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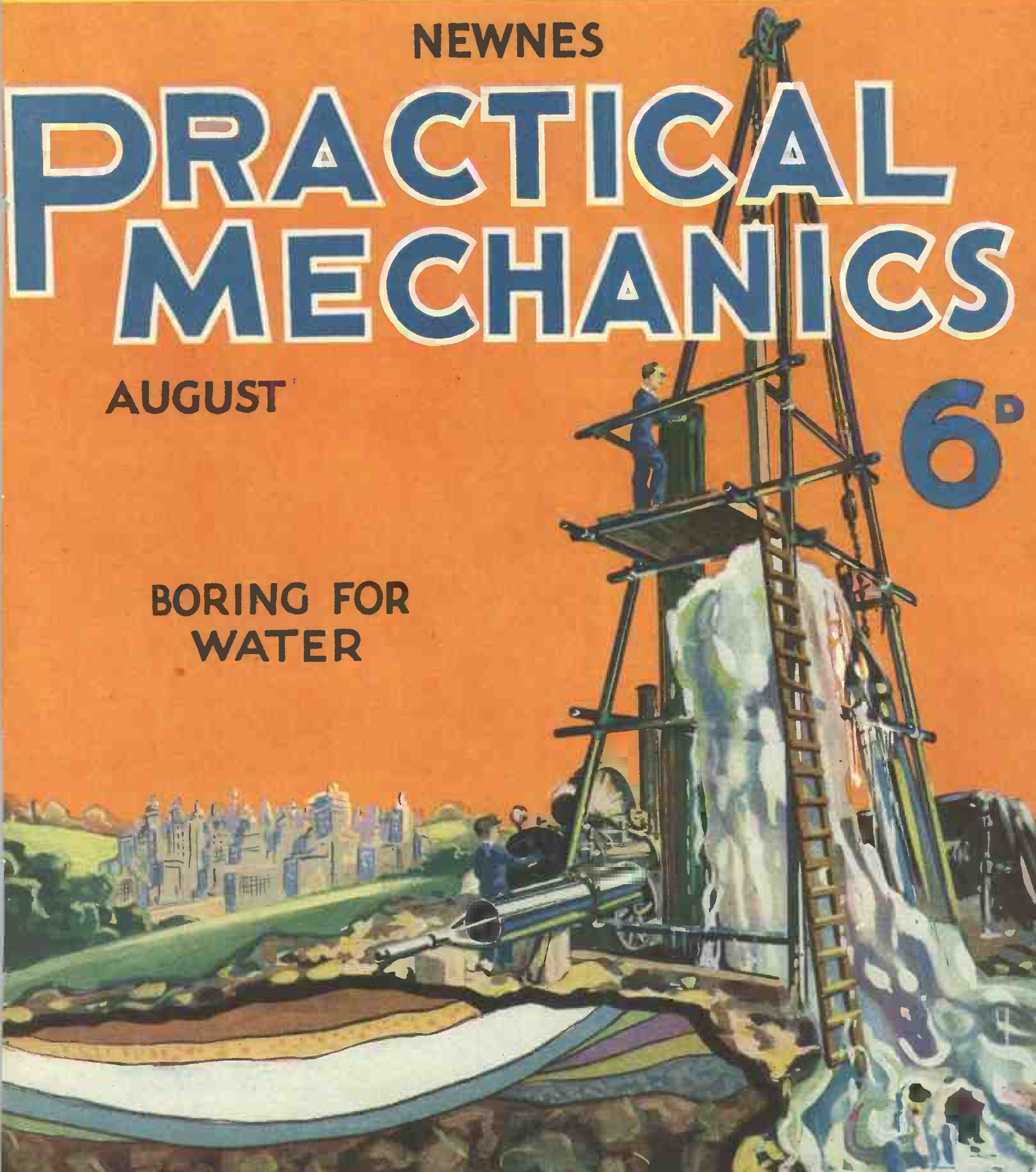

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Edited by F. J. CAMM

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Notes, News and Views

A Vibrationless Tramcar

A NEW electric tramcar recently built for service in Chicago is stated to be noticeably free from vibration, and to possess features that will greatly add to the passengers' comfort. One interesting feature is the use of a special wheel in which the axle is supported from the rim or tyre through a series of rubber plates. The result is that the riding quality of the car is greatly improved, and the noise and vibration arising between the wheel and the rail is considerably reduced. Rubber is also used at other points throughout the structure of the car, so that noise is diminished as much as possible. The car has a maximum speed of 42 m.p.h. on a level track.

A New Flex

TO meet the problem of providing a reliable method of connecting small domestic electric appliances to the mains supply, the General Electric Company are introducing a flexible cord known as "Domestaflex." It consists of tinned copper wire conductors, each insulated with two layers of vulcanised indiarubber. The two insulated cores, one red and one black, are then laid up with whipcord inserts, filled with vulcanised rubber, and braided with glazed cotton, the external braid adhering tightly to the rubber filling. The whipcord inserts provide a separate means of attachment to the plug or other connecting device, so preventing any strain on the conductors themselves.

High-speed Photography

A NEW Kodak camera has just been introduced capable of taking up to 2,500 pictures a second, which is about twenty times faster than the usual "slow-motion" films shown in cinemas. Simultaneously, it can record the time taken by the subject filmed in one-thousandth of a second. The timing apparatus has been produced by the Western Electric Company and consists of a frequency generator and a clock driven by a synchronous motor. The camera has two lenses, one of which photographs action and the other time, and both are recorded on the same section of film. When working at full speed the camera uses 50 ft. of film per second.

An Ingenious Milk Plant

A MODERN milk plant recently installed by a large dairy in New York is a marvel of mechanical precision. It is capable of dealing with 600 milk bottles a minute. The empty bottles, in their cases, come in on conveyors and are fed into five washing machines. After a thorough soaking in an alkaline solution they are scoured inside by air-impelled water sprays. From each washer the bottles are discharged on to another conveyor, where they are inspected, and they are then carried to automatic, vacuum-actuated filling and capping machines. Meanwhile the cases have travelled through a washer and around to the fillers where they are loaded with bottles of milk, after which they pass through a chilling room, and thence to the loading stations.

THE MONTH'S SCIENCE SIFTINGS

The new air-cooled aero-engine, the Napier "Dogge," has twenty-four cylinders arranged in four banks of six each. It is capable of developing about 630 h.p. at 3,500 r.p.m., and weighs about 2 lb. per horse-power.

It is reported from Ontario that a local watchmaker has succeeded in drilling a hole through an ordinary pin from its head to its point without splitting it. The hole is just large enough to allow a human hair to pass through it.

The world's largest welded bridge, which spans the River Abushka, in Russia, was recently opened for traffic. The widest span of the bridge is 85 m. and the width 18 m.

A vessel at present being fitted out in the Clyde to search for the wreck of the Lusitania carries a one-man submarine, and will combine treasure hunting with undersea film making and pearl and sponge fishing in various parts of the world.

The launching tackle for the new Cunard liner "No. 534" includes wire ropes 7½ in. diameter and weighing over 40 tons.

An ingenious method was used recently by an American repair gang for repairing a leak in a water main, the shut-off valve of which was not handy. They dug down to the leak and packed ice around the pipe, then poured in salt and froze the water. The leak was then repaired.

When the "Graf Zeppelin" made its first flight this season over Lake Constance, a glider attached to the airship was released and made a safe landing.

The first twenty-four-hour neon clock to be erected in the British Isles was unveiled recently at a motor depot in London.

A Large Diesel-Electric Passenger Ship

THE Diesel-electric passenger vessel, *Lochnevis*, recently built by Messrs. Denny & Brothers, Ltd., for the West Highland service, is 175 ft. long, 31 ft. in breadth, and her depth 10 ft. 6 in. to the main deck. The main propelling machinery consists of two 650 b.h.p. Diesel engines, each of which is coupled to a 425-k.w., 500-volt direct-current generator running at a speed of 500 r.p.m. These generators supply the current for two electric motors, each of which has an output of 525 shaft horse-power at 400 r.p.m., and is directly coupled to a propeller. Each engine has six cylinders having a bore of 13 in. and a stroke of 16 in. The vessel is designed for a speed of 15 knots, and excellent accommodation for about 700 first-class passengers is available. This includes, in addition to a lounge, dining saloons and smoke-room, a covered-in shelter amidships on the promenade deck, through the large windows of which ample opportunities for observing the scenery are afforded.

A Remarkable Steam Locomotive

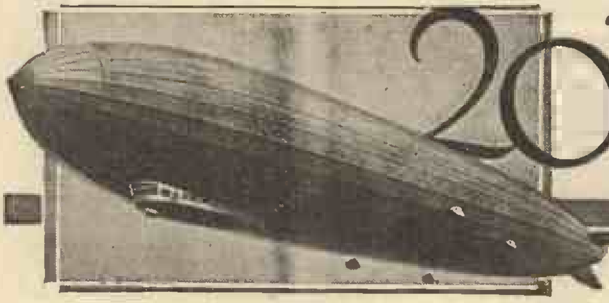
AN interesting locomotive, which is a novel departure from normal locomotive design, has just been constructed by the Sentinel Wagon Works Ltd. for a South American 1-metre gauge railway.

The engine frame is carried on two six-wheeled bogies, between which, above the footplate, the boiler is mounted, which is of a special water-tube type. This supplies steam to six high-speed double-acting compound engines mounted between the bogie frames, each driving one axle through gearing. The working steam pressure is 550 lb. per square inch. Although the rail gauge of this remarkable locomotive is only 1 metre, the overall length is about 43 ft., and the width just over 8 ft. It has a coal bunker capacity of 3 tons, while the water tank holds 1,200 gallons of water?

OUR SPECIAL TOOL KIT OFFER

May we direct the attention of every reader to our special offer of a pocket kit of engineering tools, full details of which appear on pages 524 and 525 of this month's issue?

These tools will be found invaluable to the model maker, the handyman, and the wireless constructor. Only a limited number of these cases are available, and in order to secure one of them it is necessary for you to qualify at once.



The Graf Zeppelin.

20 Years of Airship Progress

By F. J. CAMM

An Interesting Résumé and an Analysis of the Possibilities of Lighter-than-Air Craft

THE first time that a lighter-than-air craft carried human beings into the air was on November 21st, 1783, when a large fire-balloon filled with hot air, and built by the brothers Steven and Joseph Montgolfier (two French paper-makers), carried M. Pilatre des Roziers and the Marquis d'Arlandes for a distance of two miles. The balloon was constructed to demonstrate that earlier experiments in heavier-than-air craft would not provide the ultimate solution to the conquest of the air.

Encouraged by the success of this first ascent Des Roziers and a colleague had a larger hot air balloon made, and a year later succeeded in ascending to an altitude of over 11,500 feet. In the interim between these two experiments the gas-filled balloon had arrived, for it was in the Champ de Mars, Paris, on December 1st, 1783, that a large crowd assembled to witness the ascent of the hydrogen balloon built by Professor Charles. A vast crowd of over half a million people cheered as the majestic balloon rapidly ascended to a great altitude and disappeared.

The balloon was hailed as the air vehicle of the future, but it soon became apparent that it lacked what sea-going vessels and land vehicles possessed, namely, ability to steer a predetermined course. It drifted with the wind and those who partook of the sport of ballooning, which enjoyed a vogue for more than fifty years, had no idea, after ascending, exactly when or where they would land. Hence the introduction of the dirigible.

The first practical airship was built by a Frenchman, M. Henri Giffard; this had a cigar-shaped envelope and was driven by a small steam engine. It made its first trip on September 24th, 1852, and was able to travel at the very slow speed of 4 miles an hour. No airship could claim to be really dirigible at this slow speed, although it was able on this occasion to direct its course.

Many other efforts were made to produce a satisfactory design, but it was not until M. Santos Dumont, a Brazilian, fitted a petrol engine to a small airship in 1898 that really successful results were obtained.

Santos Dumont

All of these airships were of the non-rigid type, that is to say, they consisted of a gas envelope with no supporting framework inside (internal gas pressure being relied on to maintain the shape of the envelope), and there were several disasters owing to collapse of the envelope in the air. Santos Dumont, however, was really the father of the modern dirigible, for all modern designs have been based on the results of his experiments.

The Norwegian explorer, Amundsen, in the Italian airship *Norge*, crossed the North Pole on May 12th, 1926. Just before the War extensive experiments were carried out by Count Zeppelin in Germany, by the Aircraft Development Company in England, by Captain Spencer, and one or two others. It was with airships of the rigid type that the greatest success was achieved, and the British Government began to consider its possibilities as an instrument of war. A number of rigid airships were built which led up to the famous and fatal *R* 101.

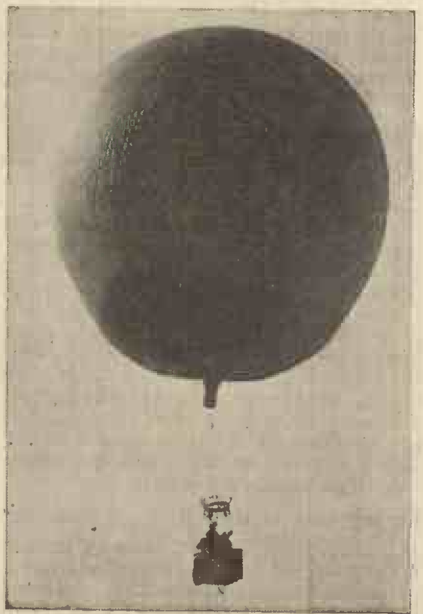
Captain Spencer was one of the pioneers of dirigible airships in England. This photograph shows the Spencer airship in flight. Compare with the more modern designs illustrating this article.

Rigid Airships

The system of construction utilised in a rigid airship is based on the designs of Count Zeppelin, who used a hull made of light aluminium girders covered outside with fabric, but divided internally into a number of cellules into which were placed small gas-filled balloons. It will thus be seen that should any particular balloon fail the airship would still remain afloat and would not collapse in the air. The most important advantage conferred by this system of construction is that the rudders and engines can be firmly attached to the hull and thus steering and propulsion may be carried out with greater accuracy. The first Zeppelin was launched from a floating hangar on Lake Constance, in July, 1900. It contained 400,000 cubic feet of gas and measured 420 ft. in length. Its maximum speed was 17 miles an hour, and it proved the forerunner of a long series of Zeppelins, all of which were financed by the German Government and public subscription. As with all other scientific achievements disaster proved the best mentor, and as the crews profited by earlier mistakes, troubles and disaster grew less until it was possible to institute the famous passenger Zeppelins which effected a regular service for many years between German towns and carried thousands of passengers without mishap. Later designs were made even larger, and those used during the War contained over two millions cubic feet of gas and were able to travel at the comparatively high speed of sixty miles an hour. One of them made the remarkable journey of over 5,500 miles from Bulgaria to Central Africa and back without landing.

Enormous Cost and Upkeep

It is doubtful whether the airship will really survive, for even in the most perfected form, of which the *R* 101 was a typical example, their cost of upkeep is enormous, and out of all proportion to the service they render, which it has been proved can more adequately, cheaply, and rapidly be effected by passenger-carrying aëroplanes. It is thought that they will become as obsolete as the balloon. For one thing it is impossible fundamentally to make them of reasonable size; they have to be lighter-than-air. Now, hydrogen is approximately 70 lb. lighter per 1,000 cub. ft. than air, hence 1,000 cub. ft. of



Another early English effort, the Butler balloon ascent from Wandsworth.

In France, Santos Dumont was probably the first to construct a successful dirigible. This illustration shows the "Santos Dumont." Later he turned his attention to heavier-than-air craft—one of his most successful designs being the "Demoiselle."

The "A.D.1."—The first private airship built by the Airship Development Co.

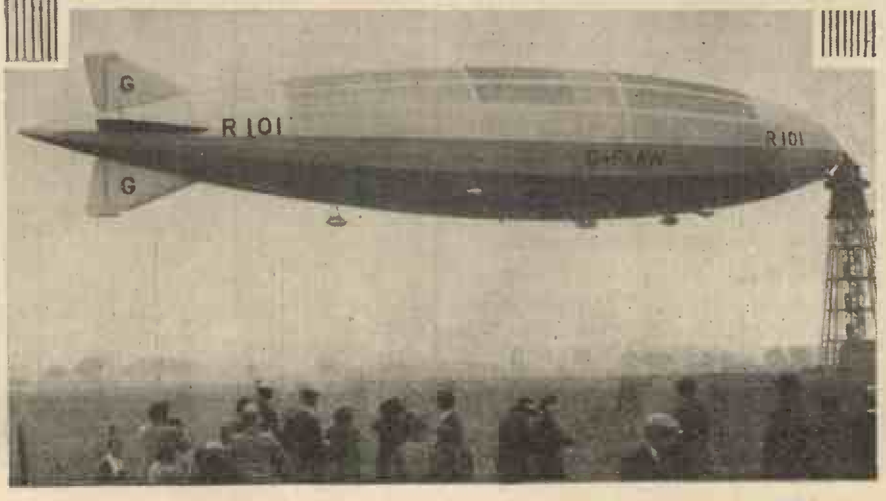
hydrogen is capable of lifting 70 lb. This fundamental fact cannot be altered, for whilst it is possible to use one or two lighter gases which lift up to 90 lb. per cub. ft., the ultimate size of envelope required to lift the engine, pilot, fuel and passengers is still enormous, as can be gauged by inspecting the size of the car attached to the airships illustrating this article.

Flights have, of course, been made from Europe to America and back by the British *R* 34 and *R* 100, and the German *Graf Zeppelin*. Our own *R* 100 was of five millions cubic feet gas capacity, and the *R* 101, which was slightly smaller, was destroyed near Beauvais, in France. Airship construction in England has long since been discontinued. In America, however, there is great activity in airship construction, notwithstanding the recent disaster to their giant *Akron*.

In spite of its unsatisfactory history, the airship does possess some advantages. The most important is that it can keep aloft even if the engine fails, and that it can travel by night and has a flexible cruising range from a very slow speed to its maximum. It is also much steadier in the air and it does not require such a great area in which to land, and when an airship liner reaches its destination it can be "landed" and run into a hangar or tethered to the top of a landing mast about 200 ft. high, through the centre of which runs an electric lift. A covered gangway connects the mast with the nose of the ship through which passengers and mails are embarked or disembarked. But the danger of fire is ever present, and even as an instrument of war they provide a comparatively still target for anti-aircraft guns. They can be (and were) used with devastating effect in war, but at a cost out of all proportions to the military damage they can do.

A New Type

Experiments are being carried out in America with an airship of the rigid type which has a gas envelope made by welding together strips of duralumin only one-hundredth of an inch thick. It is of corrugated formation, which imparts enormous strength; the corrugations, of course, are arranged to run fore and aft. Although this hull has no inside girders to stiffen it, it is extremely rigid. The hull carries a car in which is installed a boiler supplying steam to a turbine inside the hull, which in turn drives a tractor screw. Although no results are yet available, it seems that it has possibilities in that it will permit of a smaller ship for a given buoyancy.



Top—The Barton-Rawson ascent at the Alexandra Palace, and, below, the famous and ill-fated "R 101" swinging from her mooring mast.

MODERN WATERBORING METHODS

Those accustomed to peruse modern technical journals—particularly those relating to modern buildings—may perhaps have noticed the phrase, "Artesian wells provide the water supplies," and behind such a brief announcement lies a most fascinating story, the story of man's efforts to wrest from the earth vast quantities of water.

A section of the great chalk basin showing the source of London's underground water supply. Rain falling on the North Downs and the chalk escarpment near Dunstable percolates through the chalk and replenishes this natural reservoir.

In a general way water is obtained from the following sources: (*a*) From rivers or streams; (*b*) from surface springs; (*c*) from shallow wells; (*d*) from deep boreholes and Artesian wells; (*e*) from adits or headings, which are merely extensive miniature tunnels. Drilling deep holes in the crust of the earth to obtain water, brine, minerals, etc., is of very ancient origin, and was certainly practised by the Chinese and Egyptians centuries before the time of Christ; the Bible also has many references to wells. Gradually the idea of boring spread during the succeeding centuries to different parts of the world; and from 1806 until the present day well drilling (especially in the U.S.A., particularly for oil) has become a colossal industry. The credit for having the deepest well in the world goes to America, for she can boast of oil-producing borings well over 11,000 ft. deep!

This photograph shows a number of 16-in. cores obtained from a boring 1,152 ft. deep.

It is unfortunate that attempts to find oil-producing shales in this country have not been very successful, but although we lack such a useful commodity in workable and profitable quantities, it cannot be said that we have failed to produce water, as we shall see.

Comparatively little is heard of the activities of several companies in this country which have for more than 100 years been tapping various underground strata, and producing enormous supplies of excellent water from the crust of the earth.

Artesian Wells

The term "Artesian" is really a misnomer, being derived from the name "Artois," a province of France, in which a deep well was made in the year A.D. 1126. Whilst this well was in the making a very large quantity of water was found, and the hydrostatic pressure was so great that the water overflowed at the surface; thus was derived the term "Artesian," which means an overflowing well. During the early part of the nineteenth century, when the first deep wells were being drilled in this country, it was no uncommon occurrence for water to overflow at the surface, and gradually the term "Artesian" came to be applied to all deep wells, whether the water overflowed or not. It is now an almost unheard-of thing for a well to overflow in London, although occasionally it does occur in certain other parts of the country. An Artesian well, then, is a deep hole in the ground, of almost any diameter from 6 in. to 6 ft., and drilled from 50 ft. to 5,000 ft. or more through varying strata until the required amount of water is produced.

In almost every case the water which is pumped from deep wells in London is filtered rain, although in some cases it may be river water (especially in wells near the Thames), or it may be sea water. Whatever its source, however, the principle is the same, namely, that water which falls on the surface soil sinks into the ground and percolates downwards, usually following the dip of the underground strata, until its progress is hindered by a stratum which will not absorb it. The former strata

Boring operations in progress.

are called permeable, and the latter, which will not permit percolation, are called impermeable.

The Geological Strata beneath London

If it were possible to take a large knife, and remove bodily all the buildings in London, we should find a thick mass of chocolate-coloured clay, known as the London "Blue" Clay, which may generally be anything from 90 to 180 ft. in thickness, according to the locality. (Between Hampstead and Highgate and at Wimbledon it is 450 ft. thick.) It is of the impermeable variety, but is covered in places with patches of gravel and sand, varying from 1 ft. to 25 ft. in thickness. Where this gravel and sand lie in considerable quantities water may be found.

Beneath the Blue Clay

Immediately beneath the "Blue" Clay lies another bed of clays of a more sandy nature. These are termed the Woolwich and Reading Beds, as they extend roughly from Woolwich in the east to Reading in the west, at which places they outcrop, or are exposed at the surface, and thus permit certain quantities of rain to percolate into their mass. They are of a reddish-brown colour, 30 to 40 ft. thick, and contain limited supplies of water. Still deeper lies a bed of fairly fine greyish sand, termed the Thanet Sand. This contains supplies of good water, and is generally 20 ft. or so in thickness. Beneath the Thanet Sand lies a bed of dark green flints capping the chalk formation, which is the vital water-bearing stratum where London is concerned. A sectional view is shown of what is known to geologists as the London Basin, from which many millions of gallons of excellent water are drawn annually—water that is soft, pure and cool, and quite cheap to pump, as will be shown.

