tank shown in Fig. 5. The negatives are held in grooves inside the tank and the whole tank placed under a tap of running water. The water then rises in the tank until it is level with the top bend of the syphon tube; it then fills the tube, the syphon starts to operate, and water flows from the outlet at a quicker rate than it flows from the tap so that the tank is emptied. Air then enters the syphon tube, stopping the syphonic action, and the tank fills up with water again. The tank is intermittently filled and emptied until the tap is turned off.

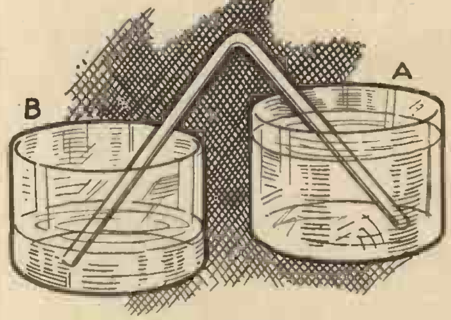


Fig. 2.—A syphon will still work with two limbs of equal length.

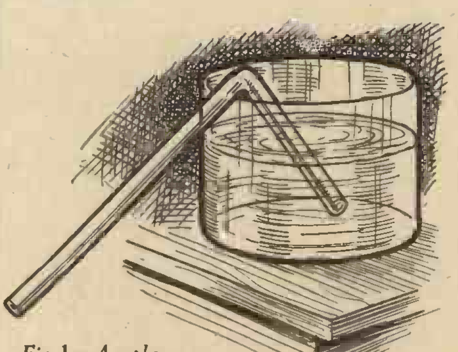


Fig. 1.—A syphon arrangement to empty a tank of water.

A SIMPLE VACUUM PUMP

A useful piece of apparatus which will enable readers to make their own Geissler tubes.

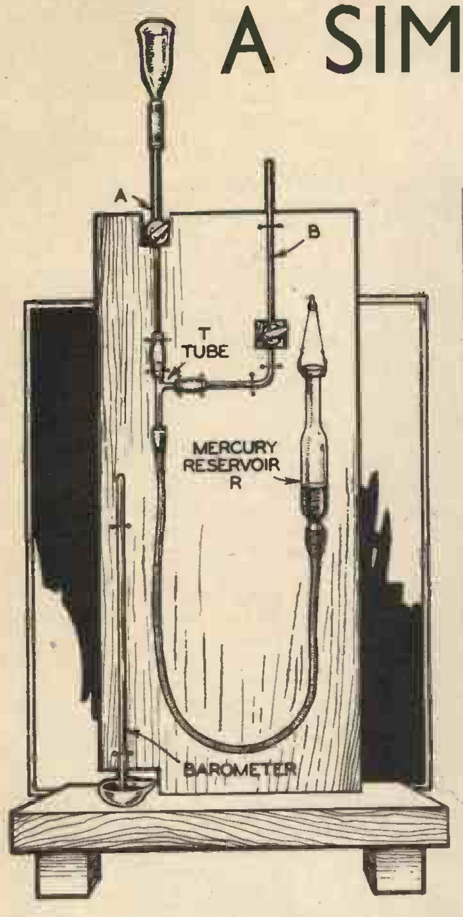


Fig. 2.—Details of the finished piece of apparatus.

ELECTRICAL experimenters who have made a spark coil generally acquire a collection of simple Geissler tubes and are struck both by their simplicity and brilliance when in operation. Attempts at making these tubes are generally unsuccessful, and many experimenters never attempt the work because they are under the impression that a complicated exhausting pump is required. A pump is certainly required, but very good results can be obtained with the following simple piece of apparatus. Expenses have been cut down to a minimum, as the pump will work quite satisfactorily with only 15 c.c. of mercury.

A small Bunsen burner and a blow-pipe giving a pointed flame are required, and should be connected to a single gas cock through a T-tube. Glass tubing is sold per pound—an average price being 2*s*. 9*d*. for a pound of odd lengths and diameters. When purchasing the above ask for soft soda glass suitable for blow-pipe work. The tubing is cut with a small triangular file. Place a length on the bench and mark round it, just scratching the surface, then grip the tube close to the scratch and give a sharp pull.

To seal a tube hold it almost vertically in the flame and rotate it slowly, and the edges will automatically come together.

When bending the glass tube the Bunsen must be fitted with a bat's-wing burner, and to save the trouble of removing the burner when the Bunsen is required for other purposes the burner may be fitted into a piece of copper pipe bent at right angles and secured to a heavy wooden block by a small metal saddle. This can be connected into the Bunsen lead by another T-piece; details for making these will be given later. Holding each end of a piece of tube, rotate it in the flame and when sufficiently soft remove and bend—don't bend in the flame.

Making a T-Piece

One of these is required for the pump, while the operation of sealing one tube to another is necessary for making all but the simplest vacuum tubes. It may be as well here to try joining two tubes end to end. Revolve the two ends which are to be joined together in the flame and when they are red-hot remove from the burner, push together, and at the same time blow gently down the tube, pulling slightly to remove the large bulge of glass.

Seal one end of a 6-in. length of tubing and play the small pointed flame on one spot on the side of the tube. When an area about ⅛ in. in diameter is red-hot, blow hard down the tube, when a small hole will result. Play the small flame on this until it is the same diameter as the bore of the tube and, keeping the edges still hot, bring to redness the end of another piece of tubing about 3 in. long. When both the main piece and side pieces are soft, push together and remove from the flame. Seal the end of the main piece with one finger and blow down the side, gently pulling at the same time. In this way all excess glass should be removed, but play the pointed flame around the join a few minutes to anneal the glass, and then remove to a candle flame and thickly coat the joint with soot. When cold the tube should be cut down to a convenient length, taking care not to put any strain on the join (see Fig. 1).

The Action of the Pump

The action of the pump is not automatic, and consists essentially of putting a vacuum in communication with the vessel to be exhausted. The barometer as shown in the sketch is not essential, as the barometric height may be obtained from the pump itself.

This work is best followed by reference to the sketch Fig. 2. Obtain a board about 6 in. wide and 48 in. long, and mount it on a suitable base 12 in. square, with a supporting piece to prevent wobbling. The most expensive parts of the apparatus are the two glass taps which must, of course, be bought. These can be dispensed with if desired, and screw clips can be used, but the taps are far superior. As long as the general principles are followed, readers may vary small details of the apparatus. One T-tube is used and all the rubber tubing is of the pressure type, including the long piece to the mercury reservoir. The top funnel is made by drawing out a test tube until the constricted portion will fit the rubber tube; do not pull out too far or else the glass will break when fitting into the tube. The mercury reservoir is made in the same way, or a 2-in. length of 1 in. diameter tubing fitted with a rubber bung through which a glass tube passes, can be used, the glass tube being flush with the inside of the rubber. The reservoir should be fitted with a wire handle so that it can be hooked in various positions on the board.

To assemble the apparatus, place the large board (the upright piece) flat on the bench, and lay out the complete apparatus correctly connected up and with all the joints wired. Arrange the whole in the most suitable way and, with a pencil, mark the positions of the taps and the holes for the fixing wires. Remove and cut holes for the projecting portions of the taps, and with a ⅛-in. diameter drill make holes for the wires. Replace the apparatus, pass loops of bare copper wire of No. 22 gauge through the holes and *with the fingers* tighten up behind the board. If you tighten the wire with pliers most probably too much force will be exerted and the tubes broken, but pliers must be used when connecting up the rubber tubes and binding on the wires. Those who wish to improve the pump may do so by fusing all the glass pieces together, thus doing away with the rubber connecting tubes. Rubber tubes are specified here because of the ease of construction and so that the apparatus may be quickly dismantled and the taps used for other experiments. A further improvement is to connect a large vessel in the form of a tube with a large bulb blown in it, between the T-piece and the tap B. More mercury will be required to operate the pump, but the rate of exhaustion is considerably increased, which is very desirable when working with a large tube.

To use and test the pump, open both taps and pour mercury into the reservoir until the mercury comes just above the tap. The mercury should completely fill the tube, so tap the board gently to remove the air bubbles. Now close the taps and gently lower the reservoir until it is about 36 in. below the taps, and the mercury will fall until it is at the barometric height, the space above it being a vacuum. Allow the apparatus to stand for thirty minutes, and if the height of the mercury column is the same the pump is in good order; if the glass taps leak, a little vaseline may be smeared round them.

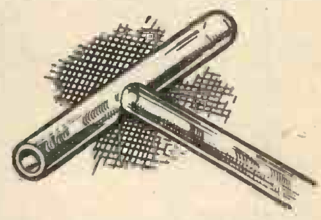


Fig. 1.—The construction of a T-tube.

The tube to be evacuated is connected to B, the funnel on A is to hold excess mercury if the reservoir is raised too high or quickly. To evacuate a tube, open both taps and raise the reservoir R, filling the tubes with mercury to a height of about ½ in. above the taps, close A and B, and connect the tube to be exhausted to B. Lower R until the mercury stands at the barometric height, now open B, and this puts the air in the tube (which was at atmospheric pressure) in communication with a vacuum. Close B, raise R to its previous height and open A, expelling the air from the tube, close A and repeat until the mercury does not fall on opening B.

If a screw clip is available this should be put on the connecting tube and fitted as tightly as possible.