To the right and left of the illustration will be seen chalk hills, and it is these hills or escarpments which catch the falling rain and permit it to percolate underground through its mass and thus provide supplies of water for borings. The water is held in the numerous fissures and cracks in the solid chalk, and as these connect and interconnect with each other and form a vast network of water channels, it will be realised that supplies of water are obtainable when borings are made to cut these fissures. When the chalk is met the well drillers begin to look for the supplies of water for which they are boring.

A tunnel in the chalk of North-west London to provide increased supplies and storage reservoirs. The photo was taken 300 ft. below the surface.

How a Boring is Made

The method by which a boring is made will depend upon several different factors: (1) the type of well needed must be considered, and (2) the geological formations underlying a particular district must be studied carefully. Speaking broadly, two systems are generally adopted in this country. These are the cable percussion system, and the shot Rotary system, and sometimes by a combination of the two methods. We will now see, in some detail, how drilling is actually done. Firstly, we will consider a boring in London—say, in the Strand. The strata are of a comparatively soft nature, and the cable percussion system can be safely used.

Briefly, the machinery necessary will consist of (*a*) a drilling derrick, probably about 30 to 40 ft. high, for the manipulation and suspension of the various tools used; (*b*) the drilling rig itself—a somewhat complicated piece of mechanism which comprises essentially, a driving unit and several revolving drums, to each of which is attached a steel cable, upwards of 500 ft. in length, coiled round the drum ready for use. For a typical drilling outfit such as would be used on a contract for a boring, say, 10 in. in diameter and 600 ft. deep, three lines are used on this rig—(*a*) the "Bull" line, (*b*) the "Calf" line, and (*c*) the sand line. The bull line is that used for attaching to the "string" of tools actually used to drill the hole; the calf line is used for manipulating the steel casing necessary to line the borehole; the sand line is attached to the partcular tool used for bailing out the accumulated *débris* in the borehole. It will thus be realised that it is possible, with three lines, greatly to increase the speed of drilling. In the American oil-fields and other places the rigs are larger and more powerful and complicated by reason of the greater depths to which it is necessary to drill, thus necessitating more numerous lines. On some of the large rigs as many as eight different cables are used.

A test in progress on a boring yielding 60,000 gallons per hour.

An 18-in. borehole at Sheringham which yields 12,000 gallons per hour.

The Spudding Wheel

A new attachment, known as the spudding wheel, has recently made its appearance in modern English rigs, and by its use the tools are raised and lowered each time the wheel revolves. Actual drilling is now carried on by a "string" of tools, the set about 25 ft. in length being attached to the lower extremity of the cable. At the top of the "string" is the connecting rope socket, which permits the rope to turn freely. Next come two heavy links, called "jars"; then comes the sinker bar, the object of which is to give additional weight to the drilling bit. One of the great risks in well drilling is getting the tools trapped in the borehole, and the jars mentioned are specially designed to allow a heavy upward blow to be struck in order to free a tool. In addition to the spudding device, a further aid to rapid drilling is added in the form of a rocking beam. One end of the beam is attached to a crank connected to the driving mechanism of the rig, and the other end to the drilling line; the result is that the see-saw motion of the beam (generally a specially designed steel beam) transmits to the tool a motion very similar to that of the spudder. A rocking beam is usually brought into operation when it is required to drill to depths below 700 ft.

Rapid systems of drilling boreholes have considerably reduced their cost, and opened up further fields for their use, and what is known as "blast hole" drilling for quarries. The system consists of drilling a series of boreholes fairly close to the face of the quarry at carefully selected points. When the holes have been drilled they are charged with explosive matter and fired off simultaneously by means of electric current. In this way vast quantities of rock can be displaced. In one instance as much as 15,000 tons of rock were removed in one blast, using 1,500 lb. of explosive. When drilling for water, extreme care is now taken to keep the borehole vertical; this used not to be given a great deal of attention, but the advent of a new type of borehole pump made it necessary to give particular attention to this point. It is scarcely possible to drill an absolutely vertical hole, but it is possible to work to a limit of 1 in. in 100 ft. There are certain types of pump which will not operate in crooked boreholes. Great care is necessary on the part of the driller, and the borehole must be carefully plumbed each day. Failure to do this may result in a considerable footage running badly out of the vertical. We will now turn to the second system, which is extensively used in this country, and see what can be learned regarding what is termed the Shot Rotary system.

The Rotary System of Drilling

This system is used where the strata are very hard, *i.e.*, granite, limestone, sandstone, etc. By this method, instead of pounding the various strata into a paste, a hollow steel tool, about 10 ft. long, is caused to revolve on a quantity of hardened steel shot, the result being that an annular groove is gradually worn in the rock, leaving a solid core in the centre of the tool. By a special contrivance, the core is broken off, and the tool withdrawn and the core removed. The drilling machine is also fitted with a set of apparatus which enables a supply of water to be passed down the hollow drilling rods to the extremity of the tool, keeping the cutting edges flushed with water. The finely ground rock is washed to the surface into a settling tank. Careful drilling by this system may produce fine solid cores many feet long; such cores are, of course, of special value and interest to geologists, and can generally be laid, and, if necessary, pieced together, to give a reasonably accurate idea of the various strata penetrated. A recent picture of a fine collection of cores, mainly sandstone, produced from a boring nearly 1,000 ft. deep in Cheshire is shown in this article.

Sometimes, when the strata to be penetrated are extremely hard, drilling is carried on by the diamond drill method; this system is similar in some respects to the Shot Rotary method, but instead of the steel shot, the actual drill is fitted with black diamonds—some strata are so hard that nothing but diamonds of this nature will penetrate — but the diamonds are expensive, and it is not easy to fix them firmly to the "bit," hence they have a tendency to fall out and thus become lost in the *débris* of the boring, causing further expense.

It is sometimes asked, "How are the tools made to reach great depths?" The answer is very simple: in the case of the cable drilling the suspended tool is lowered into the borehole by mechanically paying out cable as required; in the case of rotary and diamond drilling, where no cables are practicable, depth is attained by merely adding fresh lengths of hollow steel rod, similar to the method adopted by the homely chimney sweep!

Lining Boreholes

Borings as a rule need to be lined with steel casing or tubing. This tubing serves two purposes, namely, to hold up the sides of the well, and to prevent surface water from reaching the purer chalk water. A 10-ft. length of tubing is lowered and driven into the hole until the top is within a few inches of the surface; the drilling bit is lowered into the borehole again and a further 10 ft. drilled, after which it is necessary to bail or shell out, and another 10 ft. of tubing screwed on to the first and driven down to the bottom. It should be mentioned that at the bottom of the first length of tubing there is usually a cutting "shoe," with a specially hardened cutting edge, screwed on to assist the operation of inserting the lining tubes.

Geological and Hydrogeological Considerations

When it is realised how many different kinds of strata are to be found in this country, each with different characteristics, it is easily understood that a knowledge of hydrogeology is necessary to avoid abortive wells, which might easily result without its aid; even so, it is not possible to guarantee a supply at any point, although the chances of success are considerable. Supplies may invariably be obtained from either of the three greatest and most well-known formations in England: (1) the chalk, (2) the new red sandstone, and (3) the lower greensand. Many other water-bearing formations exist, but these are the most well-known. Gravels, limestones, sands, and sandstones will all yield water in varying qualities and quantities. Clays, marls and granite are generally considered unfavourable, although supplies may be obtained from various horizons within their mass, and in such doubtful formations the better policy is to drill a small trial boring with a view to ascertaining what supplies may be procured, before embarking upon the expenditure necessary to provide a full-sized boring. An ideal site for a borehole is one from which a natural overflow may be expected, but nowadays such sites are less frequently found than in the past; there are, however, still places from which very good supplies may be had from overflowing wells at no cost whatever for pumping.

Showing water issuing from a boring.

When the first wells were bored in London many Artesian overflows were obtained, but in consequence of the enormous demand made upon the underground storage, such conditions are not to be expected nowadays, and the water rises to the average of about 250 ft. below surface level, from which depth it is necessary to pump it into tanks at various levels on the surface. During the last ten years or so literally hundreds of borings have been made in all parts of this country, and each new boring furnishes a new record of the strata immediately beneath a particular site. Sometimes the following questions are asked: "How is it possible to say whether water will be found?" and "What is water divining, and are diviners of any particular use?" We will consider the two questions. The depth to which a boring must go will depend on the depth to the water-bearing stratum, and such matters are left largely to the experience of the well drillers, who, as a rule, are in possession of accurate details of successful wells in almost every district in this country; thus, supposing a site be proposed in, say, Watford, Hertfordshire, the well drillers will consult their records of all the known wells in the district, particularly those surrounding the new site, and by making a comparison of these wells they will be able to say approximately how much water will be obtained, what diameter the well should be, and how deep to bore.

Supposing London be considered, we may say that 500 to 550 ft. will be the required depth nowadays; 400 ft. was sufficient about twelve years ago, but the above depths are now necessary to give the proper submersion to the pumps as the water table has fallen considerably in some parts. It is impossible to lay down any special rule as to the depth to bore—in some parts of the country 150 to 200 ft. is sufficient, whilst in others 800 to 1,000 ft., or even 1,500 ft. will be the limit.

Water Divining

Recently the Press has given much publicity to those mysterious people who call themselves diviners or dowsers. Actually, divining is a subject about which little is known as yet. It has been proved many times over that certain people do possess some subconscious and possibly supernatural power to detect underground water and minerals, by the use of various methods—hazel twigs, soft iron, wire springs, etc. A still more curious development which has recently come to the writer's notice is the professed ability of some individuals to locate hidden springs and streams by passing the hands over maps of different districts. The efforts of one diviner who adopts this method were afterwards checked and found to be remarkably correct. Seeing that so little is known as to the cause of some very remarkable results of divining it would be unwise to condemn all the findings of those people who claim to possess this gift.

Dimensions and Depths of Borings

Broadly speaking, there are three types of well: (1) the driven tube well, (2) the sunk well or shaft, and (3) the bored well. In London a factory whose requirements reach as much as 10,000 gallons per hour would expect to obtain this quantity from an 18-in. bored well, 550 ft. deep from the surface. A boring 10 in. to 12 in. in diameter and 500 ft. deep shou d yield 3,000 gallons per hour. Larger supplies usually demand larger diameters, but not necessarily deeper borings. Very large supplies may be obtained by boring, and the cost of a well will depend largely upon the ultimate supply needed. The supply usually required is round about 5,000 gallons per hour, and a boring might be from 10 in. to 12 in. in diameter, and probably 500 ft. to 550 ft.

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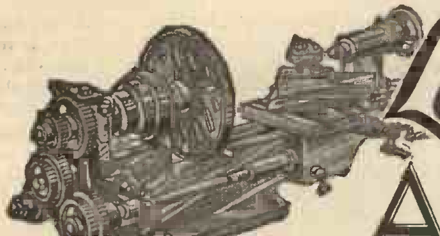


Lathe Work FOR AMATEURS

LATHE EQUIPMENT

A brief description of the various items and their uses.

By W. H. DELLER

THE contents of this article are mainly of interest to those who are contemplating the purchase of, or who have recently acquired, a centre lathe, and in such cases will serve as a guide in selecting the necessary equipment. To achieve satisfactory results, however, the equipment dealt with requires to be employed in an efficient manner, and on this score alone is worthy of the attention of amateur turners generally.

Standard Equipment

It is not intended to take into consideration the method of driving the lathe, as it is concluded that the reader will understand that a bench type of lathe will require a separate foot motor or other means of driving.

Certain standard equipment is usually included with the lathe. This consists of a face-plate, catch-plate, and centres. Additional equipment is sometimes included in the form of travelling and three-point steadies.

These items do not complete the list, as it is necessary to have chucks, tools and certain accessories for use in conjunction with the face-plate and catch-plate, and centres before every class of work can be undertaken.

The Face-plate

This is a slotted circular casting the boss of which is machined to screw on to the nose of the lathe and the front face is machined perfectly flat. The face of this plate may be marked by a series of concentric circles, but where this has not been done it is as well to remedy the omission by lightly cutting the circles at intervals of $\frac{1}{4}$ in., commencing at the edge of the plate. These circles will serve as a guide for the placing and mounting of round work on the plate in such a position that a minimum of truing up only will be necessary.

While on the subject of marking, another line that may profitably be made on the plate is a centre line. If the plate is a small one and has been machined on the edge the line may be scribed firmly against the edge of a centre square. Where such a tool is not to hand, or the plate is large in diameter, a screw-cutting tool held on its side, with the point set at correct centre height against the point of the live centre held in the mandrel, may be used for scoring the line by bringing the tool to bear against the surface of the plate and winding it across by movement of the cross slide.

Fig. 1.—Clamps of the drop-forged variety, and a face-plate.

The object of this line will be mentioned later. For holding the work on to the face-plate clamps will be necessary. These may be made from short pieces of rectangular steel bar with a hole drilled in the centre, but these are mainly objectionable in use owing to the tendency of the flat material to bend under the strain imposed by the bolts. Far more reliable are clamps of the drop-forged variety, two of which are seen lying on the surface of the plate in Fig. 1. Seldom are more than four of these clamps required to hold a job. The slots in the plate and clamps are made to clear bolts of a certain diameter, and a collection of good bolts and nuts of various lengths are required, preferably in sets of four. See that the nuts are only just finger tight on the bolt threads before putting away ready for use.

The next item is an angle-plate. This is also shown in Fig. 1. Angle-plates are made in a variety of patterns, but for general use select one that is in keeping with the size of the face-plate and has unequal sides. The short side should for preference be radiused. The advantage of this will be found when it becomes necessary to set the plate a good distance below centre and when the edges or corners of a square-edged plate might perhaps project over the outside of the face-plate by an amount sufficient to foul the bed of the lathe. The centre line on the face-plate mentioned previously will be used for setting the angle bracket for certain classes of work. Supposing that it is required to bore a hole, say, $1\frac{3}{4}$ in. up from a previously machined base—then the top or working face of the angle bracket is set at that distance below the centre and in consequence the centre line, already marked on the plate, will greatly facilitate this proceeding. In this manner the angle-plate may be bolted correctly in position off of the lathe and the job needs only to be moved in a sideways direction on the angle bracket when truing up.

Fig. 3.—A fairly representative group of tool-holders.

Catch Plate Centres and Carriers.

Work of the character of shafts or spindles is usually performed between the centres. The catch-plate which screws on to the nose of the lathe is provided with a driving pin to engage the tail of the carrier attached to the work as a means of driving it. Carriers of drop-forged steel are made in a variety of sizes. The type of carrier referred to is seen in the bottom right-hand corner of Fig. 2. The sizes of these run as

Fig. 2.—Showing carriers of drop-forged steel, a drill chuck for the tail stock, a conical lathe centre, and three- and four-jawed chucks.

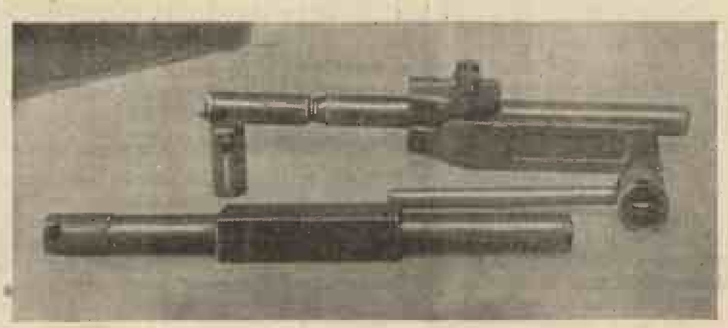


Fig. 4.—Boring bars which employ tool bits.

follows: $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and $1\frac{1}{4}$ in., etc., the dimensions are the largest diameter that each carrier will hold.

Steadies

The travelling steady, where one is supplied, is used for the purpose of supporting long or slender work while turning between the centres. It is attached to the saddle by bolts which fit into holes tapped on the side of the saddle. The actual steadying portion consists of a narrow hardened Vee block, which is adjusted on to the work, being arranged in the case of a true shaft, so that the trailing edge of the steady is slightly in advance of the cut, or where the material to be turned is rough or not running true, slightly behind the cut. Naturally when this condition obtains the turning has to be started before the steady can be brought into position. In both cases the action of the steady is the same, namely, it prevents the work from pushing away from, or rising against, the tool.

The purpose of the three-point steady is mainly to support work that stands a long way out of the chuck when boring or internal screwing operations have to be performed in the end. The surfaces of the steadies which bear against the work are in many cases faced with bronze. Sometimes, however, this material is steel or cast iron. Where this is so, pieces of leather or fibre must be introduced between the ends of the steadies and the surface of the work to prevent scoring or seizing. In any case the shaft or part being worked upon requires lubrication at the point of support.

Chucks

A drill chuck for the tail stock is a most essential item. That shown alongside the carrier in Fig. 2 is a ball bearing chuck which is tightened by gripping and turning the knurled portion. The taper shank forms part of the chuck in this instance, and the shank fits into the taper hole in the end of the tail stock. Chucks of the "Almond" pattern tighten by means of a key shaped like a bevel pinion which engages with a toothed ring on the chuck. These chucks are not supplied complete with shanks, although the shanks, finished to standard tapers, may be purchased separately.

The Geared Scroll Chuck

Perhaps the most useful chuck of the lot is a three-jaw geared scroll chuck. This, as represented in the top left-hand of Fig. 2, is the standard pattern. Two sets of jaws, one set being stepped in the opposite direction to those shown, and a key are included. The four-jaw independent chuck

(*Continued on page* 530.)

AUTOMATIC TELEPHONES

Long before the invention of the modern telephone it was said by hopeful inventors that the day would come when we should all be able to talk to our friends by touching a button. One of the limitations of life is that we have to travel long distances, and put up with discomforts, simply in order that thoughts may be transmitted from one person to another.

By A. M. L.

I DOUBT if, even to-day, the general public realises how important it is to acquire the telephone "sense." Nearly all business, and a great deal of our pleasure, can be brought to our homes by means of wires or wireless. Telephones are really a vital necessity. In spite of these facts, it is strange to find that the great principle of connecting one house to another by means of wires has been accomplished in the main by hand.

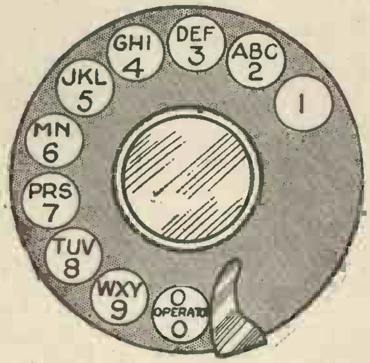
For many years engineers have been working upon various automatic systems, but the disadvantages have proved to be those of initial cost and general maintenance. The modern automatic telephone contains little that is new from the scientific or engineering point of view; rather is it an improvement upon a principle of selection, which is so simple that it can be grasped by anyone.

The Old Chinese Counting Machines

Telephone exchanges, like typewriters, are apt to look complicated, but this is due to the existence of some marvellous and intricate system. Every automatic selector of the telephone type is based upon the idea of the old Chinese counting machine, but the wooden balls which used to be strung on the wires are replaced by electric contacts which can be moved step by step as an electric impulse travels along a wire and energises a magnet.

Supposing you had an electric bell which instead of trembling gave one ring every time the button was pressed. Imagine a cyclometer so connected that, when the clapper of the bell moved, the cycle wheel was turned through one tooth, and you will realise that any number on the face of the cyclometer could be shown and obtained by pressing the bell-push any number of miles away. Distance is no object at all, other than it is concerned with amplification or current leakages, and similar difficulties.

As soon as you lift the receiver on the automatic telephone, an electric impulse is sent down a wire to the automatic exchange. This current works what is called a primary



The dial at the foot of the telephone which enables the subscriber to ring the number he or she requires.

rotary line switch, and another magnet then turns a second switch until it rests upon a clear, disengaged line which is then "booked" for it.

How the Automatic Telephone works

While this is happening, the subscriber has begun to dial, and, as the rotary line switch can attempt to make connection with one contact a second, there is very little opportunity for delay. The mere lifting of your own receiver has made a contact with a group of wires attached to a selector, which prevents other people ringing you up at the same time.

Imagine that you now want to call the number 423. First of all, you turn the dial to the figure 4, which sends four separate impulses of current to the exchange. This moves the first selector, which travels until it makes contact with an idle wire in the fourth of the 100's department. While this is happening on its own account, you have dialled the 2, which sends two more separate impulses to the second selector until it contacts with a free wire in the second of the 10's group. The last movement of the dial to the figure 3 sends three impulses until contact is made with the correct line in the last batch of units.

Separate Selectors

The moment your conversation is finished all switches are automatically returned to the same neutral position in readiness for the call. The whole idea at the base of the automatic telephone is that the units, tens, hundreds and thousands are independent in regard to separate selectors. If only one selector was used and it had to choose a number out of, say, 5,000, obviously the apparatus would be almost impossibly complicated. There may be 10,000 lines at one point, but the first selector has only to choose the right number out of the thousands batch, leaving it to the others to deal with the hundreds and units.

Dialling the Exchange

The first movement of all, *i.e.*, that of choosing the names of the exchange, merely corresponds with certain definite numbers. It was for this reason that the names of some exchanges had to be changed in order that distinguishing numbers might be appointed to them at the exchange instrument. In all kinds of automatic machinery there is a great deal of development necessary before the public understand their advantages and learn to use them in a sympathetic manner. The automatic telephone, like many comparable devices, has the great merit of intrinsic simplicity and of helping people to communicate their ideas to each other without labour, while manual workers are released for tasks more important or requiring personal originality.

The MECHANICS of SIDESHOW GAMES

This month we show the mechanism of the various "fakes" which may be operated in conjunction with such popular fair-ground games as Coin-Billiards, Cigarette-Shooting, Cone and Ball, Aunt-Sally, Bowls, The String-Stall, and the ever-popular "Spinner."

THE billiards ball and coin is a never-failing source of profit to the fair-ground worker, for, in addition to its modesty of lay-out and initial cost, it piques the conceit of those people who fancy their ability at billiards. In Fig. 1 will be seen the very simple apparatus for this game. The table is small, about 4 ft. 6 in. long, and the game, which consists in knocking the ball and coin out of the circle by aid of the cue and second ball, looks easy. The coin, usually a half-crown, becomes the player's property if it falls outside the circle, but, easy as this looks, it does not work out in practice. Try as the player may with cannons, oblique shots and plain slams, the coveted half-crown falls inside the circle every time, until the disgruntled player, who may be a really good billiards player, gives up in disgust after spending much time and many coppers. The reason for the repeated failures is obvious, for the impact of the driven ball merely knocks the supporting ball out *from under* the coin, which falls more or less vertically by virtue of its own weight. Sometimes several coins are piled on the ball, but this, far from helping the player, merely handicaps him further. A glance at Fig. 2 will show an interesting parallel. If a glass of water is placed on a smooth card near the edge of a table the card may, by a quick jerk, be snatched from under the glass without spilling a drop of its contents.

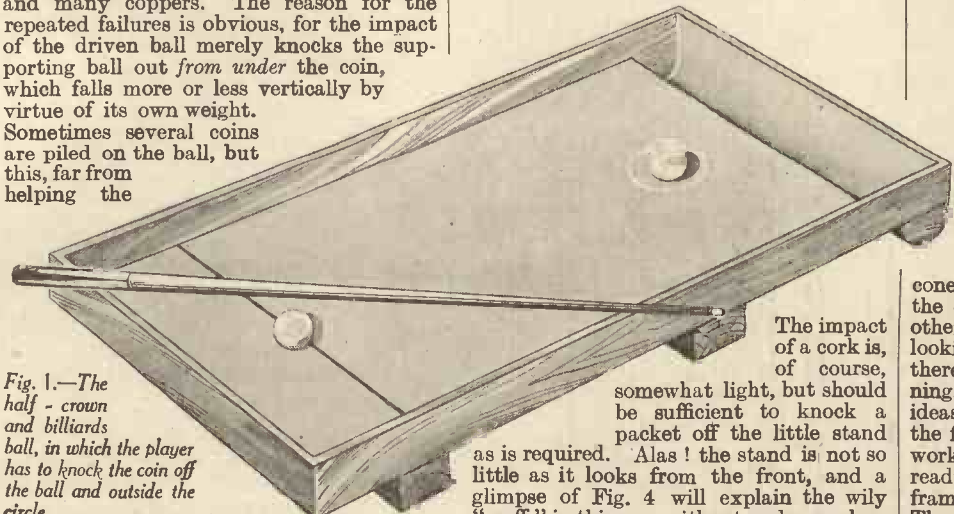


Fig. 1.—The half-crown and billiards ball, in which the player has to knock the coin off the ball and outside the circle.

How, then, does the operator of the game manage to demonstrate (as he does) that the money can be won? Simply enough; under the edge of the table, or in some equally handy place, is a smear of gum, liquid glue or other sticky substance (a fly-paper is quite popular), and by picking up a tiny dab of this substance on his finger and transferring it surreptitiously to the under-side of the coin he creates sufficient adhesion between coin and ball to ensure that they will travel together for a short distance after a gentle impact and so drop outside the circle. Figs. 3B and 3C show the play without this dodge, while 3A shows the result of the sticky business!

Cigarette Rifle Ranges

Of recent years this game has become very popular, and nearly every fair has a stall where one may shoot corks from an air-gun at popular brands of packet cigarettes. The impact of a cork is, of course, somewhat light, but should be sufficient to knock a packet off the little stand as is required. Alas! the stand is not so little as it looks from the front, and a glimpse of Fig. 4 will explain the wily "gaff" in this case without undue explanation.

A very old game, which is pretty consistently "gaffed," is the ball and cone as depicted in Fig. 5. In this, which is somewhat reminiscent of the "Spot Game" previously discussed, a wood cone stands on a painted circle, while immediately over it hangs a wood ball suspended from a light cross-bar which is supported by two little "goalposts." The idea is to draw back the suspended ball and let it swing to the right of the cone, if in its return swing it knocks the cone over the player wins a watch or other prize. Again, deceptively simple looking. Provided all was fair and square there is quite a reasonable chance of winning. The operator, however, has other ideas on the subject and the dotted lines in the figure explain his method. The framework is a trifle loose and when the player is ready to swing (with his eye on the cone) the frame is unobtrusively pushed to the left. The point of attachment of the ball is now slightly to the left of the cone's apex, and as the ball is swung to the right of this it must necessarily pass well to the left on its return. Simple, effective and highly profitable.

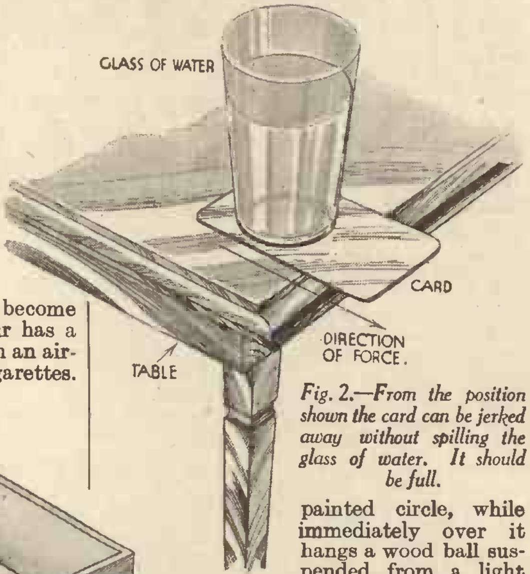


Fig. 2.—From the position shown the card can be jerked away without spilling the glass of water. It should be full.

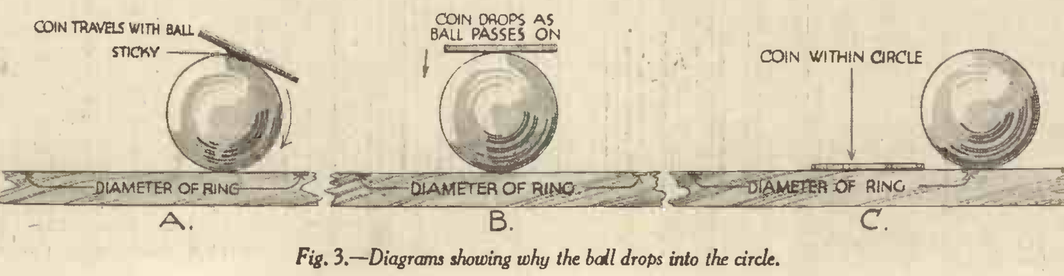


Fig. 3.—Diagrams showing why the ball drops into the circle.

Fig. 4.—The cigarette rifle range. Note the abnormal depth of the stand from the front to the back. The arrow indicates how the packet falls when lightly struck.

Our Old Friend —Aunt Sally

This is a game whose beginnings are very remote indeed, having been played for ages in one form or another. It is a wonder the dear old lady has a pleasant expression, for the idea is to knock her off her perch!

The operator does it with ease every time, yet, though provided with quite a hefty wood ball, we do not seem to be able to upset the old lady's position in quite the same manner. True we may knock her over, but not off the stand as the operator does. The reason is simple and is depicted at Fig. 6. If the effigy is placed in the position shown by the dotted line the centre of gravity comes over the edge of the stand when the figure topples and it falls to the ground. If placed against the guide pin, as shown, the centre of gravity is within the confines of the stand top and it does *not* topple. You get the front position, the operator uses the rear.

One of the more modern "joints" is shown at Fig. 7 and is known as the "String Game," "Streamer Stall," or some similar name. This is a very showy layout and so simple in operation that it is, as a rule, run by the wife or daughter of a showman, who is personally attending to some more strenuous "gaff." On a counter at the rear of the stall are set out prizes of all kinds, from the humble collar stud to the most gargantuan of teddy bears. From each runs a string which, passing through holes in the "proscenium," is brought down with the involved skein of its multi-coloured fellows to the front of the stall.

All these strings are loosely held together by a ring or band, and this is grasped by the fair operator. You pay the fee and are at liberty to choose any string end you please. The operator relaxes her grasp of the bundle, and on pulling the selected cord you hoist your prize off the table and claim it for your own. It is nearly always a small prize worth about a halfpenny. Should you be so rude as to assert that the big prizes are not connected, the operator will be only too pleased to trace the string from the most attractive prize to the bundle she has proferred for your choice. Of course it is a "wangle" and Fig. 8 will lay the secret open. The strings *do* go from the big prizes to the bundle which the damsel grasps, but that is as far as they go for the ends are neatly folded back and lost in the multitude of others.

Bowls, Walnut-shells and Peas

Another game of fairly recent innovation is the "Non-stop Bowling Alley," in which a multitude of wooden balls roll continuously down a slope, disappearing at one end and re-appearing at the top much like an escalator. The proprietor picks up a ball casually, and by pushing the end of a wand into the core of the ball causes a plug to protrude as shown in Fig. 9. This plug bears a number and the rule of the game is that all numbers from 100 up either win nothing at all or a nominal prize of trivial value, while numbers 10 to 19 inclusive win really valuable items. Of course the plug shown by the operator is a big winner every time, but the players can't find anything but blanks. The key to the problem lies in the range of numbers and the wand used to extrude the plugs. The wand has slightly tapered ends, and while the operator appears to use either end indiscriminately in reality he is extremely careful, for there is a very slight difference in the length of these tapered ends. If the longer is used the plug protrudes far enough to show a three-figure, while the shorter end will only push out sufficient of the plug to show a two-figure number. In the "underneath" of the stall is a trap containing genuine two-figure balls which can be thrown into play if enquiries by the Authorities necessitate same.

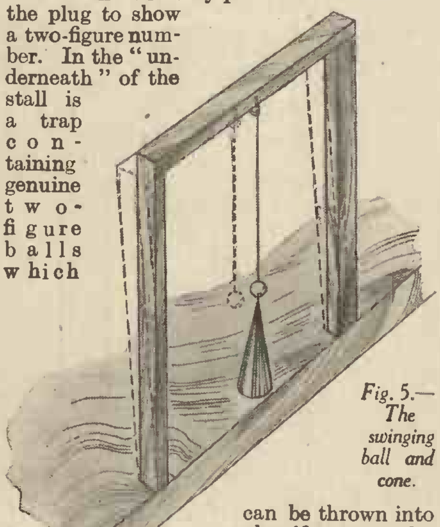


Fig. 5.—The swinging ball and cone.

The "Shell Game" or "Nimble Pea" is very much akin to that ancient swindle the "Three Card Trick" or "Find the Lady," but does not appear to be as well understood as the latter. They are both quite illegal yet may be met with at nearly any fair or race ground. The card trick belongs properly to the realm of conjuring or card manipulation, but Fig. 10 will explain the vagaries of the little pea, which certainly is nimble as manipulated by an expert. The game consists of three half-walnut shells and a pea which the operator shuffles and slides about on a table, eventually capping the pea with one of the shells. The player bets on which shell covers the pea (much like the schoolboys' game of Tip-it). Of course the pea is never where it ought to be, and the reason is not far to seek for, while the player bets, the pea is *not on the table at all!* As shown at Fig. 10A, the shell which appears to cover the pea is merely pressed, edge down on it, and as the pea is of very soft rubber it flattens while pressure is maintained. The operator pushes the shell slightly forward, while manipulation of the other shells distracts attention (see Fig. 10B), and picks the pea up with the crook of the little finger as shown in Fig. 10C. When the bet is made there is no pea under the selected shell and operator "finds" it under which ever of the others he may choose.

Fig. 6.—Details of the Aunt Sally.

"Spinners"

The number of games which come into this category is legion, but all consist in a revolving indicator which, on stopping at a number on the circular board, confers a prize on the holder of that number. Many of these games are quite profitable when worked "straight," as the number of chances sold on each run makes the deal profitable. Many others are, however, faked either to stop at a poor prize or to confer a big prize on a confederate. Fig. 11 shows a method of control which is applicable to many types of wheel, including horse-racing games. Pressure applied to the brake knob shown dotted will,

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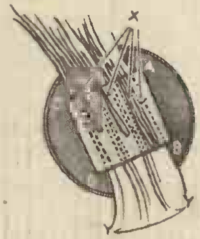


Fig. 8. — Why your string always pulls a small prize. A.B.C.D. The cloth cuff through which the strings pass. X. Big prize string ends folded back. Y.Y. Ends of small strings passing through the cuff.

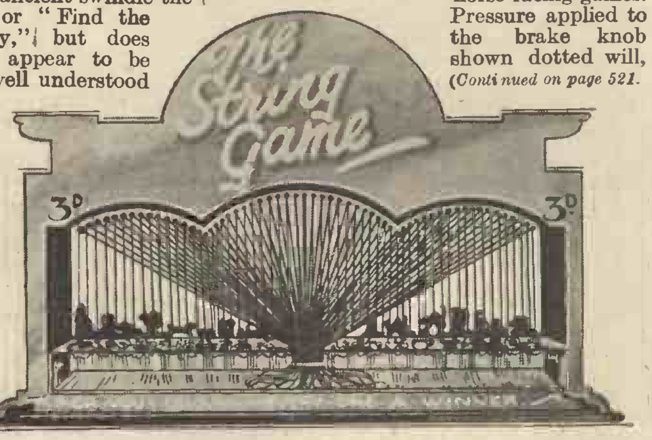


Fig. 7.—The string or streamer game. Vari-coloured strings are attached to prizes, and on pulling a chosen string a prize is hoisted off the table.

THE NEW GREENWICH TELESCOPE

Over two years have been occupied in constructing the superb 36-in. reflecting telescope which has just been brought into use at the Royal Observatory, Greenwich.

THE need had long been felt at the Royal Observatory of a telescope of a type specially adapted to astrophysical studies and, for such a purpose, the Cassegrain form is particularly suitable. The new instrument—the gift of Mr. W. J. Yapp—will, therefore, be almost exclusively devoted to taking photographs of the spectra of stars, nebulæ and other celestial bodies. The size decided upon is about the maximum that can be employed to full advantage in our often rather hazy atmosphere, and more extensive research than hitherto is now rendered possible.

For the information of those who are not versed in such matters, it may be explained that astronomical telescopes are broadly divided into two categories—refractors and reflectors. In the former the rays from distant objects fall upon a large lens (termed an object glass) at the top of the telescope, and are bent, or "refracted," down the tube in an elongated cone of concentrated light. An enlarged image of the object viewed is formed at the point of this cone and further magnified by an eyepiece or impressed upon a photographic plate or subjected to spectral analysis. In a reflector the object glass is replaced by a concave mirror at the bottom of the tube, the upper end of which is left open. In order to examine the image formed at the point of the cone of rays, which, in this case, is reflected upwards, a smaller flat mirror is usually placed at right angles within the telescope near the top. This intercepts and deflects the apex of the light cone through a hole at the side, where the eyepiece, camera or spectroscope is fixed. Such a reflector is styled a Newtonian, after Sir Isaac Newton, who invented it in 1668. In the Cassegrain pattern—the one chosen for Greenwich—the cone of light is intercepted by a *convex* instead of a flat mirror and doubled back on itself down the tube through a hole cut in the centre of the main reflector. This method gives a longer focus within the limits of a much shorter tube than is necessary for either a refractor or Newtonian reflector; it also yields a bigger primary image. The casting, grinding, polishing, "figuring" and silvering of very large mirrors can nowadays be accomplished with a degree of perfection and accuracy impracticable thirty years ago. Moreover, the ease and precision with which instruments of great size and weight can be rapidly and smoothly turned and pointed to any part of the heavens by merely handling a few electrical controls is astonishing.

Details of the Tube

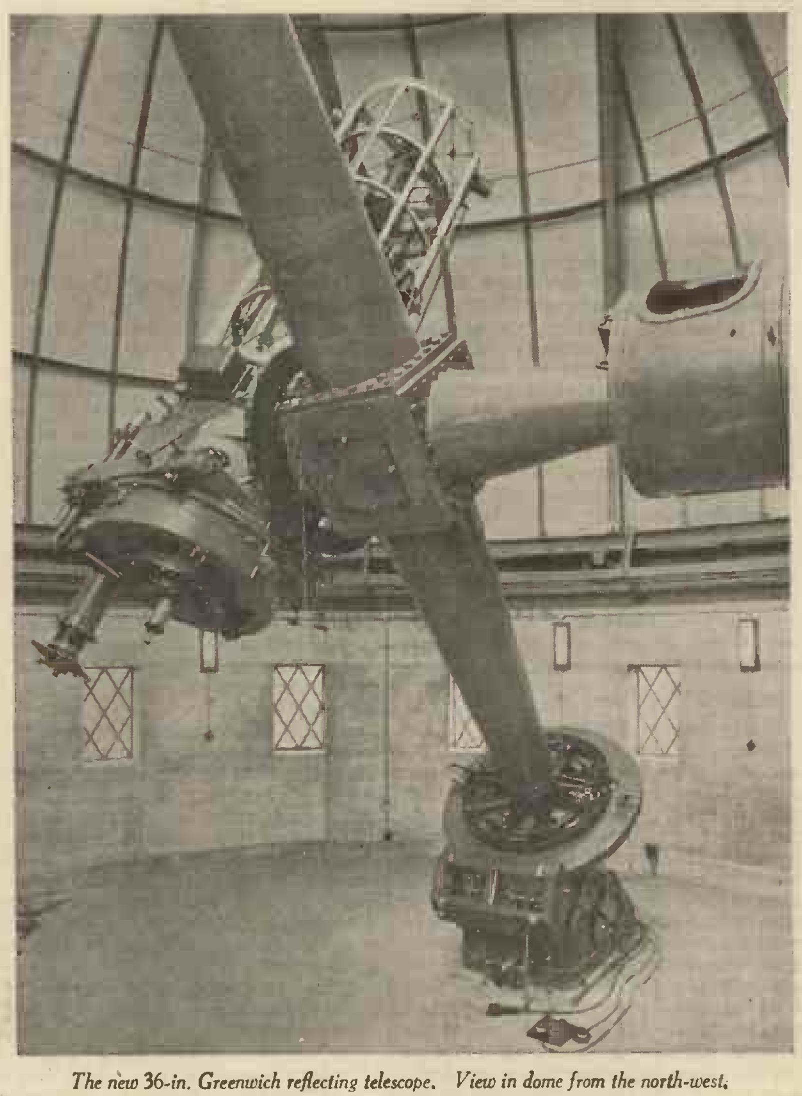
Most of the so-called tube of the Greenwich telescope is merely an open lattice of welded steel attached to a casting bolted to the equatorial mounting. Near the top of this "tube" interchangeable holders are suspended centrally by thin steel strips, placed edgeways in order to cut off as little light as possible. These carry the two secondary convex mirrors of fused quartz, either of which can be inserted as required at its proper distance within the principal focus. One of them is 11 in. in diameter and of the usual Cassegrain type, giving a secondary focal length of 45 ft. It is intended for use with a slit spectrograph constructed of ultra-violet glass and having two prism systems; eyepieces can nevertheless be employed in the usual way. The other mirror is 7 in. in diameter and arranged to return a 6-in. parallel beam through the 7-in. opening trepanned out of the centre of the main mirror. This beam will be directed into a slitless spectrograph for work on the colour temperatures of stars. The beam passes through a large prism and falls on a 9-in. concave mirror which sends it back. After reflection from a diagonal "flat," the spectrum—which is broadened by an automatic device—is focussed on a photographic plate. The great parabolic mirror of the telescope is 36 in. clear aperture and 15 ft. focal length. Its curved surface is silvered and highly polished, the grinding and polishing having taken eight months to complete. Visual tests show the "figuring" to be of excellent quality, star images being sharp and free from astigmatism.

The Glass Disc

This is 6 in. thick and weighs 550 lb. It was cast by the Parsons Optical Co. of Derby, and is enclosed in an iron cell, where it rests upon nine points of support. A roller blind is provided to protect the delicate surface of the mirror from dust and damage when not in use. Eyepieces or either of the two spectrographs can be readily screwed into the back of the mirror cell and focussing is operated by hand from the lower end of the telescope. The mirrors can be conveniently re-silvered in an adjacent building whenever necessary. The guiding telescope is an ordinary refractor of 7-in. aperture and 13 ft. focus—itself an instrument any amateur would be proud to possess. It has three eyepieces, magnifying 100, 200 and 400 diameters respectively. Intersecting "spider" lines are fitted to facilitate keeping objects in the same position on the sensitive plate or in the field of vision. There is also a "finder" of 3 in. aperture and 36 in. focus.

The substantial equatorial mounting supporting the telescope is of the modified English design permitting considerable freedom of swing. The polar axis (providing movement in celestial longitude) is 24 ft.

(Continued overleaf.)



The new 36-in. Greenwich reflecting telescope. View in dome from the north-west.
(Photo by permission of Sir Howard Grubb, Parsons & Co.)

long, and consists of two conical castings bolted to a central cube. Its upper (north) end is carried on a high steel-trellised pier which is invisible in the photograph, the ground (south) bearing being housed in a massive iron casting. Both pier and casting are embedded in concrete bases insulated from the observatory floor. The steel declination axis (providing movement in celestial latitude) passes squarely through the central cube and another conical casting. The telescope is bolted to a flange at one end of this axis, the quick motion gear with reversible motor being mounted at the other, the motor serving to augment the counterpoise weight.

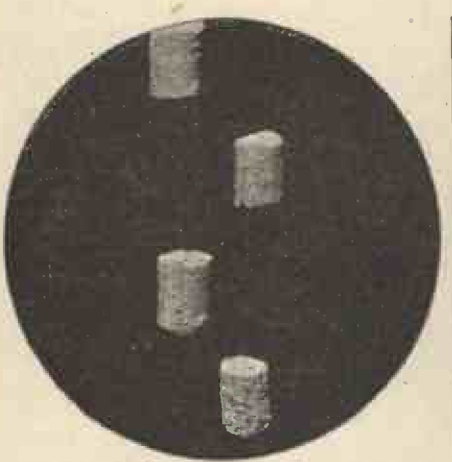
All Motions Electrically Operated

All motions are operated electrically, the bearings being in ball races to ensure smoothness. The driving clock is of the cross arm friction governor type, and is actuated by a weight automatically kept wound up by an electric motor, its speed controlled by one of the observatory clocks. When coupled to the driving circle, the clock slowly turns the telescope from east to west at the same rate as the earth rotates. This keeps objects apparently stationary in the eyepiece or camera. There are two large setting circles, the 42-in. Sidereal (R.A.) circle graduated to single minutes of time, and the 36-in. declination circle graduated to single degrees of arc; the latter is further subdivided by a geared vernier to five minutes of arc. The steel-framed dome is 34 ft. in diameter and covered with roofing material ⅜ in. thick, sheated with No. 24 gauge copper. It is mounted on the observatory wall of red brick and can be revolved at will by a 3-h.p. electric motor with push-button control. There is a parallel opening in the roof 7 ft. 6 in. wide extending from the horizon to 3 ft. 6 in. beyond the zenith. A sail cloth hand-operated wind screen is fitted to this opening in case of windy weather, and the twin shutters are opened and closed by a rope wheel.

The entire construction (except the casting of the disc) was carried out at the optical works of Messrs. Sir Howard Grubb, Parsons & Co., of Newcastle-on-Tyne, to whom acknowledgments and thanks are due for the photograph and technical details they kindly supplied. Space does not permit of even a short list of the many notable reflecting telescopes that, during the past century, this firm and its famous founder, Thomas Grubb, of Dublin, has furnished to numerous important observatories all over the world.

RARE METALS IN YOUR POCKET

Petrol-Lighter "Flints" and their Composition.



Under a low-power microscope lighter flints show themselves to be little cylinders of metal.

NOT everybody appreciates the fact that the little cylindrical "flints" which are bought nowadays for the purpose of producing sparks in petrol and similar mechanical lighters are not real flints at all, but are actually definitely-proportioned alloys containing many rare metals, together with certain percentages of manganese and iron. Many of the metals which the small greyish-looking lighter-refills contain would, in their pure and unalloyed state, be exceedingly valuable, but it is because the lighter "flints" are produced from an alloy which is worked up from a by-product of another industry that they are obtainable at a purely nominal cost at the present day. The story of these petrol-lighter "flints" is a very interesting one, the history of their discovery being, indeed, one of the minor romances of modern science.

An Accidental Discovery

The tale goes back to the year 1903. Dr. Carl Auer, Baron von Welsbach, the inventor of the incandescent gas-mantle, was experimenting in his laboratory with certain rare earth oxides. He had subjected these to a high-temperature reduction process in a crucible and had obtained as a result a little button of hard metal at the bottom of the crucible. In endeavouring to dig the lump of metal out of the crucible he noticed that every time it was struck with a hard instrument it emitted a shower of sparks. It was rather a remarkable fact, and Welsbach investigated it further. As a result, he found that certain alloys of the rare earth metals possessed the inherent property of sending out a miniature fountain of bright sparks when they are struck with a hammer or some other hard metal object. To these alloys, the name "pyrophoric" was subsequently applied (from the Greek words, *pyr*, fire; *pherein*, to carry), a pyrophoric alloy being nowadays understood to be an alloy possessing this remarkable characteristic. Welsbach dropped the subject of his pyrophoric alloys soon afterwards, but, incidentally, not before he had made a few thousand pounds, or, rather, the German equivalent of that amount, for he sold his rights in this accidental discovery for quite a substantial sum.