AN A.B.C. OF ENGINEERING TOOLS

The first article of a short series.

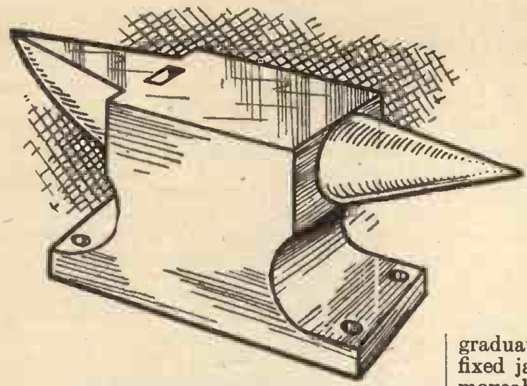


Fig. 1.—An anvil. These are obtainable in all sizes from 1 in. upwards. The two ends are termed "beaks."

Anvil

A SHAPED steel block on which pieces of metal are straightened or flattened out. For forging work the metal parts are first made red-hot, and then beaten to shape, or welded together, on an anvil (see Fig. 1).

Archimedean Drill

A hand drill used for drilling small holes in soft metal, such as brass or gunmetal. The drill spindle is formed with a spiral flute, and on this a hand-piece is fitted, having a metal bush internally fluted to correspond with the fluted spindle. The drills used with this type of appliance are diamond pointed, and are held in a split chuck attached to the end of the spindle. In use, the drill is pressed against the metal to be drilled, by means of the flat knob at the other end, and the hand piece rapidly moved up and down the fluted spindle, which is thus caused to rotate.

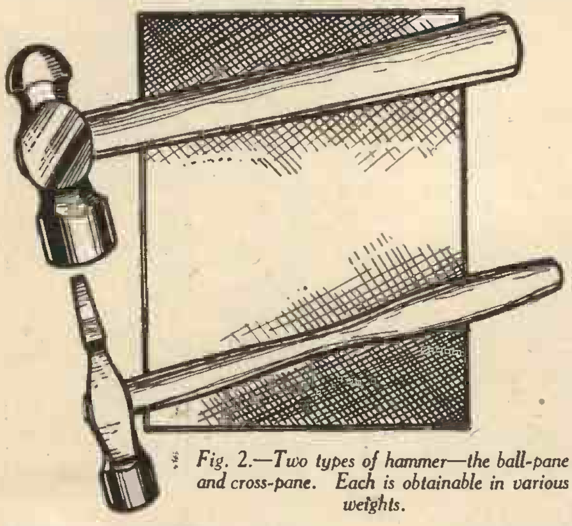


Fig. 2.—Two types of hammer—the ball-pane and cross-pane. Each is obtainable in various weights.

Ball-pane Hammer—See Hammer.

Bench Drilling Machine

An appliance fixed on the bench and used for drilling work outside the capacity of a small geared hand drill (which see). Bench drilling machines are made in a number of sizes and patterns, and are either hand or power driven. Some of the machines are fitted with two-speed gear, and have a slotted table to which the work to be drilled is bolted. Many of these appliances are also provided with automatic feed, and a flywheel used in conjunction with gearing which enables sufficient power to be applied for drilling holes up to 1 in. diameter.

Calliper Gauge

A measuring instrument consisting of a graduated steel rule having at one end a fixed jaw, projecting at right angles, and a moveable jaw, the top part of which slides along the rule. In the pattern illustrated in Fig. 3 the movable jaw is fitted with a fine adjustment screw, the end of which is carried in a bearing piece which also slides along the rule. To set the jaws to the required distance apart both the sliding parts are moved along the rule till the index mark on the vernier roughly coincides with the corresponding graduation on the rule. The sliding part holding the adjusting screw is then clamped firmly by means of the set screw at the top, and the necessary fine adjustment made by turning the milled nut provided for the purpose. By means of the vernier engraved on the bevelled edge of the opening in the movable jaw, fine measurements to 1/1,000 in. can be made. In some patterns of calliper gauges, the rule or beam is graduated in English measurement on one side, and metric measurement on the other, while in other patterns both measurements are on the same side of the rule, one along the top edge, and the other along the bottom.

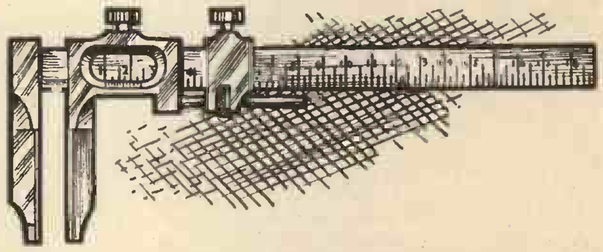
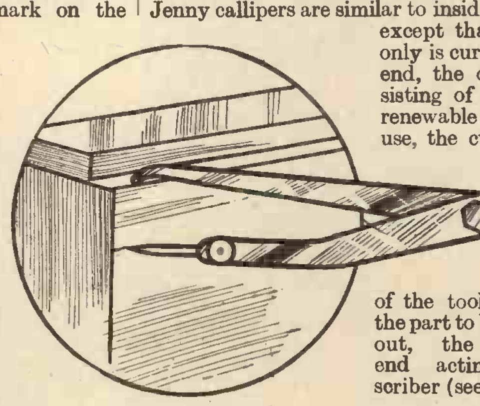


Fig. 3.—The vernier. These are obtainable marked in millimetres and in inches. The beam of a vernier graduated in English measurement is marked off in inches, tenths of an inch, and each tenth is subdivided into four parts equalling one-fortieth of an inch. The slide jaw has twenty-five divisions which equal in length twenty-four divisions on the beam. Thus the difference between a division on the vernier and a division on the beam is one-twenty-fifth of one-fortieth, which equals one-thousandth of an inch. As an example of how to read it, first note the number of complete inches, tenths and fortieths of the nought mark on the vernier from the nought mark on the beam. Thus, if nought on the vernier indicates two complete inches, two complete tenths, and three complete fortieths, and the third line on the vernier coincides with a division on the beam, the distance between the jaws will be 2 in., plus two-tenths, plus three-fortieths, plus three-thousandths, which equals 2·278 in.

Callipers

Tools used for measuring and gauging the diameters of rods, turned work in the lathe, and the diameter of holes. They are also used for marking off work, and for centring cylindrical metal parts prior to drilling the ends for placing between lathe centres. There are different types of callipers known by various names, such as "outside callipers," "inside callipers," and "jennies," or "hermaphrodite callipers." Some callipers are fitted with a spring and fine adjustments, by means of which an accurate setting of the legs is obtained. Jenny callipers are similar to inside callipers, except that one leg only is curved at the end, the other consisting of a straight renewable point. In use, the curved end of the tool rests on the part to be marked out, the pointed end acting as a scriber (see Fig. 4).



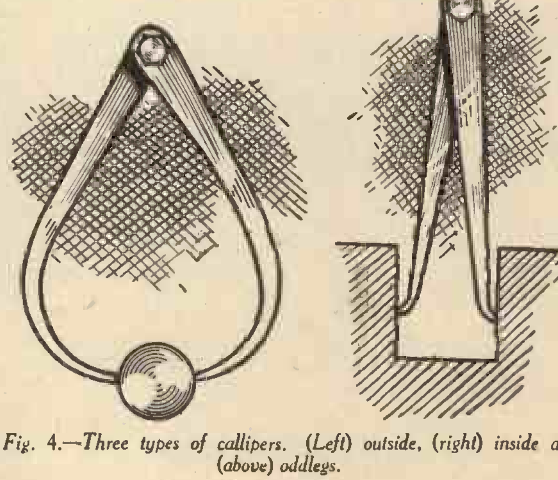


Fig. 4.—Three types of callipers. (Left) outside, (right) inside and (above) oddlegs.

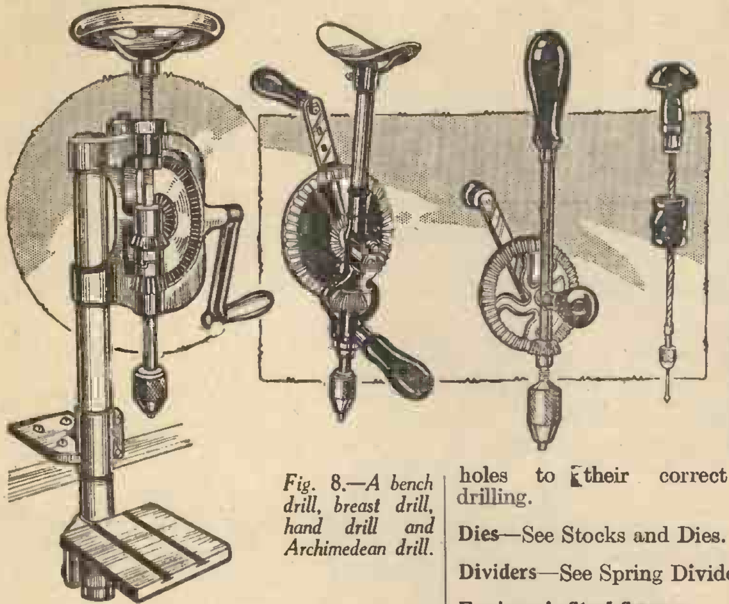


Fig. 8.—A bench drill, breast drill, hand drill and Archimedean drill.