"Mischmetal"

Petrol-lighter "flints," therefore, as we see now, are not flints at all. They are small cylinders of pyrophoric alloys. These alloys are nearly all prepared from "mischmetal" by adding to it certain quantities of manganese and iron. "Mischmetal" is a rough alloy of metals which is produced from a mixture of cerium compounds resulting from the manufacture of incandescent gas-mantles. Gas-mantles contain 99·1 per cent. of thorium oxide and 0·9 per cent. of cerium oxide, both of which substances are derived in the first place from the mineral monazite. Now monazite is mainly a cerium-bearing mineral. Since, therefore, only a relatively minute amount of cerium is used in gas-mantle manufacture it is easy to see that the cerium residue, after the abstraction of thorium from monazite, is a waste product which the gas-mantle industry is only too willing to get rid of at a low price. "Mischmetal" is made from the above cerium residues by converting them into chlorides by chemical treatment and then, after mixing them intimately with calcium chloride, by packing them into a graphite crucible which is heated to a high temperature by the passage of an electric current. The mixed chlorides are decomposed by this treatment and a metal is liberated. It sinks to the bottom of the crucible and is afterwards removed in small lumps.

Thus produced, this metal—"mischmetal"—has approximately the following composition:—

Cerium	50 per cent.
Lanthanum	45 per cent.
Yttrium	1 per cent.

The remaining 4 per cent. being made up of varying amounts of the following metals: praseodymium, neodymium, scandium, samarium, europium, gadolinium, terbium, dysprosium, erbium, and thulium. Occasionally almost infinitesimally small traces of the two radioactive metals, radium and mesothorium, are present in "mischmetal," radium and mesothorium sometimes existing in the monazite ores to the extent of a small fraction of a grain per two or three tons of the mineral.

"Rare Earth" Elements

"Mischmetal," therefore, is an alloy of at least twelve or thirteen metals, most of them being of the "rare earth" group of elements and the majority of these metals existing merely in very small amounts in the alloy. From this heterogeneous metal the pyrophoric alloys used for petrol-lighters and other sparking devices are prepared by adding manganese and iron to the molten metal. The alloying process is carried out in a vacuum container. "Mischmetal" has a strong affinity for oxygen, and at the high temperature necessary for the admixing of iron, it would take fire and burn if oxygen or air were present. After alloying, the pyrophoric metal is cast into long narrow sticks. These are afterwards cut up into the now familiar grey cylinders which constitute the sparking material of petrol-lighters.

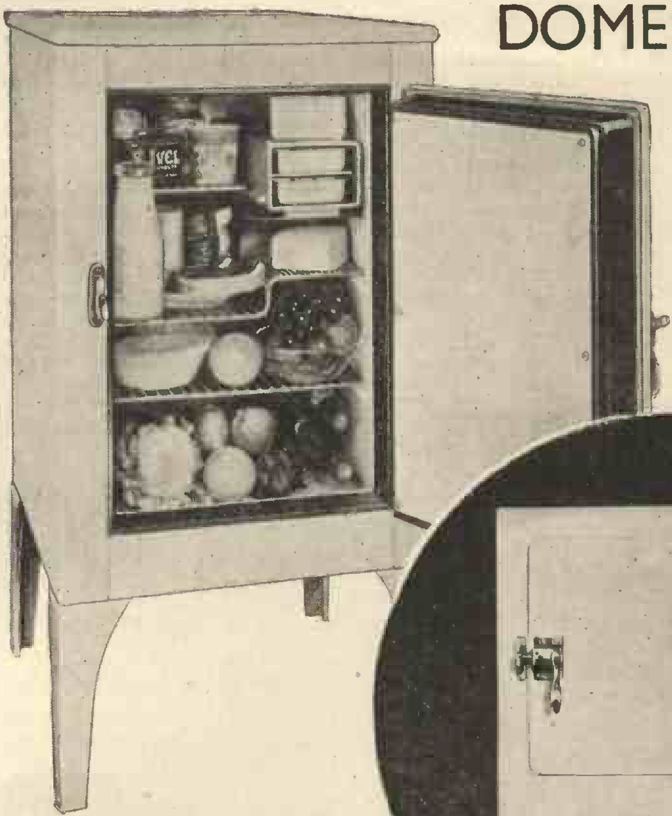
Were it not for the world-wide activities of the gas-mantle industry in searching out new supplies of raw materials, petrol-lighter "flints," instead of being available at 1*d.* per tube, would probably cost more than £1 for the same quantity, if, indeed, they were available at all.

Endeavours have been made to apply pyrophoric or spark-giving alloys such as those used in petrol-lighters as a means of securing automatic ignition in gas lighting, but they have not proved sufficiently reliable for this purpose. Also, attempts to apply these alloys as a means of igniting miner's safety-lamps have been unsuccessful, it being found that the sparks from the metal tend to spread outside the protecting wire-gauze of the lamps, thus creating a danger which it is the very purpose of the lamps to eliminate.

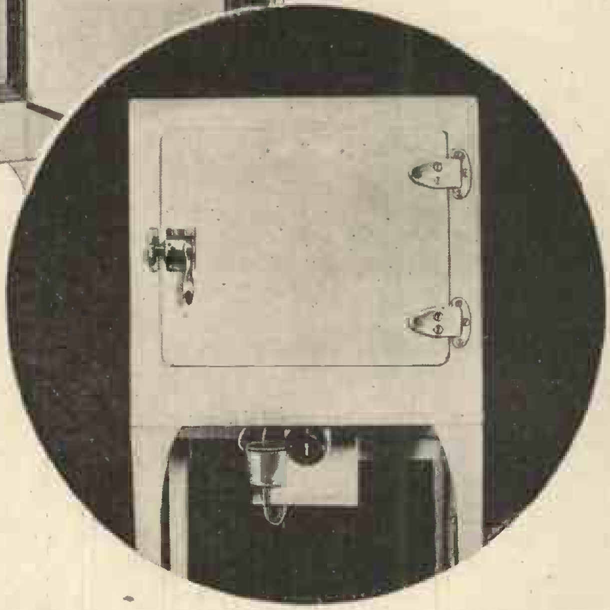
DOMESTIC REFRIGERATORS
AND HOW THEY WORK

By A. J. BUDD

The benefits to be derived from these popular appliances, and their methods of operation, are described in this article.



This illustration shows the ice trays and ample food storage in a modern domestic refrigerator.



The "Electrolux Minor," a small air-cooled refrigerator having a capacity of 1 cub. ft.

THE first people to use refrigeration in any form were probably the early Egyptians, who cooled and evaporated porous jars of water in the night air, thus forming a thin layer of ice, which was used to cool wine and foodstuffs. It was not until the end of the nineteenth century, however, that machine-made ice was made on a large scale commercially. From that time the development of refrigeration has made great strides, and to-day it is used in many households for conserving food and keeping it fresh, particularly during the summer months.

The modern domestic refrigerator is not an adaptation of the ice box of a few years ago, but is a comparatively new invention. For several years it has been successfully used in America, and is now becoming increasingly popular in this country. Among the benefits to be derived from a domestic refrigerator is the economy resulting from the conservation of foods, since there is no waste. There is also the satisfaction of knowing that everything stored in the refrigerator is kept in a perfectly fresh condition.

General Features

Consisting of a small cabinet, the household refrigerator is, to all intents, an accessory larder with thick walls enclosing a cold storage chamber where food and liquids can be kept at a temperature just above freezing point—usually between 40° and 50° F. This is important, for though food must be kept cold to preserve it, actual freezing of some kinds of food would cause a deterioration of their food value. In the modern refrigerator automatic control is provided, so that the correct temperature is continuously maintained.

But the appliance can also produce ice for the table, and ice cream when required. It has, therefore, a special compartment where a freezing temperature is maintained, and water is frozen into small blocks of ice in a few minutes. The ice-making compartment usually consists of a row of small metal drawers, which are filled with water, or ice-cream mixture, and the contents frozen.

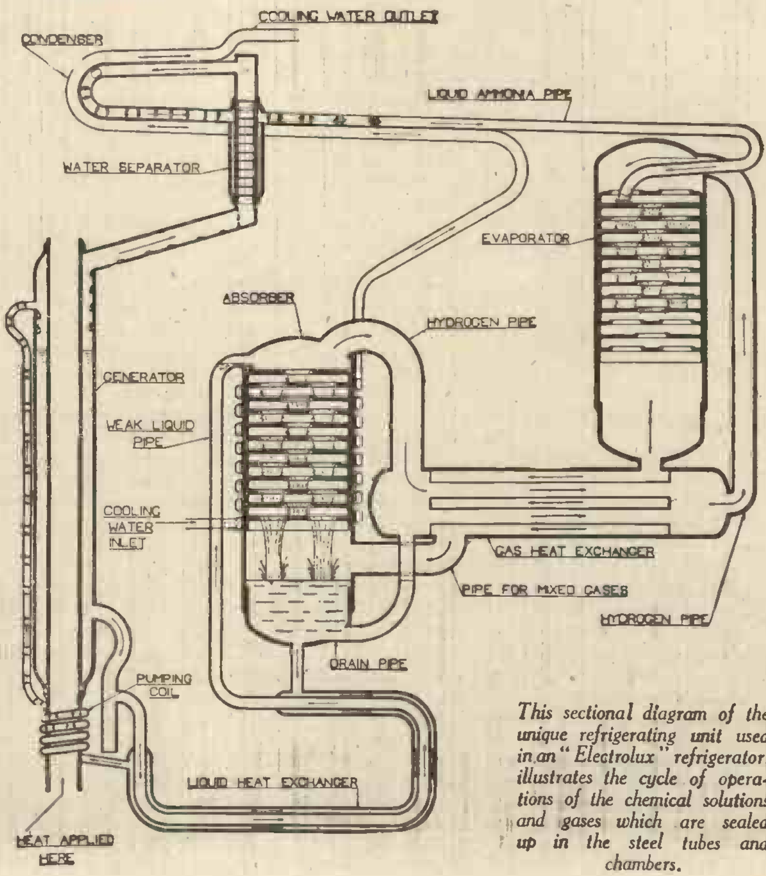
Most of the domestic refrigerators on the market consist of white- or grey-enamelled insulated cabinets, of varying sizes, and containing the refrigerating mechanism, either inside the cabinet, or mounted on top of it. In one well-known type of refrigerator, the "Electrolux," there is no mechanism whatever, the necessary refrigeration being brought about by a special chemical process.

Systems of Operation

The refrigeration unit in mechanically operated appliances consists of a small electric motor working in conjunction with a compressor, an evaporator, and a liquid refrigerant, usually sulphur dioxide. This liquid, under ordinary atmospheric pressure, boils and vaporises at 14° F.—that is, 18 degrees below the freezing point of water, so that it readily turns into a gas when passing through the evaporator which is located in the food compartment.

In boiling or vaporising, any liquid absorbs heat from its surroundings, hence the gaseous sulphur dioxide extracts the heat from the air in the cabinet through the walls of the evaporator. The process chills the entire contents of the freezing tank, and consequently the air within the enclosed cabinet.

(*Continued on page* 536).



This sectional diagram of the unique refrigerating unit used in an "Electrolux" refrigerator, illustrates the cycle of operations of the chemical solutions and gases which are sealed up in the steel tubes and chambers.

Fig. 1.—The "Kanga" taking off with the tail up and one wheel just off the ground.

PETROL-DRIVEN AEROPLANES

A description of some interesting experiments with Petrol have been seven since 1932. All these models have certain of interest and experiment they have

Fig. 4.—The "Bee" climbing in right-hand circles.

AS this is the first time that I have had the pleasure of writing for PRACTICAL MECHANICS, my name will no doubt be unknown to many readers. Perhaps I had therefore better introduce myself by giving a short history of what led up to these models. Before the war, when I built rubber models, I watched with great interest Mr. Stanger's two petrol models produced in 1914. These models may be said to have been the first successful petrol models.

However, the war intervened, and it was not until 1932 that I got into touch with Mr. T. Edgar Westbury, and he converted an old 28 c.c. two-stroke engine that had been used in a model speed boat. It was very heavy, but produced an excellent thrust. It weighed 3¾ lb., less ignition gear. I then produced the biplane "Kanga," which on its first officially observed attempt flew for 71 seconds, thus beating the Stanger record of 51 seconds set up eighteen years before.

The flights with "Kanga" proved to me that the modern model petrol engine was quite up to the job, but that there were a lot of minor snags to be overcome before the whole model could be made reliable. After a certain amount of discussion, Mr. Westbury set about producing a really light petrol engine of 15 c.c. The "Atom Minor" was the result, and was running in three months. This famous little engine is a two-stroke of 14·2 c.c. and weighs 1 lb. 3 oz. with elektron propeller, and may be said to be the successful forerunner of all the light 15 c.c. petrol engines now produced for model aeroplanes.

For this engine I designed a very simple and robust, but ugly, model called the "Bee," that could be quickly packed up and placed in a car in sections. This model on its first day out, in a heavy wind, put up the record to 86 seconds officially observed. However, it suffered from carburation troubles.

A Record Breaker

The "Bee," after a number of successful flights at various places, won the 1933 Sir John Shelley Power Cup and set up a record of 8 minutes 42 seconds out of sight. The model actually flew for 15 minutes, until the 2 oz. of fuel carried ran out. It then glided down from about 1,000 ft. into a school building. I followed below in my car, but the official timekeepers had to remain at the start to comply with existing regulations.

At the time of writing this record still stands unbeaten.

I then built a better looking low wing model called the "Gull" or "P.3" of the series. This aeroplane had an oval fuselage. It flew a fair number of times but was not a success, due to insufficient lateral stability and the tendency to damage because of the too rigid wing fixing.

The model has now been scrapped and a new low wing cabin monoplane has risen in its stead.

As most people know, a successful low wing model aeroplane is far harder to design than a high wing.

Then followed a small biplane called "Roo," built to see how small a model could be produced for an "Atom Minor" engine.

The next model was a speed model, and finally a new advanced simple type high wing model for the 1934 Power Competition, and the designs for a petrol flying boat for 1935.

Fig. 7.—The "Drone" without engine cowling. Note the fuselage for low wing location.

I will now give a description of the main features of each model with photographs which I hope will be of interest to readers, and possibly serve as useful data to those newcomers to petrol who are thinking out their first petrol model.

The "Kanga"

The description of this model is given in the past tense, as it was recently scrapped, after having given all the information desired of it. Nevertheless it is an interesting model to study, as it started the ball rolling and makes an excellent subject for comparison with later models.

The model was a biplane and weighed approximately 10 lb. It was fitted with a

Fig. 3.—The "Bee" taken after a forced landing.

Fig. 2.—The "Kanga" in full flight.

MODEL

By
Capt. C. E. BOWDEN,
R.A.S.C.

Model Aeroplanes. Up to date there
characteristic features, but for the sake
been of different types.

Fig. 5.—The " Gull " low wing monoplane

modified " Wall " two-stroke engine of 28 c.c., weighing 3¾ lb. with propeller.

The top wing was 7-ft. span and 10-in. chord, whilst the bottom wing had a span of 6 ft. and chord 10 in. The top wing had less dihedral angle than the bottom. Both wings had a modified R.A F. 34 Section, with reflex trailing edge, chosen for its stability. This section has the disadvantages of being rather fast however. This section was also used on my second model, the " Bee." But recently I have developed a section of my own which is also stable but much sl.wer. This has a decided concave under-surface and is of the thick type. The fuselage was 3 ft. 9 in. long.

The original propeller was of wood, and, strangely enough, lasted quite a long time. However, I eventually had castings made in elektron. These cost about 3*s.* each and are practically unbreakable. Propeller diameter 22 in. There was a complicated clock device fitted which, after any desired time, throttled down the engine to a slow running stop on the carburetter, so that the model was assisted on its glide. In fact it slowly flew into land.

A Perfect Landing

An arm projecting just forward of the under-carriage was connected to a forward ignition switch. Thus when the model flew slowly down with the engine just ticking over, as soon as this arm touched the ground the engine was completely switched off.

The Pathé Film Company made a film of this model in flight, and the film depicts the sequence of events on landing excellently.

However, since then I have simplified the operations considerably, as will be seen in the descriptions of subsequent models.

The flying speed of the model was about 20 m.p.h., which was rather high. The model, nevertheless, had quite a slow glide with engine just firing.

The under-carriage was of split type and somewhat similar to full-size practice, the main legs being telescopic and internally sprung. These legs were made of duralumin tube. The engine mounting was a duralumin spider with four legs bolted up to a forward bulkhead of three-ply wood.

It was found that this bulkhead used to collapse, due to the heavy weight of the engine. It was therefore strengthened by an aluminium tray (see description of the next model). This method of mounting was very strong but rather heavy, and in my latest models I have further improved the method. It is practically essential in a petrol model, if one desires the minimum of trouble, to mount engines so that there is flexibility in the event of a crash. I found that the spider bent rather then the engine. More economical and therefore desirable.

The ignition gear was somewhat involved on both this model and the present record holder, the " Bee." I have, however, simplified this for 1934 at the expense of several ounces more weight, which I have saved in other ways in the machine. A Westbury 8 oz. Non-trembler Coil was used with a Delco Remy 1 oz. condenser. A two-way switch was incorporated in the wiring, and also the forward switch already mentioned. The wiring alone weighed 4 oz.!

A 4 oz. pocket flash lamp battery of the flat sort, with a voltage of 4½, was installed in the machine and kept in place by rubber bands. An accumulator of large capacity, on the ground, was plugged into two sockets for starting up and warming up the engine in order to conserve the energy of the small flash lamp battery.

Just prior to a flight the ignition was switched over to the flash lamp battery and the plugs of the accumulator withdrawn. The throttle was opened up and the clock brake lever released, the length of flight having been previously set on the clock, and the model was released.

All these operations had to be carried out in a very short space of time and under the great excitement of the unknown! Two special wheels and tyres were made for me by the Dunlop Rubber Co., weighing 4 oz. each, and perhaps the greatest factor in the original success of this model was that the whole affair was designed to collapse if it hit anything unduly hard on landing.

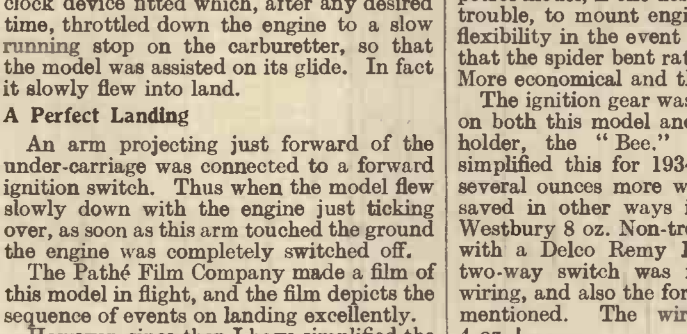


Fig. 6.—The " Drone " low-wing cabin petrol monoplane.

To this end the two main planes were kept in position by stout rubber bands (model aeroplane elastic) and were able to be slid along the fuselage to allow for correct c.a. position, or to be knocked off in the event of a crash.

The Tail Plane and Fin

These were also kept on by rubber bands. All these components were kept on just sufficiently firmly to resist the air pressure at maximum speed.

I have followed out this system in all my petrol models except in the case of the " Gull," which may be said to have been a failure because of departure from this principle. I have noticed that all the successful petrol models produced by other people since " Kanga " have similar ideas incorporated. The few rigidly constructed models have given a great deal of trouble, and in most cases the constructor has come down to some detachable device eventually. One has to remember that there is a much greater weight in a petrol model to be stopped when it hits an obstruction. There are several other important points also to be considered :—

(1) The wing loading must be light (not even 1 lb. per square ft.) so that flying speed is not excessive.

(2) Automatic stability, with exaggerated stabilising areas, must be sought after more than in a light model, for naturally the weight of a petrol model requires a longer time to change direction when righted.

(3) Any type of wire or strut bracing will be likely to become deranged after a bad landing, and thus upset one's calculations for the settings for the next flight. Cantilever construction is therefore most desirable.

(4) It is not advisable to construct a petrol model too lightly, but, on the other hand, weight has to be carefully considered in each detail. Experience soon teaches one exactly what will be required in any part to resist ordinary heavy landings.

Of course one cannot legislate for the extraordinary, and yet produce a model sufficiently light to fly well.

Figs. 1 and 2 depict " Kanga " taking off and flying overhead.

The " Bee "

As a result of the experience gained on " Kanga," a smaller and lighter model, the

"Bee," was produced after conferring with Mr. Westbury as to the practicability of producing a light two-stroke engine about 15 c.c. and capable of producing sufficient power to fly itself, a model, and the ignition gear necessary to good ignition.

The last item is still the most ill-proportioned weight. Mr. Westbury, in three months, handed one over, the "Atom Minor" two-stroke engine of 14·2 c.c., weighing 1 lb. 3 oz. with propeller.

This little engine is now quite famous, and may be said to be the forerunner of the many little 15 c.c. aero engines now being made, as I have said before.

I designed the "Bee" purely for durability, reliability and sound flying capabilities, so that anyone wishing to start the construction of a petrol model could, with the least amount of expense, produce a model, using the experience and design of the "Bee" as a basis.

To this end the working drawings and instructions for building were published, and the model, besides setting up the 1933 record, won the Sir John Shelley Cup for 1933.

It is an ugly machine and no attempt was made at beauty of line. The model has been entirely re-designed this year and a new, and I hope better, "Bee" called the "Blue Dragon" is nearly completed for its trials. The original model had a 7-ft. span, high wing cantilever monoplane, with slightly tapered wings of 13-in. chord at the wing root. The wing is constructed in two halves, which butt up against each other in the centre, and when erected are tied together at leading edge, on top, and trailing edge by strong thread, around wire hooks provided for the purpose.

There are also four large hooks underneath the two wing halves from which stout rubber bands pass around the fuselage, thus keeping the bottom parts of the wing halves butted up against each other, and the complete wing itself on the fuselage. It will be clear from this description that on striking an object the wing can easily be knocked off the fuselage, and the two halves will also give without damage. No tongues are fitted between the two wing halves.

The length of the "Bee" is 42 in, therefore, when the wing is divided, the model can be packed up in a case 3 ft. 6 in. long by 2 ft. 6 in. broad, and the model can be erected in a few minutes. The main plane section is a modified R.A.F. 34, and the ribs are cut from $\frac{1}{16}$-in. three-ply wood well fretted out for lighters; $\frac{1}{8}$-in. thick balsa wood has been used in all subsequent models for this purpose, and is considerably lighter. The tail plane measures 39½ in. by 10½ in. It will be observed that this is very large. However, it makes the model very stable fore and aft and a good glider, although the model is rather fast, due to the wing section fitted, and rather heavy loading (approximately 1 lb. per square ft.).

As a result of this tail plane and its setting the model usually lands from any height on its wheels and awaits its master the correct way up.

Designing a Large Model

A most important point in designing any large model is the correct tail setting in relation to the thrust line. This is a point often neglected by many model designers, and as a result the model, if correctly set for flying under power, will misbehave as soon as the power is off. The whole matter is really the subject of quite a lengthy discussion, but roughly can be described, with certain reservations, by saying that the tail plane must be set at such an angle to the thrust line and to the main plane that when the power is on or when it is off there must be no change in the action of the tail plane; the only change being in the speed of the model, which acts upon the main plane, so that more lift for a climb is obtained as the speed goes up.

It is quite possible by looking at a model's design to predict what it will do at the end of a flight when gliding and rise takes place, if this principle is understood.

A cambered section, with slightly concave under-surface, is used on the tail planes of all my models, and this type of tail plane is commonly known as a "lifting" tail plane. However, it should be arranged so that it does not lift until the model gets its main plane into a stalling position. It should normally float behind and lift the tail up before the main plane stalls, thus putting up the flying speed and saving the main plane from stalling.

It will be realised that this type of tail plane will raise the tail for the preliminary taxi-ing before taking off, as the model, when sitting at rest, has the tail well down and the main plane in stalled position. It therefore has the further useful attribute of controlling quite automatically the take-off run.

Fig. 8.—Petrol-driven speed model of the Bowden "Bullet" III.

The tail plane and rudder of the "Bee" are both detachable and kept in position at the correct angles by rubber bands. The weight of the "Bee" is 7 lb., and the original clock device, to control the duration of flight, has been replaced by a Kodak self-timer, which can be bought at any photographic stores for about 6*s*., weighs 1 oz., and can be made to operate a pull and push switch to control flights up to about 4 minutes. The "self-timer" acts upon the dashpot system and is very simple. The Continental pattern self-timers that can be bought are not suitable, as they are not sufficiently powerful to ensure operation of the switch. A suitable pull and push switch can be obtained from Woolworth's for 6*d*. On the "Bee" a similar system of ignition and two-way switch has been in operation as that on "Kanga," but no forward switch is fitted for landing, as the ignition is now switched off at the end of a flight by the Kodak self-timer, and the throttle is left untouched.

This simplified method was found possible by designing the model more carefully with regard to tail design and setting, and so obtaining a good flat glide as soon as the engine is switched off. I have found that this method can be carried out in the case of the high wing, low wing or biplane arrangement.

The model is covered with thin jap silk, well damped. The silk is stuck down with Kodak photographic paste. The whole is then doped with *full-sized* aeroplane dope, either one or two coats.

The forward part of the fuselage is built up in the form of a well fretted out three-ply elongated box, and a sheet aluminium tray over the front bulkhead and carried underneath the "box" for 1 ft. rearwards.

This method of construction is very strong and allows the blows received to the engine to be taken and also the under-carriage shocks absorbed. The engine spider mounting is bolted straight up to the front bulkhead. Behind the forward box the model is built up with longerons and formers of $\frac{1}{8}$ in. by $\frac{1}{8}$ in birch. There is no other method of bracing than the doped silk. Fig. 3 shows the model after it had made a forced landing the correct way up in a field, due to petrol failure. Fig. 4 depicts the model climbing in the 1933 Sir John Shelley Cup.

The "Gull,"

Fig. 5 shows this model on the ground. The model was an attempt at producing a better looking and a low wing petrol model for the "Atom Minor" engine.

However, the model had certain disadvantages and has now been scrapped. It formed the basis and data necessary to construct a general purposes low wing cabin monoplane, and also a model designed specially as a speed model.

The "Gull" has flown on several occasions, but was found to be tricky laterally owing to insufficient dihedral angle. Also damage to the wing, which was 9 ft. span and constructed in three detachable sections, was too frequent, due to the method of attachment and mounting the under-carriage on the under-surface of the centre portion of the wing. Although the wing was kept in position by rubber bands the design allowed the wing to become too firmly wedged to the bottom of the oval fuselage. The wing was cut away to position this oval fuselage, and did not allow sufficient movement if the wing tip received a blow. And, of course, it was rather fond of blows, due to poor lateral stability!

The "Roo"

This is a small biplane. This little machine was designed with a view to trying out certain improved ideas in detail construction and design that had occurred to me. Furthermore, it was desired to build the smallest practicable petrol model using the "Atom Minor" engine that would permit of a light loading and slow flying speed.

The wing span of this equal-span biplane is 5 ft., with a chord 9 in., and the wing section is of an exceptionally slow flying type with very pronounced under camber, the planes being set at a considerable angle of incidence.

Both planes and tail plane are located and kept in position by rubber bands. The fin, or rudder, is built on to the tail plane as one unit. There is also a small fin below the fuselage permanently attached. The lower part of this fin also acts as a streamline housing for the tail wheel which protrudes from it. The tail plane measures 32 in. by 9 in. chord.

The length of the fuselage is only 3 ft. 6 in. and the engine is mounted on to a detachable forward bulkhead. This bulkhead is kept in position by a coil spring attached to a wire which runs inside the fuselage to the

(*Continued on page* 530)

SYNCHRONOUS ELECTRIC CLOCKS

How Clocks are operated from the Electric-supply Mains with Perfect Timekeeping

By W. J. DELANEY

TIME-KEEPING has developed since the earliest days through many interesting phases. The graduated candle, the sand-glass, the water clock, or clepshydra, the sun-dial all represent interesting devices which have recorded the passage of time, the regularity in each case being a question of some doubt. At various observatories and other scientific institutions most elaborate mechanisms are designed to keep an invariable record of time as we know it, and the famous Greenwich clock is used throughout the world as a standard in this respect. Greenwich time is used as the basis upon which other times, such as Eastern Standard, European, etc., are founded. Ships sailing the seas use Greenwich time as standard and other chronometers on board are adjusted as various parts of the world are reached, but the log is kept in Greenwich time.

All our clocks should therefore be designed to keep in step with this particular mechanism, and everyone knows how the ordinary spring-operated clock or watch varies in its time keeping with alterations in temperature. Regulators are provided in order that the speed of the gear train may be adjusted to keep accurate time, and in our homes to-day it is not difficult to adjust all our clocks when we receive the six pips from Greenwich, denoting the exact time. Practically every type of clock requires periodic winding, and although this may vary from twenty-four hours to five years, it is still a point which has to receive attention in order to keep the mechanism working.

Electric Clocks

Various interesting devices have been introduced by horologists in order to avoid this winding and at the same time to maintain the mechanism at a definitely constant speed so that no alteration of the hands has to be carried out at any time. We have, for instance, described in these pages (see PRACTICAL MECHANICS, March, 1934) a clock which was designed to operate from simple bell-batteries and which, when properly adjusted, has remarkably good time-keeping characteristics. It will, unfortunately, vary with temperature, although such variation may be reduced to extremely small values if the pendulum rod is compensated by using oak and the weight is made "floating" and of lead. [We doubt this.—ED.] This principle is employed in many church clocks. The electric grid system has for its object the provision of electric-supply mains of the alternating current type, and, as electrical students will know, an alternating current is one which changes its polarity or flow at a certain number of periods per second. In most parts of the country this change or periodicity as it is called is 50 cycles, and many supply stations have certain apparatus fitted to the generators to maintain this frequency at a very definite speed—any slowing down or speeding up bringing certain compensating mechanism into play, and thus keeping the periodicity constant. This factor enables a synchronous motor to be designed which will operate by virtue of the frequency at a perfectly constant speed, and thus a clock mechanism may be built round the motor so that the time may be recorded, and the constancy of the frequency of the supply mains will ensure that no variation will take place in the clock mechanism.

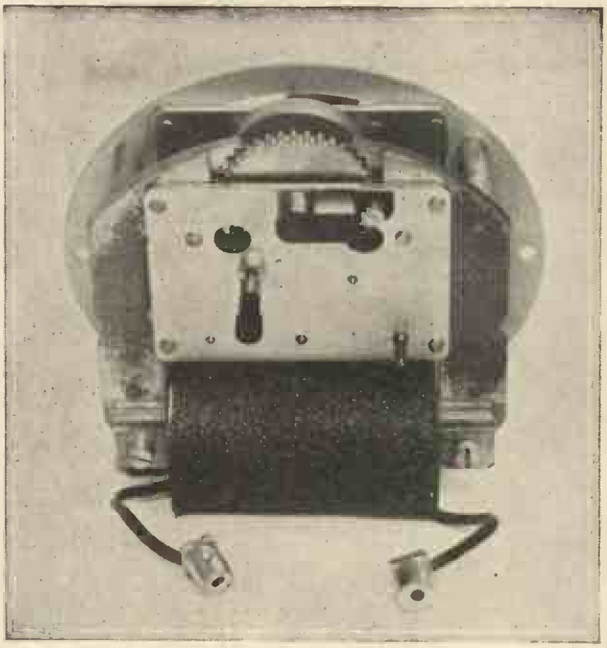


Fig. 1.—The complete movement removed from its case. Note the starting knob.

The Synchronous System

A synchronous motor operates owing to the change in direction of the alternating current. If a current is passed through a coil of wire, and a piece of iron is placed inside the coil, or solenoid as it is called, the iron will become magnetised, and according to the direction of the passage of the current one end of the rod will become a south pole and the other a north pole. Obviously, therefore, if the current passed through the coil changes its direction periodically the poles will also change their nature in accordance with the change. By arranging that the two poles are situated at opposite sides of a rotatable wheel it is possible to cause rotation of that wheel as the poles change. To obtain a suitable speed for a clock mechanism more than one face is provided for each pole, and in the illustration (Fig. 1) the two poles are very clearly shown with the solenoid at the bottom. The number of teeth (or faces) on the pole will, in conjunction with the periodicity of the supply, govern the speed of rotation of the wheel, and this relation is shown by the formula

$$\text{Revolutions per minute} = \frac{\text{twice the frequency} \times 60}{\text{Number of poles}},$$

the number of poles being the same on wheel (moving portion) and magnet pole. The wheel may, of course, be made in any size and the magnet pole may also be cut to any size provided that the number of teeth which oppose each other are the same.

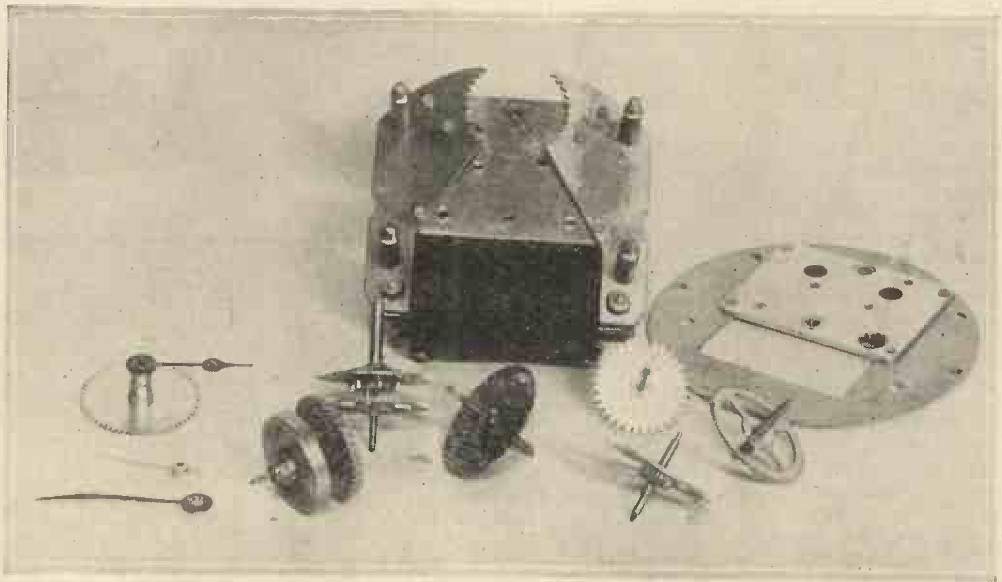


Fig. 2.—The complete mechanism dismantled. The rotor, with its balance wheel, may be seen in the foreground.

The clock movement which is used to illustrate this article is that manufactured by Messrs. Ferranti, and it will be seen that the number of teeth is eleven. By ordinary gear-ratio formulæ it is a simple matter to design this rotating wheel of such a size that the clock hands may be rotated at the correct speed, and as the frequency is governed at the supply station the clock will keep and record perfect time. For reasons of economy the solenoid must be designed to take a minimum of current from the mains.

Economy of Operation

The clock in the illustration, in conjunction with practically all other synchronous clocks on the market, takes such a small current from the mains that the average house meter will not record the consumption. In the Ferranti clock the resistance of the solenoid is 50,000 ohms, which means that the current consumed when connected to 200-volt mains is of the order of 4 milliamperes or $\frac{4}{1000}$ of an ampere. There are 1,000 amperes to a unit of electricity, so that even if the meter could record the passage of such a minute current the cost of operation may be seen to be infinitesimal. A drawback to the synchronous type of motor is to be found in its non-self-starting property. That is to say, if the wheel or moving element comes to rest with the teeth more or less in line, when the current is switched on the motor will not start to revolve. If the teeth are very closely spaced and are not in alignment when the current is switched on, the wheel may make just sufficient movement to bring the teeth in line and no further movement will take place. The restraining influence of the train of gear wheels also acts to prevent self-starting. To overcome this defect and also to assist in keeping the mechanism in good action a flywheel is fitted, and a torque balancer is provided in the Ferranti clock. In Fig. 1 the toothed wheel with its flywheel may be seen in the foreground, and a helical spring is fitted to form the coupling between the driven spindle and the balance or flywheel. This is, of course, standard practice where such small energy is in use. To reduce noise and wear the first of the gear train is a non-metallic wheel, and this may be seen on the right of the driving mechanism.

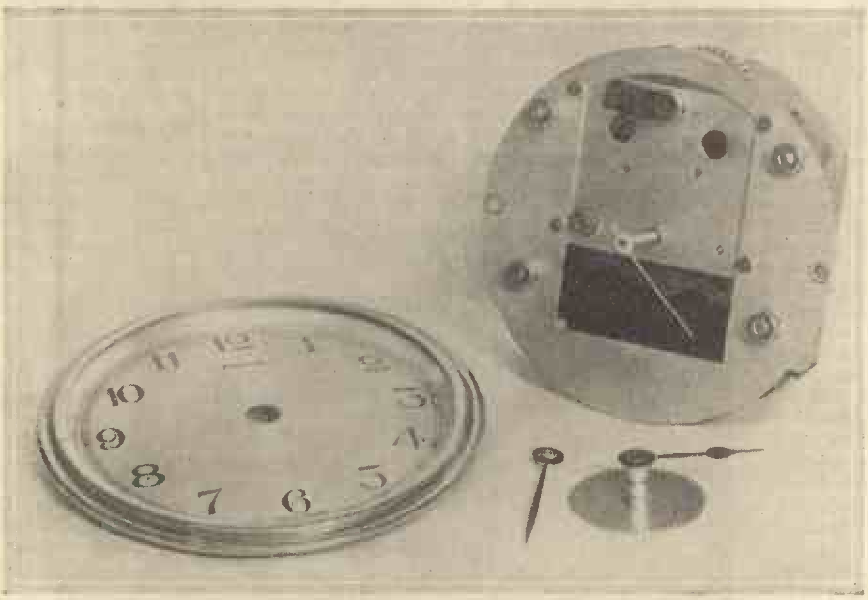


Fig. 3.—The small pointer, which gives an indication that the clock is functioning, may be seen in position in this photograph.

A Drawback

This non-starting feature results in a slight drawback, which, when the clock is first put into operation, may be overcome by arranging a key or other device to start the wheel revolving. In Fig. 2 the starting knob is seen in position, and it is only necessary to twirl this to start the motor, when it soon gets into step and keeps going until the supply is interrupted. Unfortunately, this may happen at the supply station, with the result that, if the clock is not being watched, the time will remain unaltered. On the Ferranti, the gear wheel which travels as "seconds" speed is provided, on its extremity, with a very light pointer, seen in position in Fig. 3. Whilst the motor is in operation, this travels round the face once per minute, and a glance thus serves to show that the clock is working. Should it stop at any time once the rotor (moving wheel) has come to rest, although the supply may be restored, the motor will not start again, and thus an interruption of only one minute will serve to stop the clock until it is restarted by hand. Some clocks of this type are therefore provided with a small clockwork or independent (battery-operated) mechanism which, as soon as the main supply is interrupted, will come into operation, and this separate mechanism operates a small disc which passes behind a small window. This is graduated in minutes and thus, should the clock stop, the duration of the stoppage is recorded and may be seen at a glance. If self-starting mechanism is installed, such a device is essential, otherwise the value of the synchronous clock is lost, as it will not show the correct time if the supply has been interrupted. It is, in this case, a simple matter to add on the number of minutes shown in the small window and then correct the main movement, setting the extra indicator back to zero. It is most satisfying to glance at one of these clocks when it is installed in the home and notice how it exactly synchronises with the Greenwich pips as received on the wireless, and when all supplies are time-controlled, this type of clock will obviously become the recognised method of time-keeping in the home, and no doubt the interrupted-supply drawback will be overcome, as well as means for correcting the clock in the event of such stoppage.

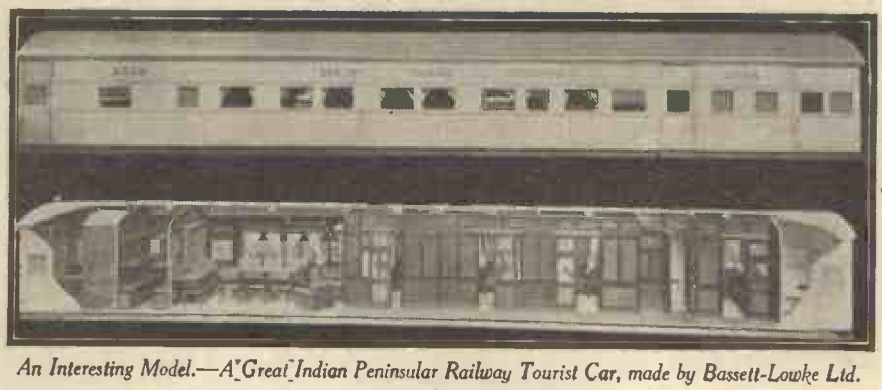
INDIAN LUXURY COACH MODELLED

THE illustration shows two views of a *de luxe* Tourist Car on the Great Indian Peninsular Railway, modelled by Bassett-Lowke Ltd., the model-makers of Northampton. The model carriage measures 4 ft. 3 in. long by 7 in. wide and 6½ in. high, and is built to a scale of ¾ in. to the foot for the Indian State Railways.

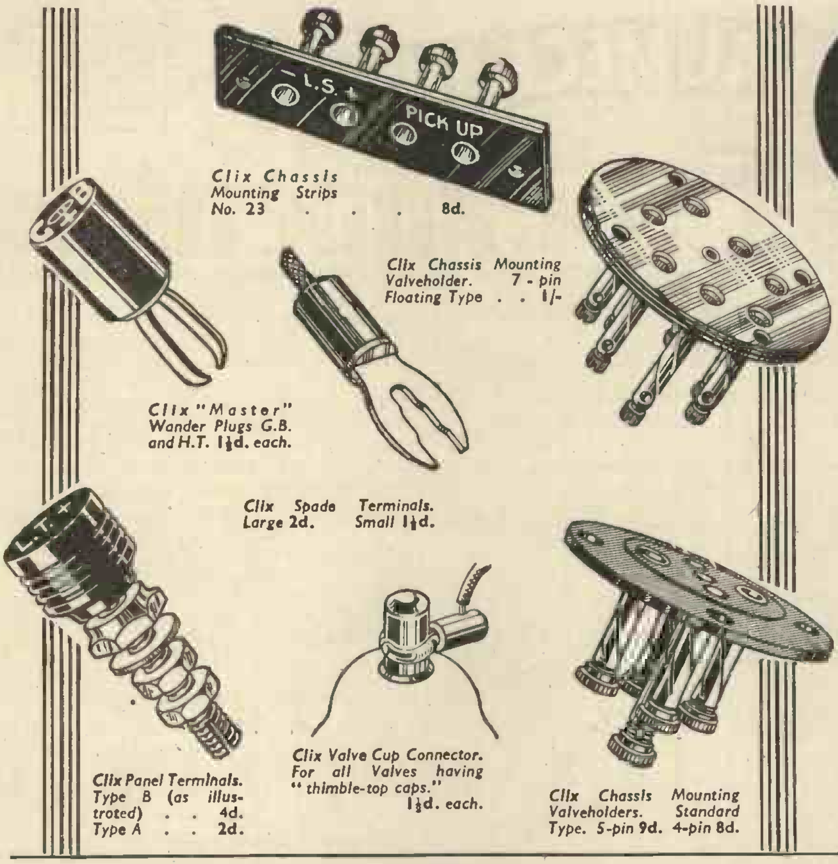
The woodwork is carried out in polished teak and oak, and the car contains a complete suite of rooms for the owner, guests and servants. The compartments in the carriage comprise the kitchen, servants' quarters, dining and day saloon, three double sleeping compartments, one special suite with private bathroom, and, at the end of the corridor, the general bathroom.

This model took six weeks to complete, and even the smallest accessory is beautifully finished. The kitchen has a scale model stove and sink, and the dining-room has yellow silk curtains and blue pile carpet, polished table and six chairs of finest teak, and easy chairs and sofa upholstered in blue leather. Each sleeping compartment is equipped with a scale model writing table, wardrobe, beds and special metal rack, and the bathrooms contain needle baths, showers, etc., in addition to the usual bath, wash-basin towel and brush rack and w.c.

Each compartment is lit by special white electric globes and has an exhaust fan to keep the room cool. The outside of the model is finished in cream with gold lines and grey roof, the glass windows are protected by two shutters.



An Interesting Model.—A Great Indian Peninsular Railway Tourist Car, made by Bassett-Lowke Ltd.



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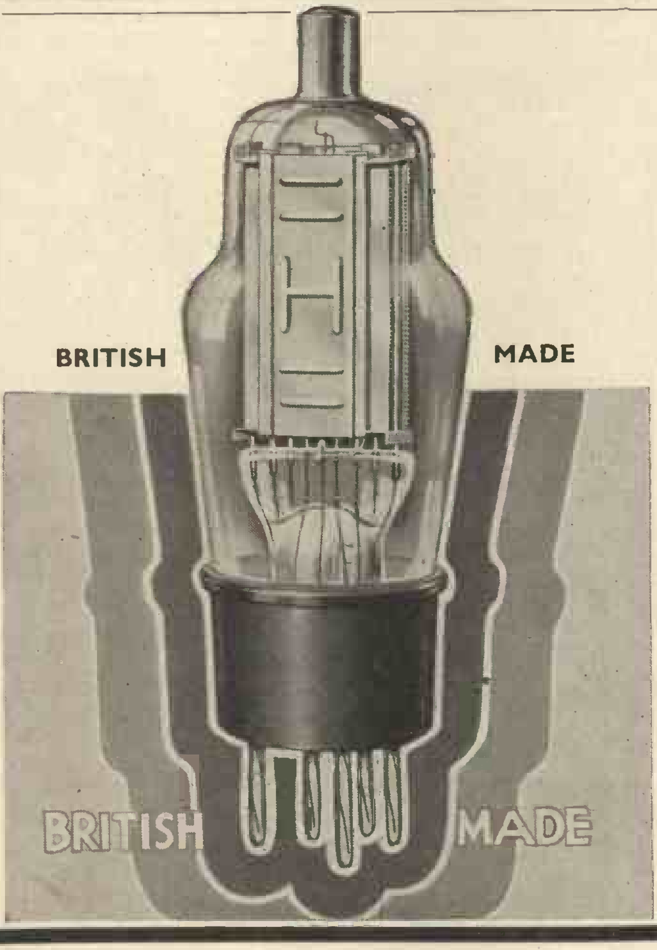

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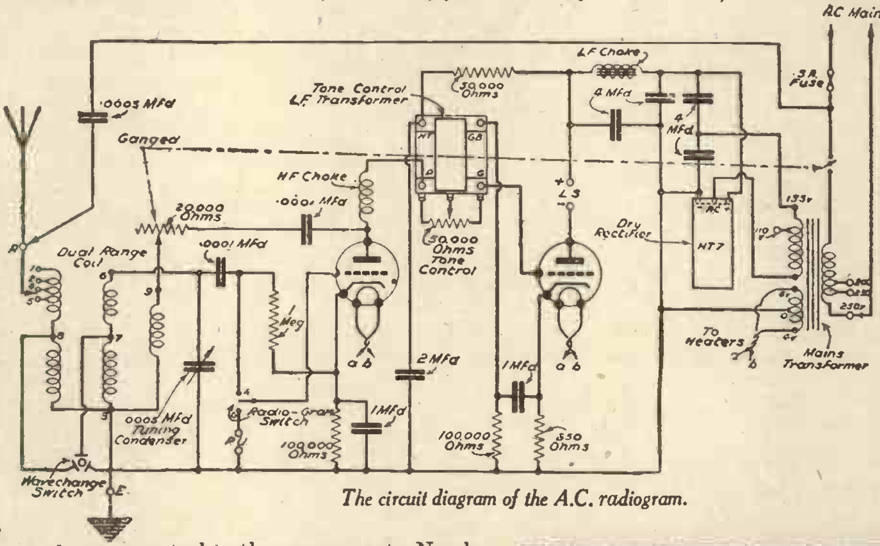
MOST radio-gramophones on the market, as well as those which have hitherto been described in the Radio Press, are multi-valve models, designed essentially as *de luxe* articles and, in consequence, costing upwards of £25. This new receiver is a two-valve job, which is comparatively inexpensive to build and of simple construction. This instrument has been designed for a definite and special purpose, which it fulfils in what we consider an ideal manner. The purpose is to give really fine quality of reproduction from more or less local stations as well as from gramophone records. It can be used either with or without an external aerial, and in both cases will give sufficient volume for all ordinary purposes.