Centre Punch

Made of cast steel. Used for marking the centres of holes in metal, for drilling, and also in the ends of work for turning in the lathe. For light work the angle of the point is usually 60 degrees and for heavy work 90 degrees.

Cold Chisels

Tools made of cast steel, and used for many different purposes, such as roughly shaping metal parts prior to filing, chipping out slots or steam ports in a cylinder casting, and cutting off pieces of sheet metal or rod. Cold chisels in most common use are made in the four patterns shown in Fig. 5. The flat chisel (A), with its broad, straight cutting edge, is used for cutting off pieces of rod or sheet metal, and for removing the rough outer surface of a casting preparatory to machining. A cross-cut chisel (B) is used for cutting keyways, slots and similar work. The half-round chisel (C), and the diamond-pointed chisel (D) are used for chipping out corners and other restricted places on a casting or other machine part, and the last-mentioned chisel is also used for "drawing over" holes to their correct positions for drilling.

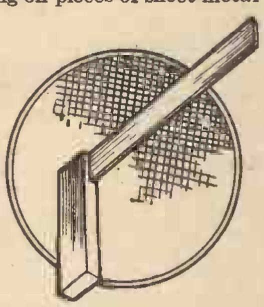
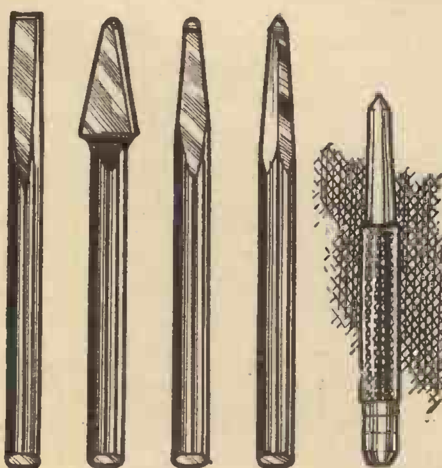


Fig. 6.—A steel set square. Adjustable universal squares and protractors are also available.



A B C D

Fig. 5.—Various cold chisels—the flat, cross-cut, half-round, and diamond point. (Right) The centre punch. Automatic centre punches are also obtainable which deliver their own blow, and do not, therefore, need a hammer

Dies—See Stocks and Dies.

Dividers—See Spring Dividers.

Engineer's Steel Square

A precision tool for testing the accuracy of work done with a file, and for setting work squarely on a lathe face-plate, or on the table of a drilling or shaping machine. A good square should have a hardened stock, or body, and a thin-tempered blade, the edges of which must be perfectly parallel to ensure accuracy for both internal and external angles (Fig. 6). In some squares the blades are plain, and in others they are graduated in inches and fractions like an ordinary steel rule.

Another type of square has an adjustable stock which can be instantly set at any position on the blade. It is a very handy tool, and has a range of usefulness not possible with a square having a fixed blade.

Files

There are many patterns of files used for various purposes, those in most general use being : (*a*) flat file, used for work on flat surfaces; (*b*) half-round file, used for many purposes, for which its shape makes it specially adaptable; (*c*) round file, for enlarging circular openings, or for use on concave surfaces; (*d*) warding file, used by locksmiths in repairing or filing the wards in keys, also suitable for use in narrow spaces where other files would not be suitable; (*e*) taper saw file, for sharpening the teeth of saws, and for filing nicks in a piece of metal before breaking a piece off. Files are made of cast steel, and their cutting teeth have various degrees of coarseness designated rough, bastard, second-cut smooth, and dead smooth. As a general rule only the larger files have rough-cut teeth. The length of files varies from 4 to 14 in. (Fig. 7).

Geared Hand Drill

Used for heavier work than can be done with an Archimedean drill (which see). The drill shaft is rotated by means of bevel gearing and a hand-driven crank, an adjustable chuck being fixed to the end of the shaft for holding drills of various sizes. Where more power is required for drilling large holes, a breast drill is used. The drill shaft in this tool is also driven by means of a hand-crank and bevel gearing, and in use the operator applies the necessary pressure by placing the shaped rest on the end of the shank against his chest. In some drills of this pattern a small spirit level is attached to the centre part of the stock, to enable the operator to hold the drill square with the work. Various types of drills are shown in Fig. 8.

Hacksaw

For cutting metal of various thicknesses. The metal to be cut is held in a vice, and the saw applied with a straight stroke to prevent the blade twisting. During the cutting operation the pressure should be applied on the forward stroke only, as with a wood saw. The frame is adjustable in length to take 8 to 12 in. blades.

Hammer

One of the principal tools used in engineering work is known as a ball-pane hammer owing to the small round knob at the back of the hammer-head, which is chiefly used for riveting. The hammer-head is made of steel, and for ordinary work is about 1½ lb. in weight. For light work, a smaller hammer of the same type, or with a cross-pane, is used.

(To be continued next month.)

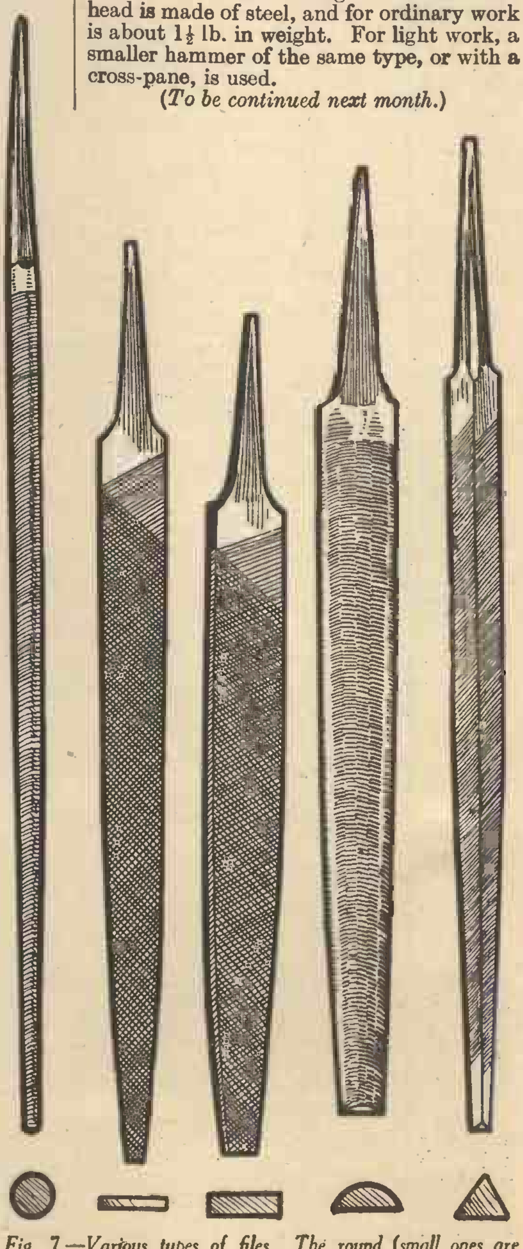


Fig. 7.—Various types of files. The round (small ones are called rat-tail files), warding, flat, half-round and taper-saw file.

ISOMERS AND ISOTOPES

The Peculiar Properties of Chemical Compounds and Elements

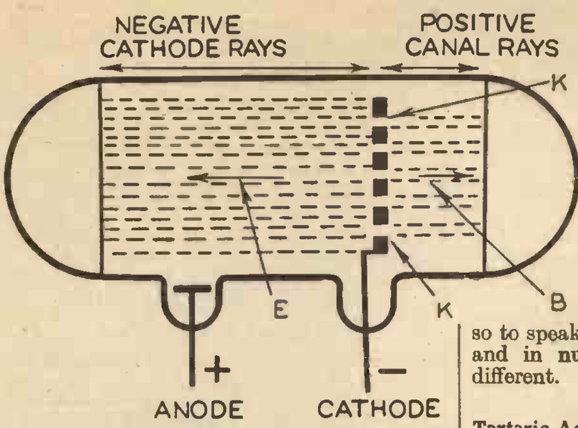


Fig. 2.—Discharge tube showing the ordinary electron stream E, and the "canal" rays B.

ONE of the first things one learns in studying chemistry is that every true compound has a fixed chemical composition. Strangely enough, the reverse is not true. That is to say, substances can be found which, when analysed, prove to have exactly the same chemical composition by weight, though they possess different physical properties, appear unlike to the eye, and may even behave differently

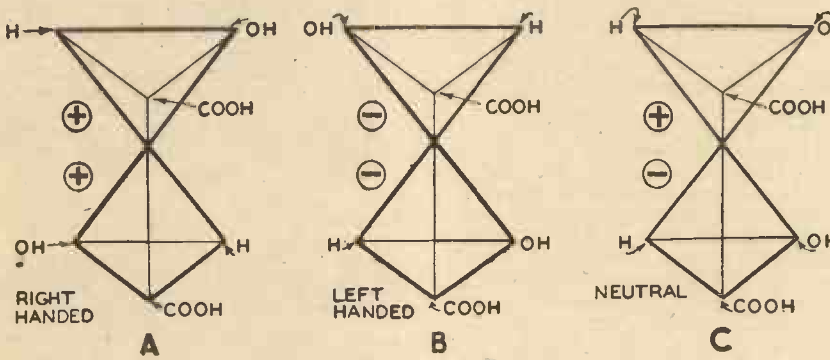


Fig. 1.—Stereo-isomers of tartaric acid.

in chemical reactions. Such chemical "duplicates" are known as isomers.

One interesting example is the element sulphur. When ordinary sulphur is heated, it first melts into a mobile yellow liquid, which then changes to a viscous mass of orange colour. As the heating is continued the melt gradually turns black at a temperature of about 440°. If the product is now poured into water, and left to stand for a few days, it gradually becomes opaque, turns first lemon yellow, and then brittle, and so reverts back into its original form.

Under analysis each of these outwardly dissimilar forms of sulphur prove to be chemically identical. The various "disguises" are commonly called allotropes, though they form part of the wider phenomenon of isomerism.

The same kind of behaviour occurs more frequently in the case of compounds than of elements. Red mercuric iodide, for instance, changes to a yellow colour when heated—though its chemical composition remains unaltered. If allowed to cool, it still keeps the same colour until it is rubbed, whereupon it changes back to the original red.

It is clear, therefore, that the physical properties of a substance do not depend solely upon its chemical make-up, but are governed, at least to some extent, by the arrangement in space, or the geometrical disposition, of the atoms or molecules of which the substance is formed. The bricks, so to speak, may be identical both in shape and in number, but the architecture is different.

Tartaric Acid

A particularly interesting case in point is that of tartaric acid, which is built up of two hydrogen atoms H, two hydrate radicals (OH), and two acid radicals (COOH). Fig. 1 shows three different ways in which these various components can be arranged in space to form isomeric crystals of tartaric acid. Each crystal is identical, so far as number and content are concerned, but the H and OH groups in A and B are "mirror images" of each other. The C crystal differs from either of the other two, because both H atoms are now arranged on the left-hand side and both OH groups on the right-hand side.

This is an instance of what is called stereo-isomerism. No amount of chemical analysis will disclose any difference between the three. But a ray of plane-polarised light when passed through the A crystal is given a right-handed twist, whilst the B crystal gives it a left-handed twist. By contrast, the C crystal refuses to twist the ray in either direction.

Isotopes

We have next to consider another curious case of apparent "duplication," this time only to be found amongst the elements. They are usually almost indistinguishable as regards chemical properties—and can only be separated from each other with great difficulty—yet undoubtedly they possess slightly-different atomic weights. These are known as "isotopes," and were so christened by Professor Soddy. He defines them to be elements occupying the same place in the Periodic Table, and therefore chemically "similar" and—save only as regards the physical properties which depend upon atomic mass—physically identical also.

The element chlorine, for instance, which has a "text-book" atomic weight of 35·46, is now known to consist of a mixture of isotopes, weighing 35 and 37, with a possible third variety weighing 39. It will be noticed—and it is a fact of great significance—that in each case the atomic weight of the isotope is a round number.

The previously-accepted "fractional" weight of 35·46 was calculated with scrupulous care and exactitude, but the figure was arrived at before the existence of "isotopes" was even suspected. In other words, instead of dealing with pure or homogeneous chlorine gas, the original tests were carried out—in ignorance, of course—on a mixture of the isotopes of chlorine. The fractional number therefore represents an "average" for the mixture, instead of being the true atomic weight of pure chlorine.

Nearly all those elements which once carried a "fractional" atomic weight are now known to be "complex" in the sense that they really consist of a mixture of whole-number isotopes. Tin, for instance, has no less than eleven isotopic varieties.

All this points to the truth of a theory, first put forward by Prout, that all the known elements are definite multiples of a basic or primary atom which he called "protyle." The modern view is that the hydrogen atom is the elementary "brick" from which all the other so-called elements are built up.

We owe most of our present knowledge of isotopes to the work done by Dr. Aston on the so-called positive or "canal"

(Continued overleaf.)

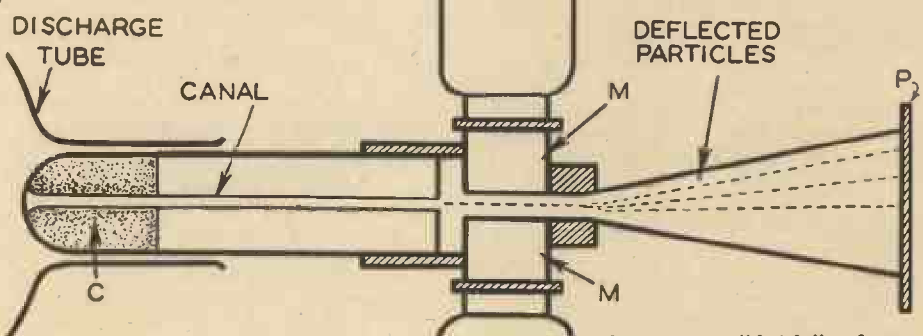


Fig. 3.—Detecting the presence of "isotopes." The deflected particles form a mass-spectrum on the photographic plate P.

ISOMERS AND ISOTOPES

(*Continued from page* 239.)

rays which stream through the perforated cathode of an electron discharge tube. In the ordinary cathode-ray tube, we are very familiar with the stream of electrons which flow from the cathode towards the anode. But in addition there is also a drift of "positive rays" or atomic particles in the opposite direction, namely, from the anode towards the cathode. If, as shown in Fig. 2, the cathode K of a discharge tube is perforated, these heavy particles stream behind it, as shown at B, whilst the electron stream E moves forward towards the positive anode in the ordinary way.

By using a hollow cathode C, as shown in Fig. 3, the positive rays are allowed to pass through the cathode where they are subjected to the action of electric and magnetic fields at M.

A "Mass-spectrum"

The result is that they are deflected before they strike against a photographic plate P. The extent to which they are deflected, and therefore the point at which they strike against the plate, depends in part upon their atomic mass. In this way a "mass-spectrum" is formed on the plate and shows up clearly any small differences which may exist in the atomic weights of the particles comprising the stream. The method is capable of distinguishing differences of one part in 10,000, and has resulted in the discovery of a very wide range of isotopes, covering practically every known element.

Great interest is now being shown in the newly-discovered isotope of hydrogen, which is known in this country as Diplogen and in America as Deuterium. It is found, in combination with oxygen, in water which has been electrolysed over a long period. Whilst ordinary water is represented by the formula H_2O, the corresponding compound formed by the isotope H_2 has the formula H_2O_2, and is known as "heavy water."

Heavy Water

Heavy water is now being produced commercially by a process of continual and intensive electrolysis. It melts at 3·8° C. and boils at 101·4° C. It is slightly more viscous than ordinary water, though its surface-tension is smaller.

In some cases it appears to have a definite toxic action. Tadpoles, for instances, die quickly when immersed in it, and although other small forms of aquatic life put up a stouter resistance, they succumb after a while. On the other hand, it also possesses certain chemical and biological properties which promise to be of great value, though their full possibilities have not yet been thoroughly explored.

Quite recently, M. and Mme. Joliot have utilised the "diplogen" isotope to bombard the atoms of other elements and have succeeded in this way in producing "artificial" radium, or at least substances which possess marked radioactive properties.

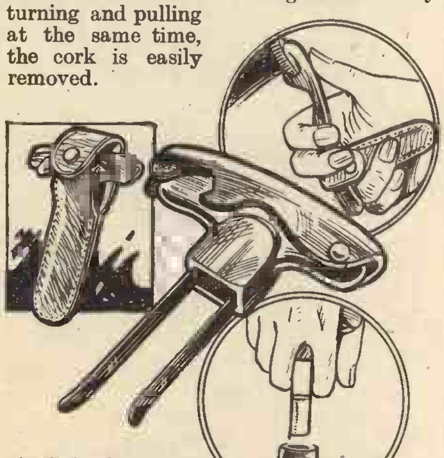
Finally, "heavy water" is now known to contain a very small proportion of a second curious isotope, called tritium, and having a mass three times that of ordinary hydrogen. Tritium is, however, so rare a substance, that it costs twenty times as much to produce as the same weight of pure radium.

The Latest Novelties

The address of the makers of any device described below will be sent on application to the Editor, PRACTICAL MECHANICS, 8–11 Southampton Street, Strand W.C.2. Quote number at end of paragraph.

An Ideal Cork Remover

ALTHOUGH there is little novelty in a corkscrew, that shown in the sketch is certainly an improvement in their design and will remove corks efficiently without damaging them in the process. The longer prong is first inserted down the side of the cork, and then the smaller is also forced down with a rocking motion. By turning and pulling at the same time, the cork is easily removed.



An ideal cork remover and (insets) showing how the device is used and the case in which it is supplied.

Incorporated in the handle is a crown-cork opener, which is operated as shown in the illustration. Supplied complete in a leather case, the device costs 2*s*. 9*d*. post free. [97.]

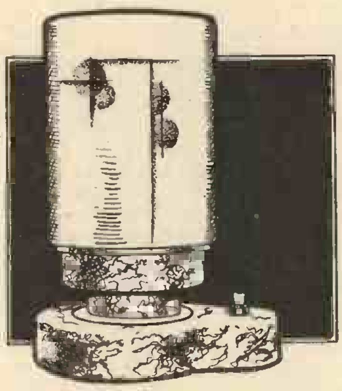
An Electric Torch-Pointer

THE ingenious device shown at the foot of this column enables a lecturer, etc., to project the image of an arrow on any desired point on a picture or other desired background. It works on the principle of a torch and is operated by pressing a button. It is obtainable complete in a box with battery, and costs 15*s*. [98.]