The constructional work is perfectly straightforward, as can be gathered from the photographs and from the complete wiring plan. It is best to commence by drilling the panel according to the scale drawing shown. The positions of the four holes for the switches and tone control potentiometer are clearly indicated in the latter figure, whilst those for the spindle and escutcheon of the tuning condenser are most easily obtained by using the metal template conveniently supplied with this component. The template should be laid on the back of the panels and the holes marked through by means of a scriber or sharp pencil. A circular hole is required for the spindle, and is made in the usual way with a brace and bit. The opening for the escutcheon plate, however, is of irregular shape and can best be made by drilling a series of small holes just inside the lines and then cutting between them with a sharp knife or chisel; the rough edge can finally be smoothed with a half-round file.

The arrangement of baseboard components can readily be followed by reference to the wiring plan and photographs. Half-inch screws are suitable for mounting everything except the L.F. transformer (with which the "tone compensator" is employed), and for this two ¾-in. (8's) screws are required. The only parts which are not screwed down to the baseboard are the four fixed resistances, which are mounted directly by means of their connecting wires.



The circuit diagram of the A.C. radiogram.

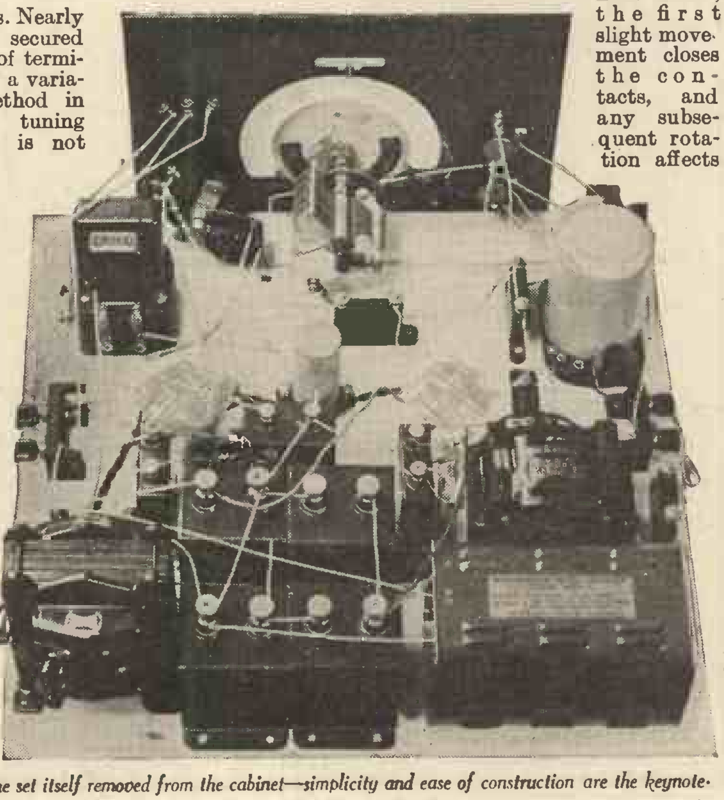
Wiring

Little explanation seems necessary in regard to the wiring; it is straightforward, and there will be no difficulty in following it. The majority of connections are made in Bulgun "Quickwire," but those between the filament terminals of the valve holders and corresponding terminals on the transformer are in twin flex. Two flexible wires are attached to the smoothing choke instead of the more usual terminals, and these are, of course, joined directly to the other components. Nearly all the wires are secured under the heads of terminals, but there is a variation of this method in respect to the tuning condenser; this is not fitted with terminals, but has two tubular soldering tags instead. The wires may be soldered to the latter, if desired, or may be attached by inserting them into, and nipping up, the tubular tags. Notice that a wire is taken from one of the holding-down screws of the H.F. choke to high tension negative; the object of this is to "earth" the metal screen.

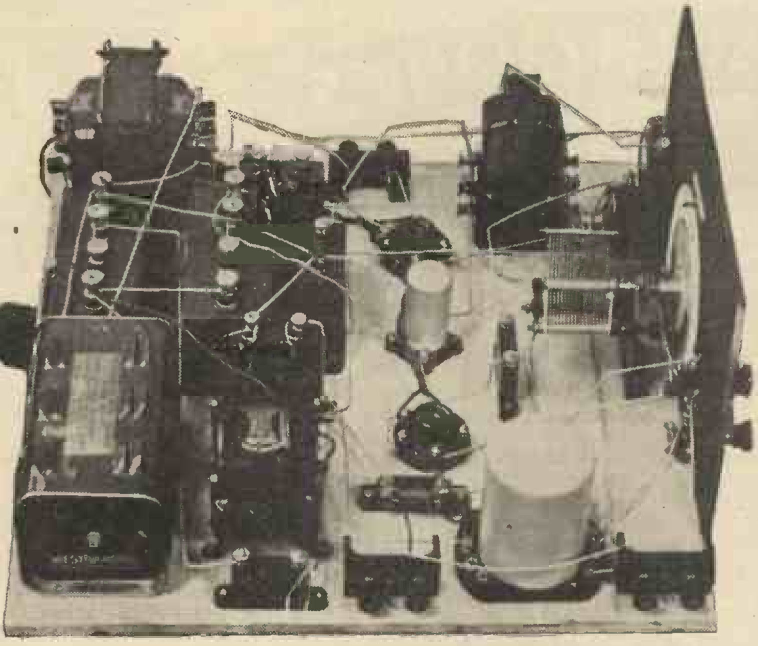
One wire from the mains flex is attached to the 5-amp. fuse, whilst the other must be taken to one of the three primary terminals on the mains transformer, marked "200 v." and "250 v.," respectively. Naturally, connection must be made to that terminal which is appropriate to the mains voltage available. In case the latter is not exactly the same as that marked on any terminal, the wire should be joined to the one which most nearly corresponds to the mains voltage. For example, if the voltage were 220, the wire would be taken to the 230 v. terminal, or if it were 240, connection could be made to either of terminals "230 v." or "250 v."

Operating Note

Having completed the constructional work you will be ready to give the set a thorough test. Insert the metallised valve in the left-hand holder and the power valve in the other one. Connect the earth lead and then an external aerial or the mains lead into a convenient lampholder and then switch on. Switching is, of course, done by means of the bottom right-hand knob; the first slight movement closes the contacts, and any subsequent rotation affects



Here you see the set itself removed from the cabinet—simplicity and ease of construction are the keynote.



This view shows the simple component layout. It can be seen that the mains equipment is mounted all together at the back of the baseboard.

reaction control. For "radio" the top left-hand switch knob is pulled out, when the lower switch sets the tuner for long waves (pushed in) or medium waves (pulled out).

Tuning

The method of tuning is the same as with any ordinary type of detector L.F. set, and the variable resistance used for reaction is operated in precisely the same way as is a reaction control. It might be added at this juncture that the set can cause interference to neighbours listening if it is allowed to oscillate, and, in consequence, reaction should be slackened off at the first signs of a whistle. Having suitably adjusted the volume, try the effect of the tone control. By turning the potentiometer knob to the right there should be an increase in high-note response and a consequent reduction in bass; rotating the knob in the other direction gives the reverse effect. It should be noted that variation in tone alters to a certain extent the overall volume, and this is at a maximum when the control is set to its midway position.

Adjusting the Selectivity

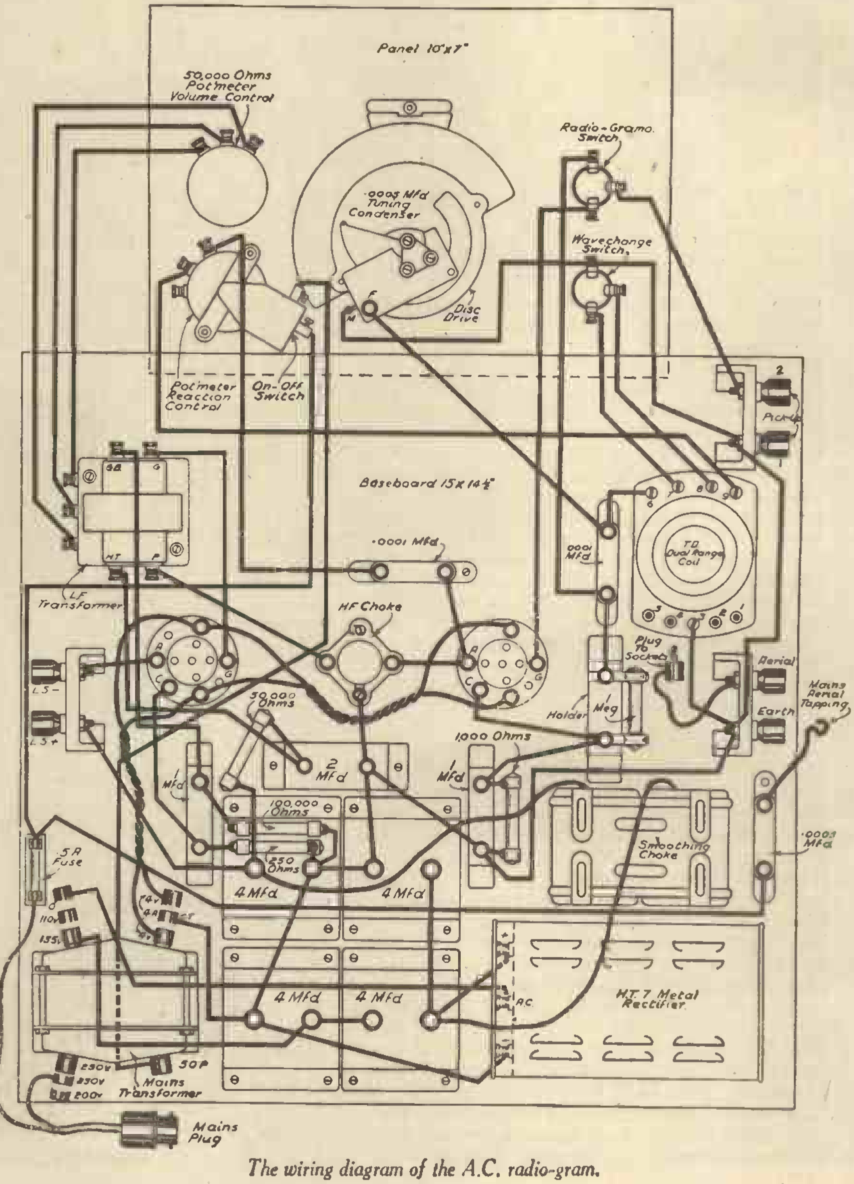
As previously mentioned, the degree of selectivity can be varied by inserting the coil plug into different sockets. The least amount of selectivity and, incidentally, the greatest volume, is obtained when the plug is in socket No. "1"—by putting it into sockets "2," "4," and "5," the degree of selectivity is progressively increased and there is a corresponding loss in maximum volume. When using the mains as aerial it will probably be found best to put the plug into socket No. "1," but in the case of an outside aerial its best position will be dependent entirely upon the length and characteristics of the particular aerial in use; a certain amount of experimentation will, therefore, be necessary in this respect.

Results

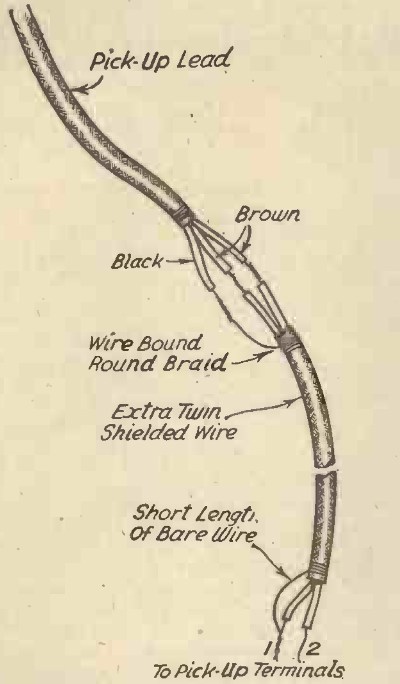
It might be of assistance to mention the approximate tuning positions of a few stations, since they will give you some idea as to where your own local transmitters are to be found. On the medium waveband (switch pulled out), London

LIST OF COMPONENTS

One Polished Plywood Panel 10 × 7 in. (supplied with Cabinet specified).
One 5-ply Baseboard, 15 × 14½ in. (supplied with Cabinet specified).
One Utility "Mite" ·0005 mfd. Condenser with Disc Drive.
One "Wearite" 3-point Wavechange Switch (Type G.W.C.).
One "Wearite" Changeover (Radio-gram) Switch (Type G.C.O.).
One "Wearite" 20,000 ohm Volume Control with combined Mains Switch.
Two Clix 5-pin Valve Holders.
One Colvern Type "T.D." Coil.
Two Tubular ·0001 mfd. Fixed Condenser (T.M.C.).
One Tubular ·0005 mfd. Fixed Condenser (T.M.C.).
One Graham Farish Ohmite 1-megohm Grid Leak.
1 Graham Farish Horizontal Grid Leak Holder.
1 "Wearite" Screened H.F. Choke (Type H.F.P.).
One L.F. Transformer, Multitone Toco.
Three Belling-Lee Terminal Mounts.
Six Belling-Lee Type "R" Terminals, 2 marked "Pick-Up" and 1 each marked "A," "E," L.S., L.S.—.
One Heayberd Type W.25 Mains Transformer, giving outputs of 135 volts, 70mA. and 2–0–2 volts, 4 amps.
One Heayberd, Type 751, Smoothing Choke.
One Westinghouse, Style H.T.7 Metal Rectifier.
Four (400 volts D.C. working) 4 mfd. Condensers.
One (400 volts D.C. working) 2 mfd. Condenser.
Two (400 volts D.C. working) 1 mfd. Condensers.
One Microfuse Holder with ·5 amp. fuse.
One Graham Farish Ohmite 100,000 ohm, 1 watt Resistance.
One Graham Farish Ohmite 50,000 ohm, 1 watt Resistance.
One Graham Farish Ohmite 1,000 ohm, 1 watt Resistance.
One Graham Farish Ohmite 250 ohm, 1 watt Resistance.
One Heayberd Mains Flex with Lamp Adaptor.
Two Coils Wire, Screws, Short Length Flex.
One Hivac A.C. H.L. Valve.
One Hivac AC. L. Valve.
One B.T.H. True-Speed.
One Becker Q.M.B. On-Off Switch.
One B.T.H. "Minor" Pick-up.
One Amplion Lion Speaker.
One Peto-Scott Cabinet.



The wiring diagram of the A.C. radio-gram.



This sketch shows how the pick-up lead is lengthened.

National comes at 60 degrees, Scottish National at 80 degrees, North National at 90 degrees, London Regional at 115 degrees, Scottish Regional at about 120 degrees, Midland Regional at 135 degrees and North Regional at 150 degrees. On long waves Daventry is received at about 150 degrees and Radio-Paris at 165 degrees.

Aerial and Earth

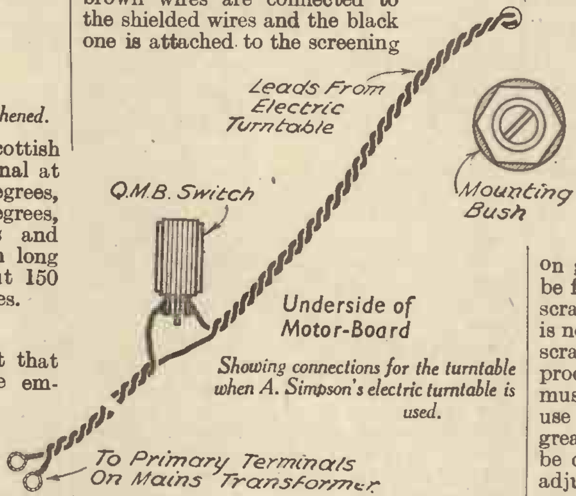
It has been found very important that a really good earth lead should be employed, but the aerial is of much less consequence, especially within thirty or forty miles of the local station; up to such distances the mains aerial is perfectly satisfactory and probably better than a short indoor one. At least, this has proved to be the case with the mains on which the set has been tested, but it should be pointed out that occasionally one finds that a particular mains supply is unsatisfactory for use as an aerial, due to the fact that it carries a good deal of H.F. current, which produces an unpleasant hum, or some kind of instability. In a case of this kind it is generally better to employ an external aerial, although an improvement can often be obtained by connecting a suitable H.F. choke in series with each supply lead—special chokes are made for this purpose, since those of the usual type are incapable of carrying the necessary current.

Mounting the Turntable

The first thing is to mount the electric turntable, and the motor-board of the cabinet is already drilled for this purpose when obtained. The turntable has single-hole mounting, so it is only necessary to pass the bush through the hole provided, and secure it on the underside with the ring nut. Felt washers are supplied with the electric turntable, and these should be arranged on the mounting bush to insulate the motor-board from vibration. Next, the Q.M.B. switch must be attached to one corner of the motor-board and a $\frac{7}{16}$-in. hole will be required for this purpose. Connections to the switch should then be made as shown in the sketch; it can be seen that one wire of the twin flex is broken and the two sides of the break are attached to the switch terminals. As the flex supplied is a good deal longer than necessary, it must be cut off to such a length that it will just reach the primary terminals of the mains transformer when the set is placed in position.

Connecting the Pick-up

The pick-up can next be attached, its exact position being determined by means of the thick cardboard template supplied with it. As a matter of fact, the small hole in the right-hand corner of the motor-board almost exactly corresponds with the position for the centre of the pick-up base, so the connecting leads can be passed through this. It will be found that the pick-up lead is not long enough to reach the appropriate terminals on the set, and so it must be lengthened with a short piece of twin shielded wire which is connected as shown. There are three wires from the pick-up lead—two brown and one black—and the former two come from the pick-up proper, whilst the latter is connected to the metal parts and to the metal-braided shield; it is for "earthing" purposes only. The two brown wires are connected to the shielded wires and the black one is attached to the screening braid. These three connections are best made by soldering, and afterwards the joints should be covered with short lengths of insulating tape. At the "set" end of the pick-up lead a short wire is secured to the metal braiding and is joined, along with one of the ordinary pick-up wires, to that terminal which is connected to earth—this detail is also shown in the sketch.



Showing connections for the turntable when A. Simpson's electric turntable is used.

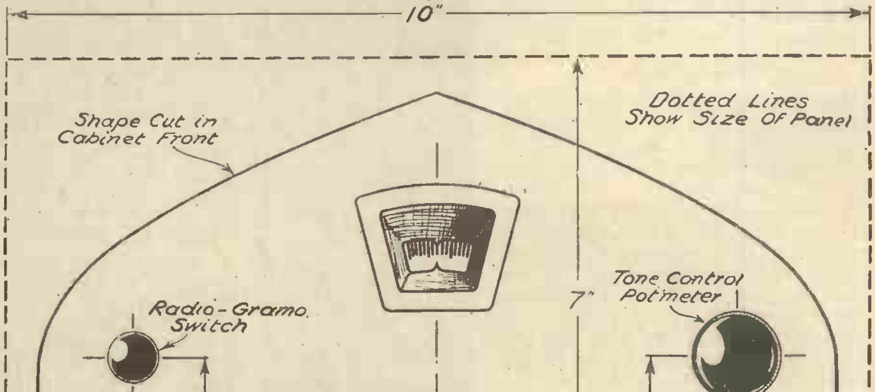
As the metal screening braid of the pick-up lead is earth-connected, care must be taken that it cannot come into contact with other parts of the receiver. For this reason it is best to take the lead along the underside of the motor-board and down the side of the cabinet, loosely fastening it into position by means of small staples or brass cup-hooks.

Using the Gramophone

To set the gramophone into operation the radio-gram switch should first be pushed in, the set switched on in the normal way and the gramophone turntable connected by means of its own switch. Since the driving mechanism of the turntable consists of a synchronous motor, it will not rotate until the turntable is given a flick with the finger. Let it run for a few minutes to attain its normal speed before putting the pick-up on the record. The volume of gramophone reproduction is varied by means of a small lever projecting from the base of the pick-up track arm, and it will probably be found that this has to be set to very nearly its minimum position in order to reduce volume sufficiently to make it suitable for an average room.

The Tone Control

The tone control operates just the same on gramophone music as on radio, and will be found very useful for cutting out needle scratch as well as for its normal purpose. It is not difficult to find a setting at which the scratch is almost entirely eliminated without producing any noticeable loss of higher musical frequencies. By making intelligent use of the tone control potentiometer the greatest possible amount of enjoyment can be obtained from any record, and a slight adjustment for different kinds of music will prove beneficial. Clockwise rotation of the knob increases the set's response to the higher notes (and to needle scratch, incidentally), whilst an anti-clockwise movement produces a greater response to the bass.



This drawing shows the layout of all the panel components.

HOW A GRAMOPHONE RECORD IS MADE

Those circular black discs called gramophone records, from which are heard the performances of some of the world's greatest artists, are manufactured under conditions of utmost secrecy. In fact, definite details of some of the processes employed are never divulged by the record manufacturers. It is possible, however, to describe the general methods by which the sounds of a human voice are captured on wax and thus may be heard again twenty or more years later.

A recording engineer examining a wax recording immediately after a record has been made.