Details of the electric torch-pointer which projects the image of an arrow on to any desired background.

A Cinema Screen-Box

A DEVICE that enables the home-cinema to be used in any room without turning out the lights is now on the market. It makes a splendid, self-contained screen which can be used conveniently anywhere. The screen itself is "silver" and gives a very bright reproduction of pictures. The size of the screen is 18 in. deep by 12½ in. wide, and it can be folded up to a convenient size and be easily carried about. It has a wide frontal opening to allow easy projection of films and clear vision for the audience. The dark box provides an excellent and quick way of demonstrating films to anyone who is interested, because it can be erected and put away again in a few seconds. It is low-priced, costing only 5*s*., and is a really sensible companion for the cinema itself. [99.]



An attractively designed reading lamp.

A New Design in Table Lamps

THE lamp shown herewith is undoubtedly an added attraction for any room, especially a bedside table. The base, which is fitted with a push-button switch, is of bakelite, and is obtainable in three colours—birch, red and mahogany. The glass dome has a frosted effect with a delicate-coloured design. The lamp is supplied with 4½ ft. of silk flex and a two-pin plug and will take a 40-watt bulb. It is 7½ in. high and the base is 4 in. deep. It costs 11*s*. 6*d*. [100.]

A Combined Hone and Strop

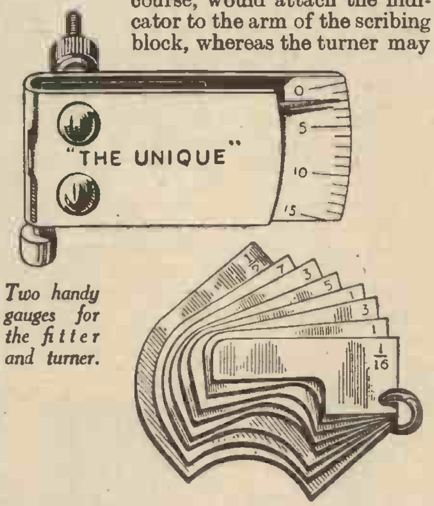
THE combined hone and strop shown on page 243 will be found ideal for sharpening safety-razor blades. If used in accord-

(Continued on page 243.)

A Review of the Latest Devices for the Amateur Mechanic. *The address of the Makers of the Items mentioned can be had on application to the Editor. Please quote the number at the end of the paragraph.*

Handy Gauges for the Fitter and Turner

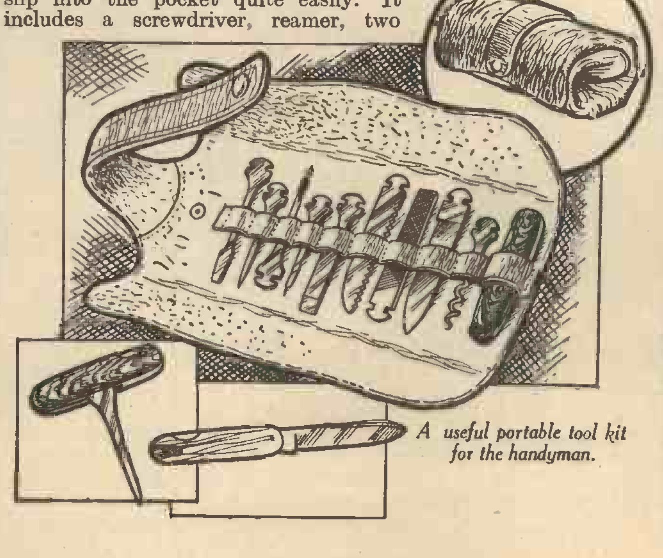
THE unique test indicator illustrated here is intended for use by fitters and turners for testing the roundness of work, the truth of phases, locating high spots, and similar jobs where the micrometer or calipers cannot be used. The fitter, of course, would attach the indicator to the arm of the scribing block, whereas the turner may attach it to a rod secured in the tool post. The graduation indicates thousandths of an inch. The radius gauges supplied by the same company are comparators for inside and outside radii and are of great use when fillets, etc., have to be turned to accurate proportions. The same gauges are supplied in a holder. The price of the test indicator is 3*s.* 6*d.* and the radius gauges are supplied in different sizes. Set No. 1 (·05 in. to ¼ in.), 2*s.* 6*d.*; set No. 3 (·3 in. to ½ in.), 2*s.*; set No. 5 ($\frac{1}{16}$ in. to ½ in.), 2*s.* 6*d.*; set No. 6 ($\frac{9}{16}$ in. to 1 in.), 3*s.* 6*d.*; and set No. 10 (1 mm. to 10 mm.), 2*s.* [104.]



Two handy gauges for the fitter and turner.

A Useful Tool Kit

AN extremely handy portable outfit for the handyman is shown at the foot of this column. This tool-roll will slip into the pocket quite easily. It includes a screwdriver, reamer, two gimlets, chisel, saw, file, knife blade and corkscrew, each of which can be fixed in the side or top of a universal handle which is supplied with the outfit. Obtainable complete in a strong leather case, it costs £1 1*s.*, post free. [105.]



A useful portable tool kit for the handyman.

An Ingenious Tool

A PERCUSSIVE rotating drill, known as the "Rapper," for making holes for the accommodation of wall plugs, etc., will be found a useful adjunct to the up-to-date tool-kit. It is compact, handy and weighs 1¾ lb. It works by an ingeniously designed combination of a drill, hammer head and worm, which raises and releases the hammer head, at the same time rotating the drill at a uniform speed. By the use of a very stubborn spring moving through a short distance, blows are imparted to the hammer head at a high velocity. Some idea of the effect of this may be gained from the fact that it is equivalent to blows of a hand hammer at the rate of 600 to 800 per minute. The weight of the blow is adjustable for various materials and should be heavy for hard materials and gentle for friable materials. All wearing parts are made of special steel, suitably case-hardened, and are easily renewable. Its price, including one bit and ejector, is £1 2*s.* 6*d.* [106.]

A New Type of Pocket Knife

INGENIOUS pen-knives of novel design make their appearance from time to time on the market. That shown in the sketch is strongly constructed, and the blade is held perfectly rigid when open. The blade and guard are pivoted to the handle, and when the blade is opened the guard is swung back, thus holding the blade rigid. It costs 2*s.* 6*d.* post free. [107.]

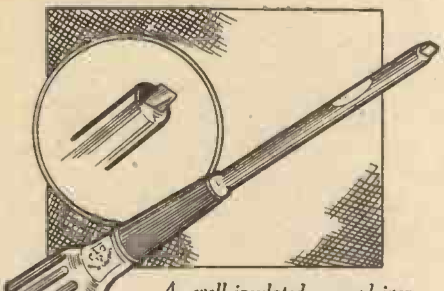
An ingenious one-blade pocket knife which is easy to open, and the blade is held rigid when the knife is in use.

An Insulated Screwdriver

NEW designs in screwdrivers appear on the market with utmost regularity, and this month we deal with a screwdriver suitable for an electrician. The whole shank is thoroughly insulated, and it may be used for work up to 2,000 volts. Finished in green, red or black, it costs 2*s.* 3*d.*, post free. [108.]

Self-Feed, Sensitive Adjustment Drilling Machine

THE above machine is for holes up to ½ in. in diameter. The feed is self-acting and pressure can be adjusted to the diameter of the drill in use. The end thrust is taken up by ball bearings, and the



A well-insulated screwdriver, which is extremely useful for the electrician.

drill automatically rises from work immediately drilling ceases. The drill has a 3-jaw chuck with capacity 0 to ½ in. The maximum height of the drill is 26 in., and the distance from the frame to the drill is 5¾ in. Its approximate weight is 40 lb. and it costs 27*s.* 6*d.* **[109.]**

A Combination Tool

ITS numerous uses will be evident at a glance at the sketch shown herewith, when it will be seen that this really practical combination tool can be used as a hammer, hatchet, nail extractor, and case opener. Its general handiness, low cost and general utility make it quite invaluable and essential for many purposes. It is English made, of best quality heat-treated and tempered steel, with the head and haft in one solid piece. The tool has a well-polished wooden handle 2¾ in. in length, and weighs 1½ lb. It is of exceptional build, and will withstand the hardest usuage for many years; in fact, with fair use will prove practically indestructible. **[110.]**

A combination tool which can be used as a hammer, hatchet, nail extractor, etc.

Four-in-one Rawldrill Tool Kit

IN order to facilitate the carrying out of jobs which call for Rawlplugs sizes 8, 10, 12 and 14, a four-in-one Rawldrill tool kit has been introduced. This outfit comprises a No. 14 toolholder, Nos. 8, 10 and 12 adaptable Rawldrills, and a No. 14 standard Rawldrill and ejector. All these Rawldrills fit the No. 14 toolholder. The complete set is supplied in a strong, neat drill case, smartly bound and divided into three compartments. It is sold complete for 4*s.* 3*d.* The tools can also be supplied mounted on a card instead of a case for 3*s.* 9*d.* **[111.]**

LATEST NOVELTIES

(Continued from page 241.)

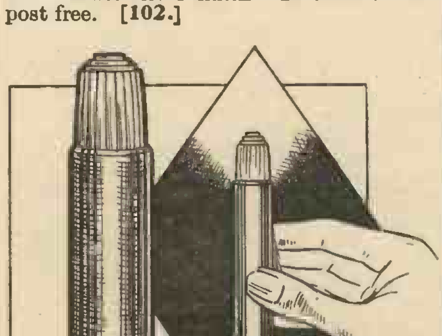
ance with the instructions, it will be found to be a perfect hone and strop for all wafer blades, for which it has been expressly designed. Do not try to conform the blade to the curve, but press just sufficiently to hold the blade in position. The "Newstrop," as it is called, sharpens because of the nature of the composition from which it is made. The radius of the curve and the grooving on the honing half are scientific-

Showing the method of using the "Newstrop." This device can be used to hone or strop safety-razor blades.

ally correct, so as to give a perfect shaving edge. To hone, lay the blade on the grooved half of the device and place your fingers on the blade. covering its whole length. Move the blade briskly from side to side as indicated by the short arrows in the illustration. To strop the blade, repeat the same process mentioned above, but on the smooth half. Best results are obtained by drying the blade and using the "Newstrop" immediately after shaving. Leaving the razor wet, even for a short time, ruins the shaving edges of the blade. The cost of the device is 1*s.* 6*d.* **[101.]**

An Electric "Candle"

THE sketch at the foot of this column shows an ingenious portable light which remains alight all the while it is carried in the hand, but goes out automatically when it is stood down. If it is desired to have a continuous light, a switch is provided on the underside of the base which enables the "candle" to be switched permanently "on" or "off." The "candle" works off an ordinary tubular pocket battery and has a matt silver finish. It costs 5*s.* 9*d.* post free. **[102.]**



An electric "candle" which lights when lifted as shown, but automatically goes out when replaced on a table, etc.

OUR MODEL SPEEDBOAT "STREAMLINIA"

(*Continued from page* 211).

sq. in. This took six minutes. I then "ran the engine up" to get rid of the inevitable condensed steam, and warm her up before setting her off. Having seen that the engine was to my liking, I set the boat in motion.

For what she is, the power of acceleration is great.

She left me, and rapidly gained speed till she was caught and turned at the other side of the pond.

Her speed is about eight knots maximum. I say "about" because it is not easy to handle a boat and time her accurately as well. My impression was that she was capable of 9 knots, but I could only be sure of eight.

Her steering is more accurate than on any boat of her type I have handled. She is a good sea boat, and her duration is about 30 minutes.

Outstanding Points.

I consider that the three best points in this boat are the hull, the engine, and the propeller. The hull is a lovely job by Messrs. Bassett-Lowke; the engine is the best thing of its kind put on the market, and the boiler is of copper and brazed throughout.

The boat is a happy combination of good parts and it is simple to build. It is cheap to engine, and is easy to carry. In the water it goes where you want it to go. It has all the speed that can be required by anyone outside the ranks of speed-boat men. And since the boat is "everyman's boat, and not meant to be a speed boat, I do not think one can ask any more. It is one of the easiest boats to handle I have met. I have a fleet of my own of some thirty vessels (there are some tartars among *them* to handle), and in all I have run and tested some hundreds of model boats this last twenty-five years.

MODEL SUBMARINES

(*Continued from page* 217.)

(Fig. 3), the torpedo is held between A and B. A is a piece of metal moving in a slide (not shown) fastened to the hull. A copper wire runs from this slider to C, which is capable of turning in a vertical plane about a horizontal pivot D. A light rubber band (not shown) goes round the tubing C and around the gimp pin P (see Fig. 9). This has the effect of slackening the wire when the rubber motor is wound up. Its pull is far greater than that of the rubber band and the wire becomes taut. The slider A, then moves forward. The torpedo is firmly gripped at the points marked A and B, and the propellers rest on the horizontal metal platform H (see Fig. 3). This platform is essential, or the propellers will grip the upper deck and the torpedo will stick. As the motor runs down, the copper wire becomes less taut and finally slackens and the torpedo is released under the combined efforts of the "kick" of the propellers on H and the thrust of the light spiral spring on the slider.

One strip of $\frac{3}{16}$ in. rubber to each propeller is sufficient to drive the torpedo.

How to Start and Run the Model

Get a friend to hold the model amidships with one hand and the two propellers with the other, remove the rings from the front hooks, and using the double winder, wind up the motor. Place the prow in the water and lower the stern until the model is in position and then release.

The vanes or fins should be set previous to winding up the motor.

NIGHT-FLYING KITES

(*Continued from page* 214.)

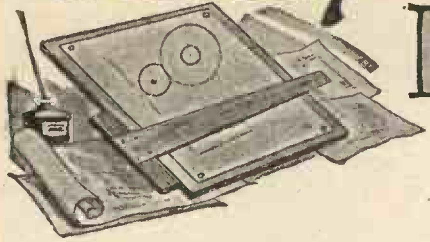
chassis. The brass tube is covered with cartridge paper or celluloid, through which are pierced a number of slots, so that the contacts fixed to the insulating block make and break contact with the brass as the barrel is rotated. This is done by the same sort of slide as shown in Fig. 2, but the pawl is arranged to operate on teeth cut into the side of the brass tube. The slots in the paper should be cut after the barrel is mounted to ensure clean alignment. Any arrangements can be chosen to give various changes of lights. All, or only one at a time, can be switched on. If the switches have a tendency to turn round the string axially, this may be stopped by fixing a vane to the switch as shown in Fig. 4. This can be made of stout paper or thin sheet aluminium.

A Mercury Switch

Another type of switch which indicates movements of the kite is shown in Fig. 5. A glass tube closed at the ends is fitted with three pieces of wire forming contacts. The tube is slightly bent in the middle, the lowest part forming a reservoir for a quantity of mercury. The switch is taped up to the cross-stay of the kite, so that as the kite sways one way or the other, the mercury floats in that direction and links up the centre contact to the outer contact and lights the lamp connected thereto. The port lamp should be stained red and the starboard lamp green. When the kite is flying vertically no lights will be shown, unless additional riding lights be added.

A fine scale model of the Graf Zeppelin made by Messrs. Bassett-Lowke, of Northampton.

Money Making IDEAS



ADVICE BY OUR PATENT EXPERT

A ROTARY MULTI-FUSE

"Re your patent advice section of your splendid paper, 'Practical Mechanics,' I would like your advice on the following: (1) I have a design for a rotary multi-fuse. The actual fuse container carries about six fuses, and when one fuse blows, another can be brought into service by turning a small handle, thus eliminating the trouble of having to open the fuse box and replace new fuse wire, as is the usual method.

"Would the device be patentable, and if so, would principle only protect the entire article?

"(2) Would it be permissible to use a special type of bakelite moulding." (E. H. Newport, Mon.)

The rotary multi-fuse as far as one can gather from the meagre description of the device appears to form fit subject matter for protection by Letters Patent. It is, however, doubtful if the broad principle involved in the invention is novel. If the principle be not novel, it would not be possible to obtain a basic patent covering every means for carrying the invention into practice. It would be advisable to have made a preliminary search amongst prior Patent Specifications relating to the device before applying for protection. It is probably doubtful if the Board of Trade Regulations or the Fire Insurance Offices would allow the baseplates of fuses to be made of a phenol condensation product, such as "bakelite," but such material could probably be used as a casing to enclose the parts of the fuse.

A NUMBER OF INVENTIONS

"As I have many valuable inventions worthy of 'Patent Searches' which may then be followed by 'Application for Patent' and Sales Promotion, I cannot afford to exploit more than one invention at once, which takes time. Can you give any advice as to financial assistance?" (W. B., Herts.)

The proposed device for protecting the edges of chisels could probably be protected by Letters Patent, but it is not thought that any Patent granted on the device would have very much commercial value. The inventor is possibly aware that it has long since been the practice to protect the edges of cutting tools by guards, for instance the employment of a grooved piece of wood fitting over and protecting the teeth of saws, or the use of corks or bungs for protecting the edges of sharp and pointed tools.

With reference to the apple-corer and slicer, the invention would appear to consist in the combination of radially arranged blades with an apple-corer of known construction for the purpose of coring the apple and cutting it into sections in one operation. This might form the subject-matter of a Patent, but the commercial value of the invention would depend largely on the way it was marketed.

Probably the best way of obtaining financial assistance for the marketing of inventions is by press advertising, but in such case the inventor must be prepared to forego a large share of his rights to the person financing him. In the present cases it would probably be better for the inventor to concentrate his attention on a single invention and make or have made a proper workmanlike sample, and then submit it to manufacturers specialising in the class of goods to which the invention relates. It would certainly be advisable to file a Patent Application for the selected invention before submitting it to manufacturers.

PROVISIONAL SPECIFICATIONS

"Some months ago I filed a provisional specification containing two alternative systems. It would appear, however, that one of these systems is not original or patentable, although the other system appears to be original.

Is it possible, then, to file a final specification in which only the latter system is outlined?