WHEN artists are performing especially for the gramophone, it usually takes place in a special recording studio. The finest in the world are generally considered to be those of the "His Master's Voice" Company at St. John's Wood, London. They are the only studios which have been specially built for gramophone recording and have not been converted from existing buildings; they were opened a few years ago and have since been inspected by Royalty. There are four studios, varying in size from a small one in which talking records are made to the largest, which can house an orchestra of 250 musicians on the stage and 1,000 vocalists in the auditorium. Special precautions have been taken to ensure that performances can take place in all studios simultaneously and that one does not interfere with the other. The walls are more than 14 in. thick, and no studio is adjacent to another one, corridors intervening. The walls of the studios are also uneven in order that no echo will take place. Next to each studio, and communicating with it by double windows, is a recording room in which are two recording machines.

A Session in Progress

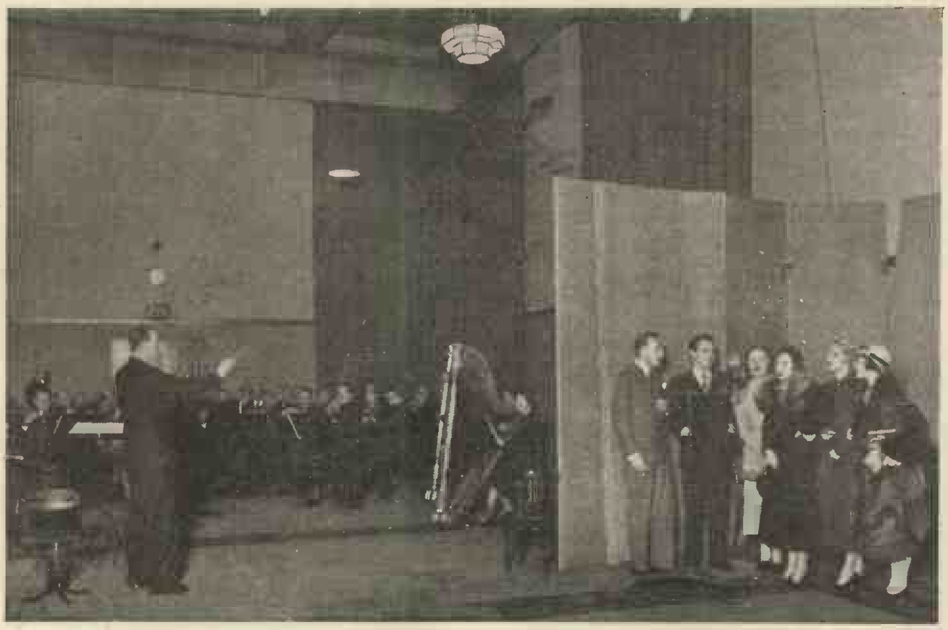
Let us visit one of the studios whilst a session is in progress. On light stands are the moving-coil microphones which have been designed especially for gramophone recording, although they are now used by the B.B.C. The orchestra is grouped in front of one microphone, whilst the vocalists stand before another. Large screens are placed round the singers in order that their microphone shall not pick up the sounds of the orchestra. One of the many problems of gramophone recording is to ensure that the items being recorded do not exceed the length of the record. The maximum playing time of a 10-in. record is 3½ minutes, and a 12-in. record 4½ minutes. These details are usually attended to before the session takes place, but sometimes a verse or chorus of a song may have to be cut or added to in order that the item may be of the appropriate time.

First the artists try through their pieces so that the engineers can determine whether the placing of the orchestra is correct and hear whether the singers are standing at the correct distance from their microphone. Two buzzers are then heard, which is a signal to the artists that a record is about to be made and that the recording box is just going to be lowered on to the revolving wax. As soon as this is down a red light glows in the studio simultaneously with another outside the door, thus warning the staff not to enter the studio whilst a record is being made.

At the end of the item there is a deathly silence for a few seconds until the red lamp is extinguished, the engineers thus indicating that the recording box has been removed from the wax and the artists may talk. This first test record is usually a "play-back," which means that it is reproduced by a pick-up through to the studio so that the artists can hear their own performance. "Playing-back" means that the recorded wax is irretrievably ruined, and thus only test records can be treated in this way. However, very possibly it can be learnt from a "play-back" that alterations in the placing of some of the instruments are necessary. One of the singers will probably be standing too close to the microphone, whilst another is too far away. After these alterations have been carried out and it has been ascertained that the time is correct, a master record is made.

The Recording Room

Let us now visit the recording room and see how the performance is engraved on wax. The recording room is kept at a temperature of not less than 70° F. in order that the wax recording blanks may be at the correct degree of softness for recording. They are stored in heated cupboards, which are kept at a constant temperature by a thermostatic control. Mounted each side of the communicating window are two recording machines, which are a triumph of engineering. They consist of heavy turntables which rotate, queerly enough, by the most primitive form of motion—gravity. A heavy weight is suspended from the ceiling by a wire which passes down through pulleys up into the recording machine. Before each record is made the weight is wound up; as this drops to the ground it revolves the turntable at an absolutely constant speed of seventy-eight revolutions per minute. Electric spring motors have been tried for driving the turntable, but it has been found that gravity is the only method by which constant speed is assured. Mounted above the turntable is a recording box; this is somewhat similar in construction to a pick-up fitted to a radio-gramophone, although it is made to a finer degree of accuracy. Instead of a steel needle there is a sapphire point, which has taken more than a day to make; this point is absolutely free from any imperfections in its surface, and



A recording session in progress in the middle-size "His Master's Voice" studio at St. John's Wood. Noel Coward, Yvonne Printemps, Heather Thatcher and other members of "Conversation Piece" are singing on the right, whilst the orchestra is playing in front of another microphone. The screens are provided in order to ensure that the orchestral accompaniment is not prominently recorded by both microphones.

is examined before use by being magnified by an optical arrangement on to a screen. If there was the faintest trace of roughness in its surface, a scratch or hiss would be heard in the finished record.

The Wax Discs

When the artists are ready to make a record a wax blank is taken out of the cupboard and placed on the turntable. The preparation of this wax is a close secret, but it is believed that soap is one of its chief ingredients. Each wax disc is more than an inch thick, in order to prevent any warping, has a mirror-like surface and is handled by the recording engineer with the utmost care, for even the lightest finger touch on its face would render it useless for record making. After the engineer has made a preliminary test to ensure that the waxes are to the correct degree of softness, he presses the warning buzzer and lowers the sapphire point on to the edge of the revolving wax. It is interesting to note that as the wax revolves it passes at right angles under the cutting point, and thus a spiral is cut from the edge to the centre of the record. In a gramophone or radio gramophone the pick-up swings across the record. As soon as the sapphire needle point is lowered on to the wax, the engineer presses a switch which illuminates the red lamp in the studio and indicates that the artists should commence their performance, which is heard in the recording room through a loud speaker.

Sir Thomas Beecham examining the recorded wax after he had conducted the London Philharmonic Orchestra at the Columbia studios, playing Bizet's "Fair Maid of Perth" Suite. The orchestra had twenty-four rehearsals before making this record, which Sir Thomas believes is a perfect one.

Regulating the Power

By the side of the recording machine are meters, knobs and volume controls by which the engineer can regulate the power being passed to the recording box from each separate microphone. The actual method by which the sounds in the studio are able to be recorded on the wax are as follows :—The diaphragms of the microphones in the studio are vibrated by the sounds of the artists and minute electrical currents are generated, they pass through many yards of wire to the amplifier room, which is situated at the top of the building. These amplifiers, which use valves as large as footballs, amplify the electric currents from the microphones more than 10 million times ; they are then passed down to the recording box through volume controls. They vibrate the sapphire point and thus a wavy line is cut in the wax. The fine thread of wax which is removed is drawn off into a suction tube. The making of successful records calls for a high degree of technical skill and many years of experience on the part of the engineers. Some of those in the H.M.V. studios have been making records for nearly a quarter of a century.

At least three waxes of each item are made, and it is surprising how long it takes to obtain this number, perhaps at the end of a record a violinist will play a wrong note and the whole record will be ruined. As soon as the session is finished the recorded waxes are placed in special boxes and taken in heated vans to the "His Master's Voice" factories at Hayes, where they undergo a number of processes.

MORE ABOUT HISTORIC LOCOMOTIVES PART IV.

By E. W. TWINING

This month we deal with faster and more powerful machines.

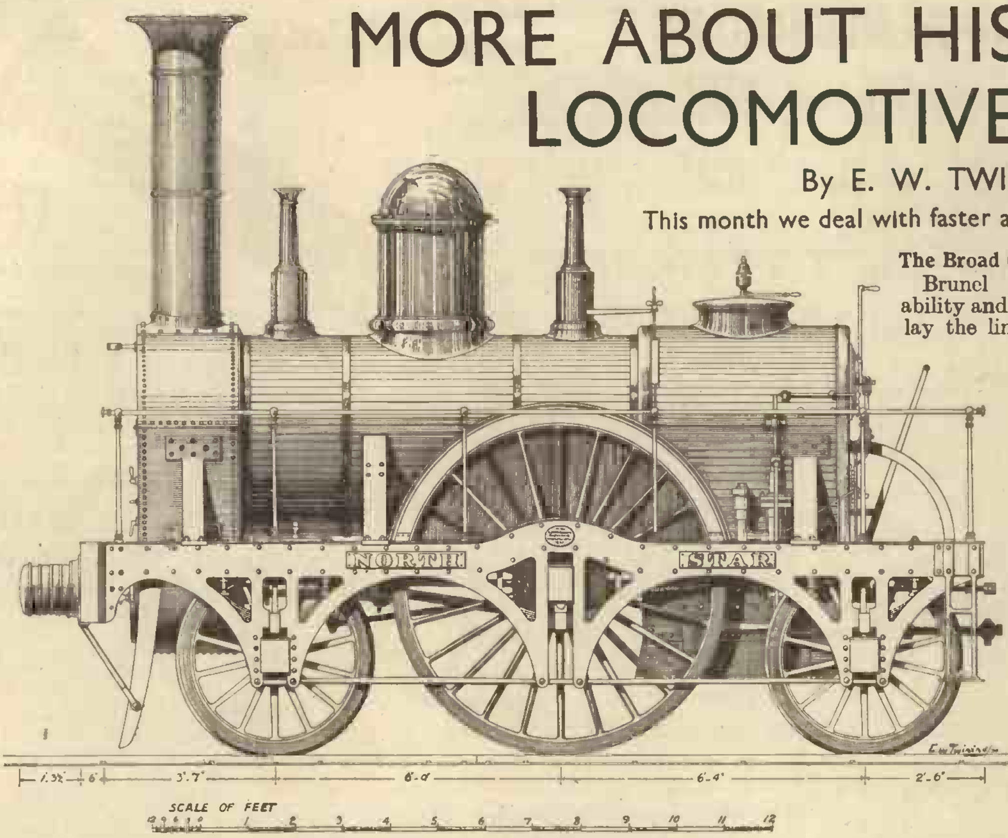


Fig. 10.—Stephenson's "North Star," G.W.R., 1837.

DURING the few years following the introduction of the "Patentee" class of locomotive, illustrated in Fig. 9 in the last article, and the 0—4—2 and 0—6—0 types of similar design, apart from wheel arrangement, nothing occurred in development which need be chronicled here, although the four-coupled and six-coupled engines were very fine machines. The six-coupled, particularly, with their 16 in. by 20 in. cylinders, 4 ft. 6 in. wheels, and large boilers, as supplied to the Leicester and Swannington Railway, were very powerful, but from the time of the "Rocket" onwards I am compelled to limit our attention to express passenger locomotives, and so I pass on to the year 1837 and to that great engineering work which gave such a tremendous impetus to the construction of more and still more powerful and fast machines. I refer, of course, to the Great Western Railway.

Great Western Railway

This line was first projected as early as 1824 by a number of Bristol merchants who proposed to connect their city with the metropolis by a railroad, to be worked by steam locomotives, and a company was formed. No active steps appear to have been taken, with the exception of the making of a somewhat ineffectual survey, for several years, and then the scheme was revived, again in Bristol. In 1833 an engineer was appointed to make a full and proper survey. Isambard Kingdom Brunel, son of a famous father and himself well known, was the chosen candidate.

Parliamentary powers were sought, and a Bill authorising the construction of the line was, after much bitter and unjustifiable opposition, passed by both Houses and given the Royal Assent on the last day of August, 1835.

The Broad Gauge

Brunel was a man of extraordinary ability and originality, and in setting out to lay the line he made two very important decisions: the first was that the prevailing gauge of 4 ft. 8½ in. was not wide enough; the second that the existing form of track—fish-bellied rails carried either on stone blocks or cross wooden sleepers—did not conduce to smooth and silent running.

At least one firm of locomotive builders admitted that a little increase in the width between the engine frames would be an advantage, so even at that early date it was being found that space for machinery, with cranked axles and inside cylinders, was somewhat cramped.

Although Brunel stated that his chief object in adopting the broad gauge of 7 ft. between the rails was to enable him to use large wheels and place the bodies of his carriages between them, it must be evident to any unprejudiced mind that his outlook and foresight went far beyond that, for, if otherwise, why did he adopt a loading gauge which was in all dimensions proportionate to his rail gauge. Brunel was undoubtedly right, and the factor which ultimately drove the broad gauge out of our railway system, though its founder did not live to see it, was vested interests far greater than those of the Great Western. Although I say

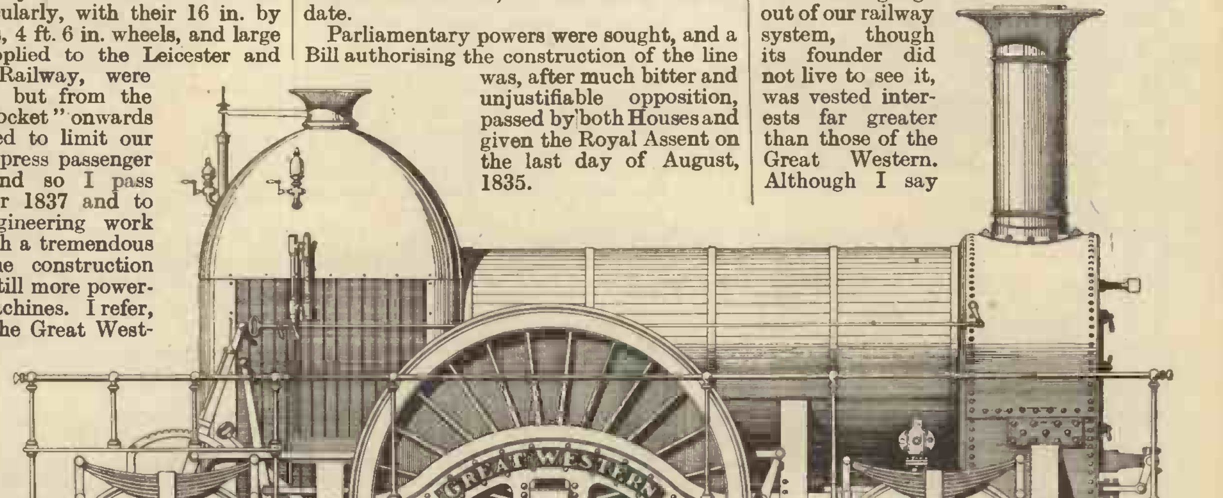


Fig. 11.—Gooch's broad-gauge engine, "Great Western."

Brunel was right, I would not go so far as to say that 7 ft. was the best gauge that could have been universally adopted, but I do consider that the standard 4 ft. 8½ in. is too narrow and that 5 ft. 6 in. or 6 ft. would have been much better.

Longitudinal Sleepers

For his permanent way Brunel adopted a form of sleeper not entirely new, since the timber was laid longitudinally beneath the rails as in the very earliest form of track, but the section of the rail was new and designed by Brunel himself. At the commencement he made the mistake of driving piles into the soil to the tops of which his sleepers were bolted; this made the road too rigid at the points of support, and after a short length had been thus laid the piles were abandoned. The sleepers were baulks of Oregon Pine laid longitudinally with transoms at intervals to tie them to gauge. On these longitudinals bridge rails, having flanges on either side, were secured with coach screws. It is only during recent years, when the weight of locomotives and trains became so great, that Brunel's form of track was replaced by the usual cross sleeper and chair road on the Great Western. It survived long after the broad gauge itself was abolished, and I can myself testify to the perfect absence of vibration, rattle and noise in running over it.

By the time the first portion of the line from Paddington to Maidenhead was ready for opening—the opening took place on the 4th June, 1838—a locomotive superintendent had been chosen by Brunel and a number of engines had been delivered to work the trains. This engineer, then a young man of only twenty-one years, was destined to become famous both as a locomotive designer and eventually as Chairman of the Great Western Railway. His name was Daniel (afterwards Sir Daniel) Gooch.

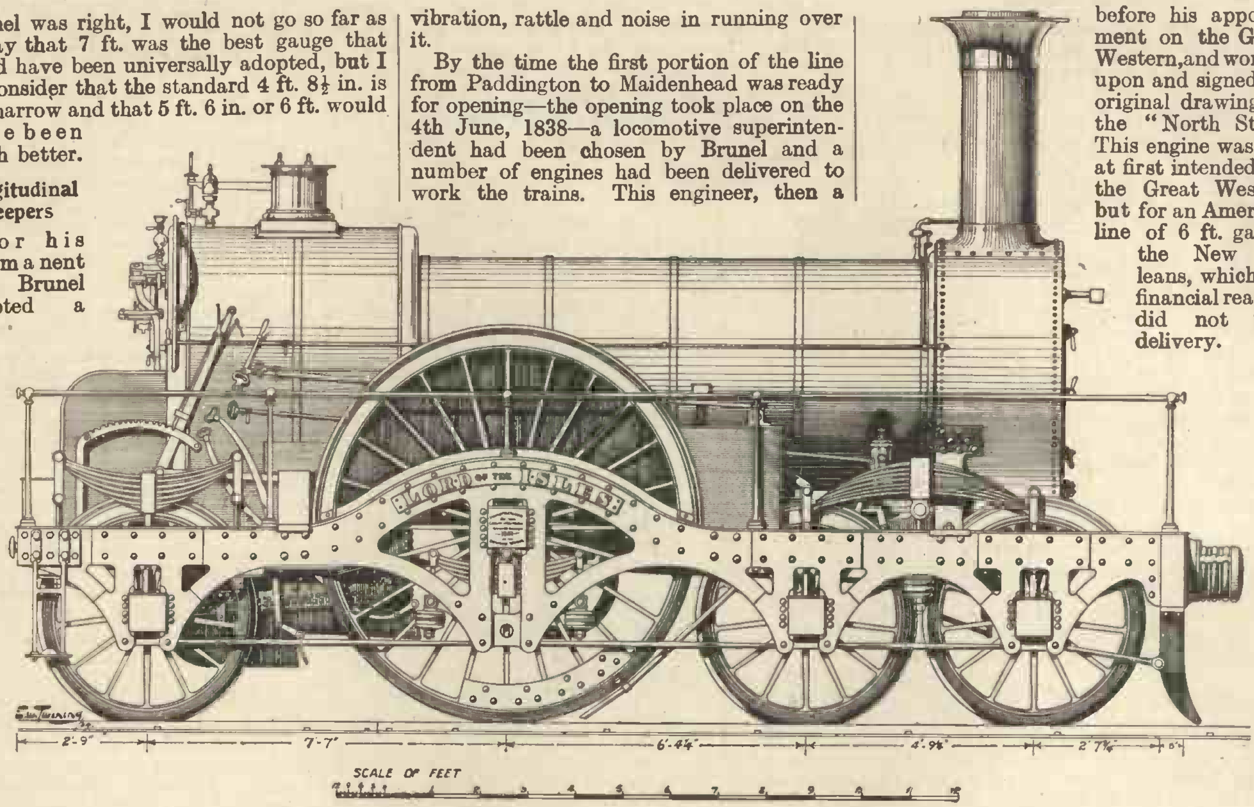


Fig. 12.—The broad-gauge engine, "Lord of the Isles," 1851.

First Engines of the G.W.R.

Of the ten locomotives of which the Company was possessed at the time of opening there was only one upon which Gooch could put perfect reliance, that one was the "North Star," built by Robert Stephenson & Co., Ltd., and delivered in November, 1837. It is illustrated in Fig. 10. The rest were a curious lost, mostly freaks which were full of weaknesses and always breaking down. For a full description of them I would refer the reader to "The History of the Great Western Railway," a two-volume work by E. T. MacDermot, M.A., published by the Great Western Railway Co., 1927.

Curiously enough Gooch had been in the employ of Stephenson's some little while before his appointment on the Great Western, and worked upon and signed the original drawings of the "North Star." This engine was not at first intended for the Great Western but for an American line of 6 ft. gauge, the New Orleans, which for financial reasons did not take delivery. The axles were therefore lengthened to suit Brunel's gauge, the driving-wheel diameter increased, and she then became the most famous of all the broad-gauge engines.

This locomotive it was which drew the first train upon the opening day. Its total weight was 21 tons. Driving wheels 7 ft. diameter and cylinders 16 in. diameter by 16 in. stroke. The total heating surface was 711·2 sq. ft., nearly double that of the "Patentee" of four years previously.

From this point onwards until 1879 our story of locomotive development concerns, with only one or two exceptions, the work of Daniel Gooch, since he led the way with engines of outstanding size, power and speed, all of course for the broad gauge.

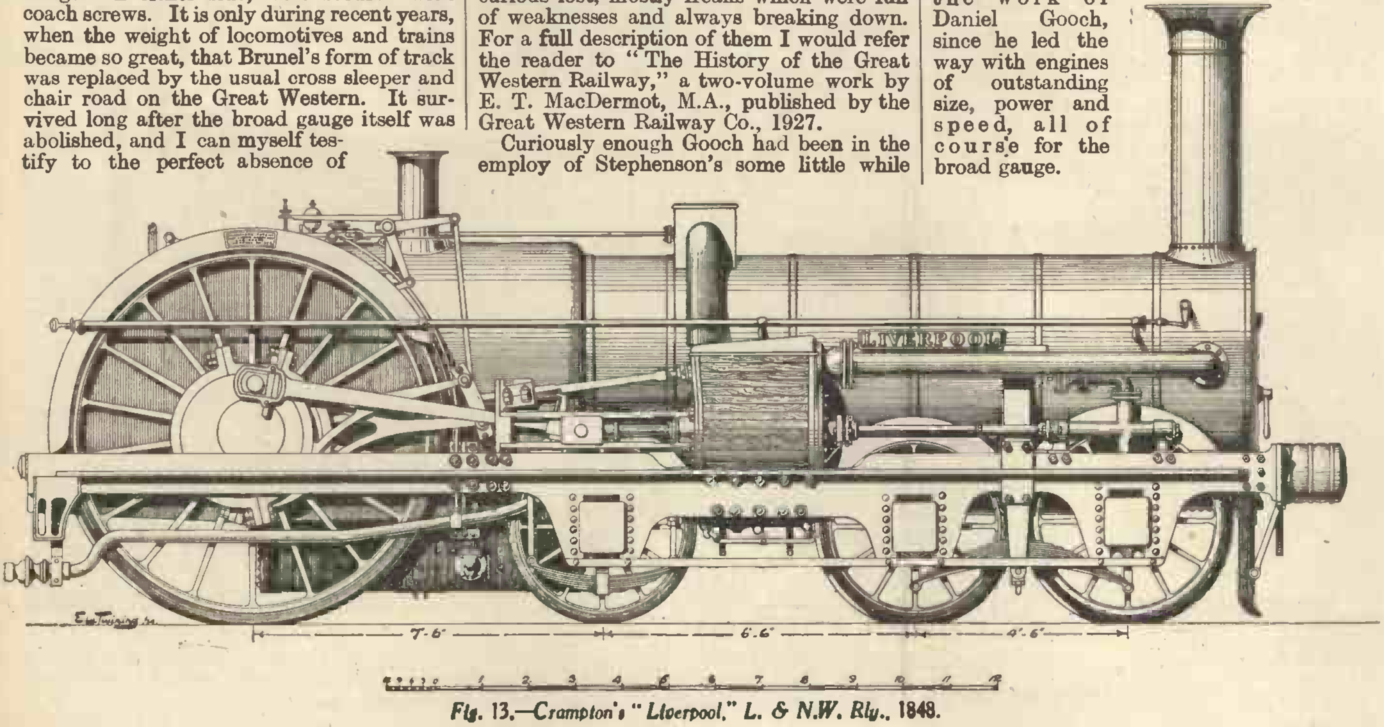


Fig. 13.—Crampton's "Liverpool," L. & N.W. Rly., 1848.