"Also, the description in the provisional specification specifies 'systems.' What should be done about this, as obviously the description would be inaccurate as applied to only one system? (W. H., Northumberland.)

It is understood that the applicant has filed an application for Patent with a Provisional Specification in which the nature of two separate inventions is described, and has now discovered that one of said inventions is not original. He can file a Complete Specification confining the description to the one invention he believes to be novel. The Patent Office will allow the Provisional Specification to be amended by excising the matter, *i.e.*, the description of old invention, from the document on file, in which case no publication of the excised matter will take place after acceptance of the Complete Specification.

Any amendment of the title and description of the documents filed will also be allowed to render them grammatically in order.

AN ALL-METAL HAMMER

"I have thought of the two following ideas—namely 'An All-metal Hammer' and an 'Egg Separator.' Will you please give me your opinion as to their commercial possibilities." (W. B., Herts.)

If the proposed device will actually separate the yolk of an egg from the white, it should have a distinct commercial value if properly marketed. The device so far as is known from personal knowledge is novel and forms fit subject-matter for protection by Letters Patent.

With regard to the second invention relating to metallic handles for hammers, the mere substitution of metal for wood is, of course, not a patentable invention, but it would probably be possible to obtain a Patent for the particular construction of the metallic handle if novel, but the commercial value of the invention would not be great.

The inventor is warned not to reply on the supposed "Evidences of Invention" as giving him any legal protection; the only protection which is legally recognised is that given by filing an Application for Patent.

THE DEVELOPMENT OF THE TALKING MACHINE

(*Continued from page* 213.)

There are still, however, a few of these early gramophones to be picked up about the country here and there, and, as a curiosity and even a financial investment, one of these machines is worth acquiring whenever possible. Their general features, of course, have been immortalised in the well-known "His Master's Voice" picture painted by Frances Barraud.

About 1910 Edison's phonographs began to disappear, the gramophone completely superseding them. At this time, also, hornless models became popular. Subsequently portable gramophones were first placed on the market.

The progress of the gramophone from these latter days is well known to every reader. With the advent of wireless the gramophone industry began literally anew with its introduction of "electrical recording," a system which revolutionised the standard of all previous recordings.

Then came the complete union of wireless with the gramophone. It produced the radiogram, the talking machine of modern times by means of which sound-reproduction is so faithfully and realistically accomplished that it is difficult to see how much greater improvement can be forthcoming in this particular direction.

Between the earliest phonograph and the most modern radiogram an interval of fifty-seven years exists. It is a period of time which in the matter of sound-recording and reproduction has been packed with interest and experiment.

THE WONDERS OF GRAVITY

(*Continued from page* 218.)

elastic bodies immersed in water and made to pulsate are drawn together. If two people hold a rope and set it vibrating they are drawn together. If it is possible that ether vibrations (a substance so tenuous as to defy all our attempts to prove its existence experimentally) can so act on gross matter—say the earth and the moon—in such a manner as to bind them in invisible bonds, we are no nearer an ultimate solution of the mystery. What is gravity? We do not know, although we know much about what it can do and also how it does it.

To gravity is due not only the fall of an apple to the earth but also the daily ebb and flow of the tides, the rotation of a satellite round a planet and a planet round the sun floating isolated in space, and of the whole solar system around some grand centre, describing an immense but purely ideal curve. It is the mystery of mysteries.

REPLIES TO QUERIES & ENQUIRIES

If a postal reply is desired, a stamped addressed envelope must be enclosed. Every query and drawing which is sent must bear the name and address of the sender and be accompanied by the coupon appearing on page iii of cover. Send your queries to the Editor, PRACTICAL MECHANICS, Geo. Newnes Ltd., 8–11 Southampton Street, Strand, London, W.C.2.

ELECTRIC MOTOR QUERY

"I have in my possession a small electric motor. Unfortunately, it will only work off a 6-volt car accumulator, and I do not happen to possess one. Could you please tell me a way to run it?" (H. R., Skegness.)

We are sorry that we cannot tell you how to run the electric motor economically by any other means than a 6-volt accumulator.

CORRESPONDENT REQUIRED

Mr. H. F. Walker, 54 Marsh Hill, E. 9, wishes to correspond with other readers residing in foreign countries.

A CHEMICAL QUERY

"I would be pleased if you could inform me on the following :—

"(1) What apparatus will I need for the preparation of metallic sodium and potassium from their fused hydroxides by electrolysis?

"(2) How is the process carried out?

"(3) Where can I obtain yellow phosphorus? I have tried several chemists, but have been unsuccessful." (W. B., Hants.)

(1) and (2) The apparatus is costly and somewhat involved. Metallic sodium is manufactured by the electrolysis of fused sodium hydroxide by Castner's method. The negative electrode projects through the bottom of the iron vessel containing the fused hydroxide, and here the sodium and hydrogen are liberated. This electrode is surrounded by a wire gauze partition to permit circulation in the fused mass and prevent the escape of the globules of sodium. This is surmounted by a bell-shaped vessel of iron. The positive electrode is an iron cylinder surrounding the gauze. The sodium and hydrogen liberated at the cathode, being lighter than the fused mass, ascend into the iron vessel, under the edge of which the hydrogen escapes; oxygen is set free at the anode; the top is closed to prevent the sodium from burning and the melted sodium is ladled into moulds. The process for potassium is identical, although molten potassium chloride is the substance electrolytically decomposed. The process is obviously only practicable on a commercial scale, and querist will be able to learn more about it on referring to text-books on "Industrial Chemistry."

(3) Yellow phosphorus is obtainable at any big chemists (not fancy dealers), the likeliest being one who furnishes laboratories. The large London drug houses have stocks of this substance, but I think there are restrictions regarding its transit in post on account of its dangerous nature.

A LIGHT-SENSITIVE TRANSPARENT CRYSTAL

"I wonder if you could advise me on the following conjectures? Possibly you are aware of developments or experiments which have been (or are being) investigated on similar lines.

"(1) Is there any transparent crystal you know of which is light-sensitive and also a good electrical conductor? My idea is this: A crystal has the properties of light refraction and A.C. rectification to D.C. If a crystal could be found having both these properties, and be distributed in the form of powder or emulsion on the surface of, say, a glass plate, it is my belief that it would be capable of transposing variations on an electric current which could be transmitted or broadcast. My idea is that an ordinary cinema, with a contact synchronised with the shutter and the impulse current fed through this powder surface, would give a momentary impression and that this could then be collected by a receiving set and reproduced on a similar powder-covered plate illuminated from behind. The crystals must obviously be of a transparent nature (giving a frosted surface) to do this. The point is, that if the crystals could affect the light reception at the transmitting end, the amplified potential at the receiving end would equally affect the absorption or rejection of the illumination at the receiver end. It possibly would produce a "negative"—but there are ways of dealing with that. Silver iodide?

"(2) If various colours can be obtained by the neon sign makers, why can't the television neon lamp makers produce a white light? Even a combination of blue and yellow lamps fed through a prism might be better than a sickly orange glow.

"(3) Have any attempts been made to deal with spectral light, e.g., passing the image through a prism and then transmitting each colour band and reuniting them at the other end? This explanation must be brief, but I dare say you can get the idea.

"(4) Would it be possible to transpose ordinary light on one special form (superhet), transmit this, and restore it again at the receiving end, e.g., filtering out all but the violet rays?" (A.C., S.E.10.)

(1) By your use of the term "light-sensitive," it is presumed that you infer the property of generating an electrical current or changing in electrical resistance under the influence of light. Some crystals, such as clear Iceland spar, are "light-reactive," that is, they act on the light rays passing through them in a peculiar manner. Iceland spar, for instance, possesses the property of "double-refraction."

There is no transparent crystal known which is light-sensitive in the manner which you infer in your query. Or, at least, if any such crystal is known, its properties have not been published. Nor is there any transparent crystal which is a good electrical conductor. Nearly all crystals, including even isolated metal crystals, are more or less poor conductors.

Your idea is an ingenious one, and provided that you could find a transparent, light-sensitive, conductible crystal, there are considerable possibilities in it. This proviso, however, is a very formidable one. Rochelle salt (sodium potassium tartrate) is a crystal which has several uninvestigated properties. It is transparent, and it might possibly be found to be light-sensitive. But it is a very bad conductor.

An objection to your idea is that by powdering up the crystal you might destroy its properties, for the properties of very minute and partially-disintegrated crystals frequently vary considerably from the properties of large crystals. However, this difficulty might be overcome by mixing the powdered crystals with some very finely-divided metal which, in correctly proportioned amounts, might impart the necessary conductivity to the screen and at the same time maintain its transparency.

Still, your main difficulty is to find a transparent, conductible, light-sensitive crystal—and this will take some finding, we imagine.

(2) Neon lamps which give an approximation to white light are obtainable. Enquire from The General Electric Company Ltd., Magnet House, Kingsway, London, W.C.2. It must be remembered that neon-sign lamps are crude affairs compared with the delicately-adjusted neon lamps used for television reception. Pure neon glows with a characteristic orange colour. A gas which, under similar conditions, glows with a perfectly white light is not known. Consequently, the problem facing manufacturers of these lamps is to produce a mixture of "glowable" gases which will give out a white light. This problem, admittedly, is not yet satisfactorily solved, but no doubt its solution will be accomplished in the near future.

(3) Yes, one of the earliest systems of colour television operated on the lines you indicate. The image was scanned thrice, once in red light, once in green, and once in blue light, this triple scanning being accomplished by means of a scanning disc perforated with three sets of scanning apertures, provided with red, green and blue gelatine filters respectively. Each colour band was transmitted, and at the receiving end a similar triple scanning disc revolved in front of the illuminant, which consisted of a combination of an ordinary neon lamp (giving an orange glow) and a helium-mercury lamp (giving a greenish-yellow glow). By a special method of synchronisation, the "red" impulses were fed to the neon lamp and the other light impulses to the helium-mercury lamp. In other systems, a single "neon" lamp, giving a fairly white glow, was used in place of the duplex illuminant.

(4) This query is not quite clear. If you mean, is it possible to transmit any particular wavelength of light, the answer is in the affirmative. Light-cells which are sensitive to any required wavelength of light can now be obtained. Thus, one can procure light cells specially sensitive to blue, green, yellow, red or infra-red rays. Hence, all but the violet rays could be filtered out from light. These could be transmitted by television methods and received as usual. At the receiving end, of course, they would not appear actually as violet rays, but as electrical currents created by the violet rays at the transmitting end.

SPOT LIGHTS FOR STAGE

"Could you let me have any particulars about reflectors for spot lights for stage equipment, especially for Mangin parabolic reflectors (mirror) and lenses?" (L.C., Nr. Stroud.)

If you desire to make a spot-light suitable for a small stage, obtain a motor car head-lamp reflector, and, if necessary, have it replated, a small bayonet cap-holder and a light, tight box. Mount the holder in the reflector and adjust the lamp position, *i.e* move it in or out, until a parallel beam is obtained, the whole is then fixed in the back of the box, the opposite end of which is removed; thin coloured gelatines may be placed over this, paint the inside black, and the apparatus is complete. The above is more suitable for operation from a car battery rather than the mains; in the latter case, a far better result may be obtained by using, in a similar but well-ventilated box, a 500-watt lamp and a lens. The lens is mounted in the front of the box, and the lamp position adjusted until a parallel beam is obtained.

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PRACTICAL MECHANICS, FEBRUARY, 1935

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MODEL AIRCRAFT SUPPLIES LTD. have just published at 4*d.* post free their Green Book for 1935. This is a handy little catalogue, well produced in a strong cover, detailing the prices of all materials necessary for making scale and flying model aircraft.

This firm stocks wood in all sections, blue prints, piano wire, silks and tissues, propellers, gears, rubber, dopes, etc., etc.

The volume also includes an official list of British records. Readers interested in model aircraft should certainly obtain this useful catalogue, which they will find a handy stand-by when building any of the models described in our own handbooks, "Model Aeroplanes and Airships" and "Power Driven Model Aircraft," which are obtainable from us for 1*s.* each, or by post for 1*s.* 2*d.* from Messrs. George Newnes Ltd., 8/11 Southampton Street, Strand, W.C.2. The Catalogue costs 4*d.*, post free, from the above firm at 171 New Kent Road, S.E.1.

ILLUMINATING ENGINEERING POSSIBILITIES

THE continuous growth in the importance of lighting is already creating a demand for young men who are prepared to make a study of this field.

In order to encourage students to take an interest in this important work, the Council of the Illuminating Engineering Society has decided to admit students of either sex between the ages of 16 and 25 as "affiliated students" of the Society for a specially reduced subscription of 10*s.* 6*d.* a year. Affiliated students will have the right to attend meetings, take part in visits, and receive the Society's monthly journal, *The Illuminating Engineer.*

Forms of application for membership are obtainable from the Honorary Secretary, Mr. J. S. Dow, 32 Victoria Street, London, S.W.1.

CLUB REPORTS

Club Reports for inclusion in this feature should not exceed 250 words in length, and should be received not later than the 12th of each month for inclusion in the subsequent month's issue.

STREATHAM COMMON MODEL RAILWAY CLUB

OUR clubroom at 201 Gleneldon Mews, Streatham High Road, is open every evening for members' use. Each night has been allotted to a definite object. A card should be addressed to the secretary requesting particulars of the fixtures.

We had a very interesting Track Night in December, and had a very good attendance of members. We hope to hold another soon.

We welcome new members and any friends to our meetings. Further particulars, including a copy of *Concerning Ourselves,* will be sent on receipt of an application addressed to the Secretary, L. J. Ling, Brooke House, Rotherhill Avenue, Streatham, S.W.16.

INSTITUTE OF SCIENTIFIC RESEARCH

ON Saturday, December 8th, a visit was paid to Cookridge Street Baths, Leeds, where members were shown the filtration and purifying plant for the swimming pools, and where we also saw the Turkish, Paraffin, Sun-ray and Zotofoam baths.

On Wednesday, January 2nd, a visit was paid to Bryant & May's Match Works, Leeds. After seeing crates, each containing 600,000 match stalks, imported from Canada, we saw how the mixture with which the matches are tipped is made, and then inspected the wonderful automatic machines which make the match-boxes, dip the match stalks into the tipping mixture of phosphorus sesqui-sulphide, potassium chlorate, etc., allow the matches to dry, and finally insert them into waiting boxes. We concluded this interesting visit by having tea in the work's canteen

Owing to an unforeseen occurrence, it was found impossible to arrange a meeting for January.

A branch has now been formed at Canterbury. Further information may be obtained from Mr. J. H. Potts, 26 Whitstable Road, Canterbury.

On Saturday, February 2nd, a meeting will be held, at which Mr. P. Tyndall will give a lecture, illustrated by experiments, entitled "Radio Control."

On Friday, February 22nd, a visit will be paid to the Gas Apparatus Maintenance Plant, Bridge Street, Leeds.

For further information concerning the club or its Correspondence Section, send a stamped, addressed envelope to the Secretary, Mr. D. W. F. Mayer, 20 Hollin Park Road, Roundhay, Leeds 8.

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Please obtain and send to me particulars from the Advertisers in your February issue whose names I give on list attached.

Advertiser	Page No.	Information Required.

Attach sheet of paper, with particulars, and your name and address (written in **BLOCK** *letters), with date, to this announcement.*

MAKE BIG MONEY

28/6

Or Save Money

WITH THE NEW

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PRINTING MACHINE

CASH OR EASY TERMS

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The enormous profits which can be made with the new "ADANA" Machine are forcibly demonstrated by the following examples :—

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Cards cost	3/3
PROFIT	**7/3**

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Sold for	12/9
Paper costs	3/–
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EVERYDAY NEEDS

Private Noteheadings	Sports Printing
Visiting Cards	Competition Cards
Business Cards	Correspondence Cards
Gummed Labels	Christmas Cards
Showcards	Wreath Cards
Greeting Cards	Mourning Notices
Small Wrappers	Advertising Blotters
Price Tickets	Wedding Cake Cards
Entertainment Cards	Wedding Invitations
Sports Scoring Cards	Hairdressers' Cards
Card Games Scoring Cards	Scented Cards
Small Programmes	Admission Tickets
Tag Labels	Window Tickets
Commercial Noteheadings	Dance Invitations
Billheads	Calendars, etc.

OFFICE PRINTING

Commercial Noteheadings	Overprinting Ledger Cards
Business Cards	Commercial Envelopes
Overprinting Circulars	Motto Desk Pads
Card Index Slips	Letter Reference Slips
Urging Notes	Account Remittance Slips
Instruction Chits	Cash Receipts
Price Tickets	Exhibition Cards
Overprinting Cheques	Travellers' Cards
Stationery Samples	Address Slips for Envelopes
Proofing of Blocks	Book Indices, etc., etc.
Advertising Tickets	
Advertising Blotters	

HOTEL PRINTING

Menus and Wine Lists	Forthcoming Attractions
Writing Room Stationery	Small Programmes
Tariff Cards	Dance Invitations
Porters' Labels	Reservation Cards
Room Notices	Receipt Slips
Suit Case Labels	Guests' Name Tickets
Greeting Cards	Tag Labels
Entertainment Cards	Cloakroom Tickets
Card Games Scoring Pads	Waiters' Pads
Dance Cards	Billheads, etc., etc.

FACTORY AND SHOP

Works Instructions	Wrappers' Number Tickets
Overprinting Carded Goods	Bonus Stamps
Overprinting Cartons	Photographers' Imprints
Chemists' Labels	Titles on Negatives
Instructions for Games	Snapshot Wallets
Parcel Labels	Wage Envelopes
Small Wrappers	Jewellers' Envelopes
Cloth Name Tapes	Seed Envelopes
Printing Cloth Samples	Hairdressers' Cards
Printing Bags	Window Tickets
Billheads and Statements	Interior Forms
Overprinting Drawings	Boot Repairers' Tags
Printing Wrapping Seals	Stores Labels, etc., etc.

PRINTING FOR THE CHURCH

Special Hymn Sheets	Pew Seat Cards
Collection Box Labels	Mourning Notices
Church Announcements	Wreath Cards
Notices of Meetings	Duplex Envelopes
Bazaar Tickets	Wedding Hymn Sheets
Greeting Cards	Admission Tickets
Concert Admission Cards	Funeral Service Sheets
Small Programmes	Calendars, etc., etc.

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