The Locomotive Great Western

Shortly after the opening of the railway the works at Swindon were built, and there, in 1846, during what is known as the "Battle of the Gauges," Daniel Gooch designed and constructed, in the short time of thirteen weeks, an express engine far surpassing in size and power anything which had ever before been put on rails. As will be seen from Fig. 11, it ran upon six wheels, the drivers being 8 ft. in diameter. The cylinders were of the unprecedented large size of 18 in. diameter by 24 in. stroke, and to supply these with steam the large boiler had a total heating surface of no less than 1733·2 sq. ft. The grate area was 22·64 sq. ft., and the working pressure 100 lb. per square inch. The outer firebox was domed, as shown, and sheathed in polished brass, the splashers being also of bright brass.

Some months after being put into service, during which she reached the hitherto unapproached speed of 60 miles an hour, the leading axle broke through faulty swaging at too low a temperature, and Gooch decided to replace the single pair of leading wheels with two pairs arranged in a group, so distributing the excessive weight in front of the drivers. Thus was inaugurated the class of locomotive which became the most famous in all the world.

The Lord of the Isles Class

From 1846 onwards Gooch continued to build his 8-ft. singles: the next after the "Great Western" was an engine named the "Iron Duke" of 1847, being an improvement upon the first, whilst by the time the third, the "Lightning," was turned out, also in 1847, finality in design was arrived at, and the type, of which a total of thirty were built, remained standard until the abolition of the broad gauge in 1892. Exactly similar to the "Lightning," except for a further increase to 1919·47 sq. ft. of heating surface, was the famous engine, the "Lord of the Isles." Built in 1851, it was exhibited at the Great Exhibition of the same year, and, after withdrawal from service, in 1881 was again shown at Chicago, at Cardiff, at Edinburgh and at Earl's Court, London. It is illustrated in Fig. 12.

Both the "Lord of the Isles" and the "North Star" were preserved at Swindon until 1906 and then, more is the pity, they were both scrapped on the grounds that they occupied valuable space. What would many of us now give to be able to see them amongst other veterans at South Kensington or in the Railway Museum at York.

The Liverpool

The narrow gauge advocates in the north could not ignore the challenge thrown down by the "Great Western." They believed, even at that time, that whatever could be done on the broad gauge could be done equally well on the standard 4 ft. 8½ in., so Mr. T. R. Crampton, who had patented a wheel arrangement in which the driving axle was behind the firebox, designed, and Messrs. Bury, Curtis and Kennedy, of Liverpool, built—in 1848—the exceptionally large machine shown in Fig. 13, having 8 ft. driving wheels, 18 in. by 24 in. cylinders, and 2,290 sq. ft. of heating surface. The grate area was, however, only 21½ sq. ft.

This engine, which ran intermittently on the northern section of the London and North Western Railway, was only a qualified success. For one thing it was too heavy for the permanent way—its weight was 35 tons—and so was scrapped in 1858 after a not very active life of ten years. Like the "Lord of the Isles," it was shown at the Exhibition of 1851.

It will be seen that the "Liverpool" was fitted with Stephenson-link motion, invented in 1842 by Williams, a draughtsman, and Howe, a pattern maker, both in Stephenson's employ. In all engines built for the broad gauge at Swindon Gooch introduced a new form of link gear invented by himself. In this the slotted expansion link was suspended from a fixed point, and did not rise and fall as did the link in the earlier gear. Reversing and notching up for expansive working was accomplished by moving a radius link, between the slotted link and the valve spindle, up and down in the slot, as the case required. The curvature of the expansion link was therefore arranged the opposite way to that of the Stephenson link. The beneficial results accruing from this arrangement were several. Two advantages were that there was less weight to be lifted by the reversing lever and the lead of the valve was constant for all points of cut-off, just as it is in the now popular Walschaerts' gear. Strangely enough the Gooch gear was never fully taken up in this country in spite of the perfect steam distribution which it gave, though on the Continent it was very popular. Even on the Great Western standard gauge engines, after 1879, were fitted with Stephenson gear, whilst the broad gauge locomotives retained the radial gear of Gooch right up to the end.

(*To be continued.*)

MECHANICS OF SIDE SHOW GAMES

(*Continued from page* 502.)

in the hands of an expert, stop the wheel or indicator just where the operator chooses, yet so unobtrusively as to be imperceptible to the players. Naturally the form of control varies with the type of game, but all are based on the artificial braking of the wheel's impetus.

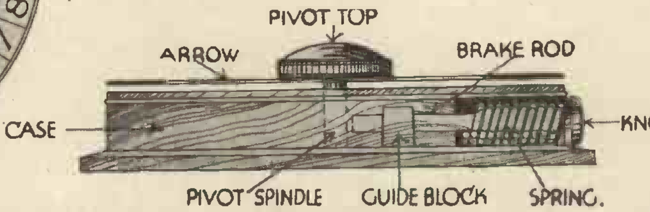
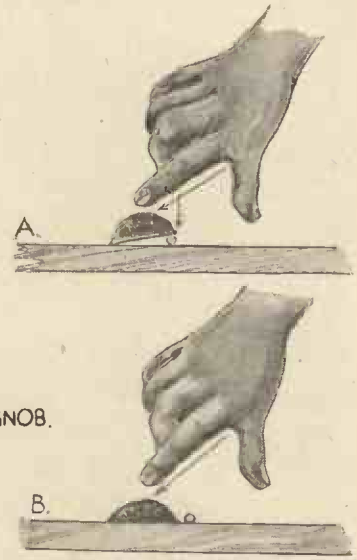


Fig. 11.—A side and plan view of one of the many forms of spinner. The "gaff" is shown by dotted lines.



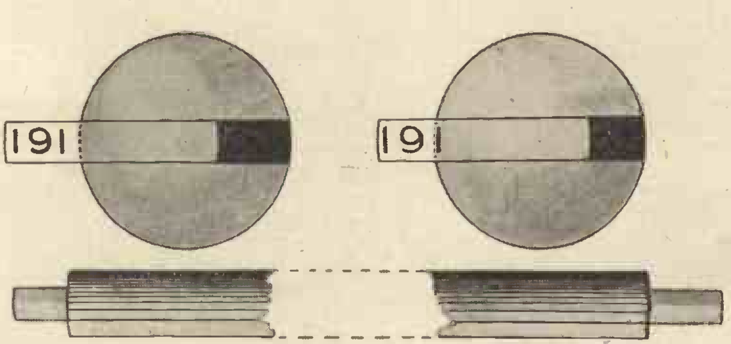


Fig. 9.—The non-stop bowling alley.

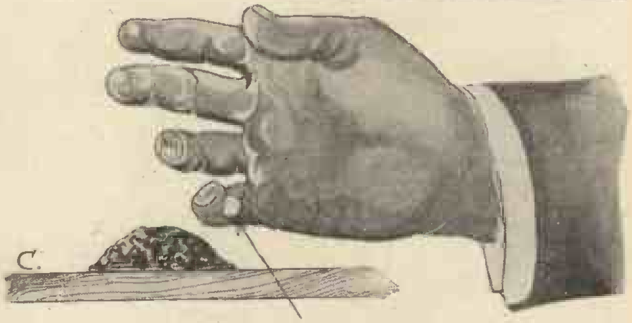


Fig. 10.—The shell game. A. The shell cage pressed down on a soft rubber pea. B. The shell slid forward clear of pea. C. The pea picked up by the crook of the little finger joint.

MECHANICS 2000 YEARS AGO

By V. E. JOHNSON, M.A.

Interesting and practical data on ingenious machines that were in use many years ago.

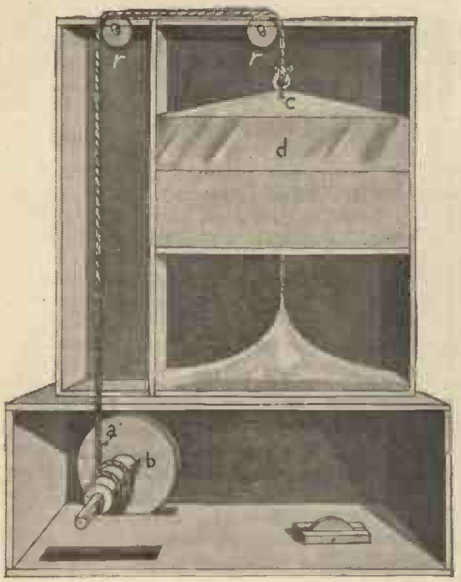


Fig. 1.—The first self-propelled vehicle.

IT is certainly generally believed that the motor car, or indeed any vehicle which contains, within itself means of its own propulsion, and that the fact of the adhesion of their wheel rims to the earth or a supporting rail in order that adequate power may be applied to the wheels, was a discovery of not earlier than the middle of the last century. Such a belief is wrong. Writers on locomotive machines have not delved far enough or stayed down long enough among the records of antiquity to discover the ultimate source.

The First Car or Self-propelled Vehicle

The first car or self-moving vehicle of which we have any account was the invention of the famous Heron of Alexandria, who lived about 100 B.C. Fig. 1 illustrates how this self-moving machine, mounted upon three wheels and containing the shrine of Bacchus, was moved. Within the base are seen two wheels, one supporting, one driving, the driving wheel nearest the front having been removed. On the axle of the driving wheels was a drum, *b*, about which was wound a rope, *a*, which passed through a space on one side of the shrine and over the pulleys, *r*, *r*, and was then fastened to the ring, *c*, of the heavy weight, *d*, which rested upon a quantity of very dry sand. The escape of this sand through a hole in the middle of this upper compartment containing the heavy weight allowed *d* to gradually descend, and by pulling the cord *a* caused the shrine to move forward in this case in a straight line. But Heron also describes the method by which it can be caused to move in a circular path.

The Steam Turbine

This, in its present form, is a very modern invention, but Fig. 2 shows us the first steam turbine, also invented by this same Heron—and for over 2,000 years no further progress was made. The illustration also shows a ball suspended on a column of steam, just as modern showmen suspend them on a column of escaping compressed air.

The Penny in the Slot Machine

Fig. 3 is an illustration of a lustral vessel described by Heron. Compare its mechanism with a modern perfumery automatic machine; you will find that they are almost identical. In the illustration is seen a lever, O, fulcrumed into a standard, N, connected with the valve in a reservoir, H. This lever has a pan, R, for receiving the coins dropped through the slot, A, at the top. An enlarged view of the valve is shown on the left. The priest of ancient Egypt who distributed holy water by this means made quite a good thing out of it; for no coins no purifying water.

It is a curious fact that this ancient invention escaped the notice of the Patent Office until long after patents were granted for the earlier modern automatic vending machines.

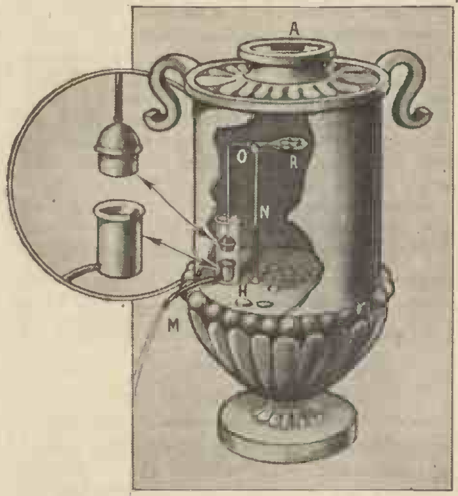


Fig. 3.—Details of the first coin in the slot machine.

Fig. 4 is an illustration of Heron's odometer, or, as we should term it, speedometer, for measuring the speed of vehicles.

Sanitary Plumbing

Modern—humph! Well, I suppose so, more or less; in the accepted sense, probably yes. But there is a certain recent application to sanitary plumbing, namely, *the intermittent siphon*, which is more than 2,000 years old, and is the main principle in the Ancient Automaton illustrated in Fig. 5. The illustration shows an airtight box divided into four compartments. O is a basin on top for receiving the water from the device shown above. Four birds are seen perched on branches, which are hollow and communicated with one of the compartments by pipes shown by dotted lines. In the hollow body of each bird were two musical reeds. One responded when air flowed outward through the beak, the other when it flowed inward. The water from O entered compartment 1 near the bottom, compressing the air in this compartment as it rose and forcing air through one of the reeds in the bird's beak (note 1); but when the water reached the top of the bend of siphon 5, the siphon at once began to discharge it into compartment 2, but this siphon was so proportioned that, level of the water in compartment 1 fell much faster than it was supplied, the air was sucked in and note 2 sounded. Similarly, compartment 2 now begins to act on bird B and so on. The second note of the bird D is obviously sounded by the escape of the water by means of siphon 8. By properly proportioning the discharging capacity of the siphons, etc., it is possible to ensure the repetition and admixture of the notes in a bird-like manner

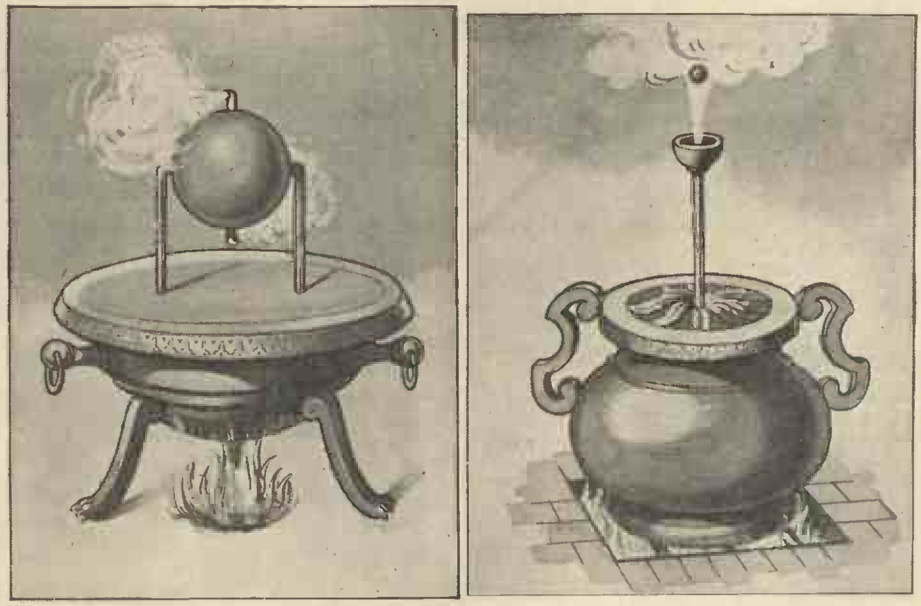


Fig. 2.—A steam turbine invented 2,000 years ago by Heron of Alexandria, and (right) a ball suspended in a column of steam.

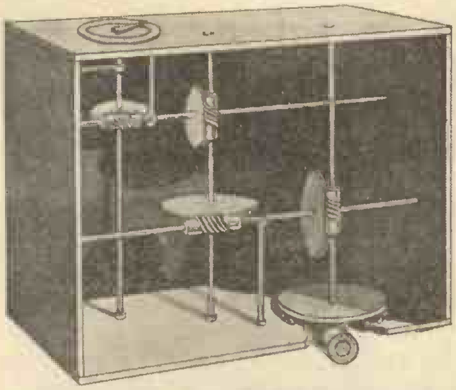


Fig. 4.—Heron's odometer for measuring the speed of vehicles.

For simple ingenuity can any modern device beat it ?

Ancient Mechanical Magic

Figs. 6 and 7 are two illustrations of a device described at the end of Heron's *Pneumatics* under the heading : "To cut an animal in two and make him drink."

Imagine the pedestal in Fig. 6 divided by EF. The horse is traversed by the tube MN, which terminates on one hand in the horse's mouth and the other in the upper compartment of the pedestal and travelling down one leg. Assume this compartment filled with water by means of the opening T, afterwards closed, then a tap is turned, opening a communication between the upper and lower compartment, itself fitted with an open air hole ; the water will flow and in so doing cause a partial vacuum in the tube traversing the horse, so that if a vessel, full of water, be brought to the horse's mouth water will be sucked up. This tap was so arranged that it connected with the man statuette in such a way that the horse drank when the man's back was turned and ceased drinking when the man threatened him with the club. Fig. 7 shows quite clearly the manner in which a knife or thin-bladed sword could be passed clean through the animal's neck without causing the head to fall or interrupting communication between the head and pedestal.

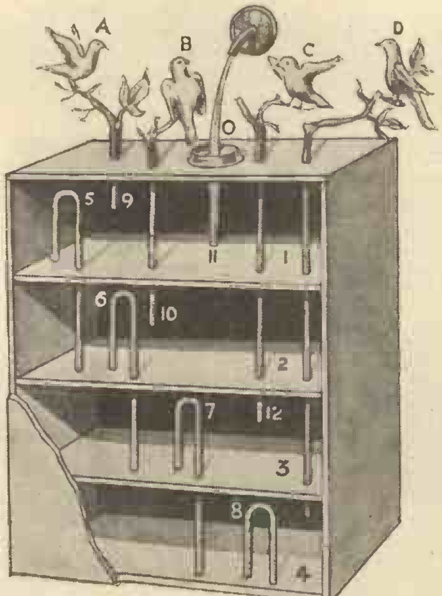


Fig. 5.—A most ingenious ancient automaton.

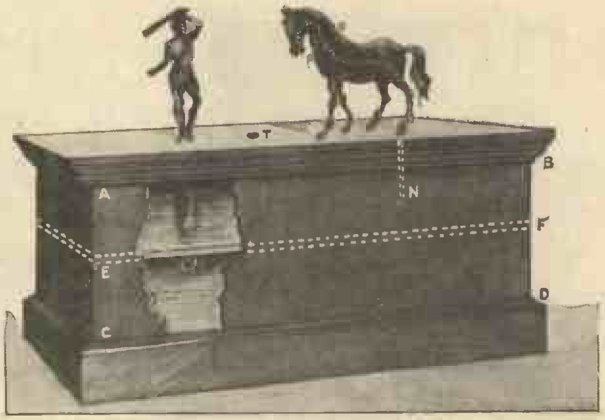


Fig. 6.—Heron's decapitated horse.

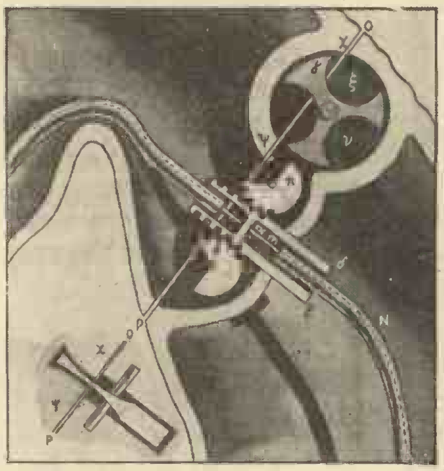


Fig. 7.—The mechanism of the horse shown in Fig. 6.

I think the reader should have no difficulty in following what happens without any further explanation.

Heron's Vessels.

Fig. 8 represents one of Heron's miraculous vessels which always remained full no matter how much water (in reason) was drawn from it. A is a vessel containing a very large quantity of water. At its base are tubes (designated by Greek letters) which puts it into communication with a smaller reservoir lower down. Near this tube there is fitted a lever, fitted at one extremity with a cork float, K, and to whose other extremity, Z, there is hooked a chain carrying a weight. The whole must be so arranged that the cork, K, which floats on the water, will close the tube's orifice, but when the water flows out from the smaller reservoir the cork, in falling, will leave such aperture open, and, finally, when a new supply from the larger and higher reservoir, A, enters the cork shall rise with and close the orifice afresh. To bring this about the cork must be heavier than the weight suspended at the other end of the lever. The top of the smaller reservoir and the miraculous vessel should obviously be at the same level.

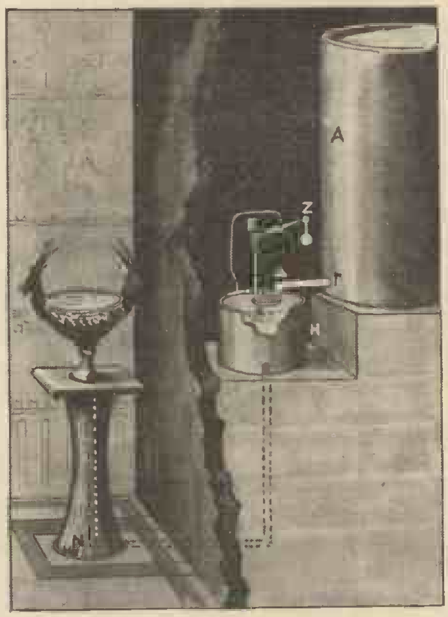


Fig. 8.—Heron's miraculous vessel.

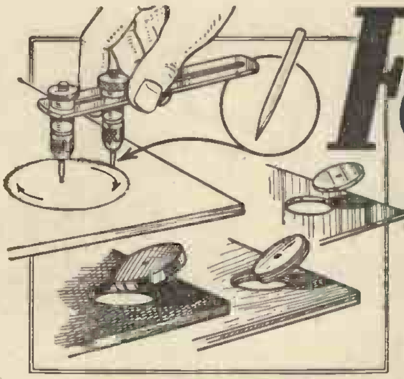
THE FIRST TRIP OF ITS KIND

THE first air-liner cruise of the principal cities of Europe, in which a party of twenty-four holidaymakers were accompanied by uniformed couriers and interpreters in exactly the same way as with surface travel cruises, left a London air port on July 21st.

The air liner which has been chartered for this unique pleasure voyage by the Polytechnic Touring Association is one of the big four-engined Heracles type of Imperial Airways. During its fortnight's air cruise of Europe it will fly a total distance of approximately 3,000 miles, visiting Amsterdam, Berlin, Vienna, Budapest, Venice, Rome and Marseilles, and returning to London by way of Paris. In addition to the wonderful panorama of Europe which the passengers will see while aloft, ample time will be available for motor-car tours and similar excursions, while the tourists are at their various halting-points. And the total cost of this fourteen-days' Polytechnic air tour, which, in addition to all the flying, includes thirteen nights' accommodation at first-class hotels, is only 75 guineas.

The chartering of air-liners for holiday cruises, just as ocean liners are chartered for a similar purpose, is a feature of modern pleasure travel which is growing steadily in public favour. But whereas the ocean liner is restricted to its one medium, the sea, and can only call at sea ports, the air liner not only passes above stretches of water, or along picturesque sea-coasts, but also penetrates far inland, visiting famous cities and beauty-spots everywhere.

Not only are big luxury aircraft now being chartered for air trips over Europe, but cruises by flying-boat can now be enjoyed amid the coastal and island beauties of the Mediterranean ; while another aspect of holiday travel takes the form of combined cruises by air liner and ocean liner, in which it is possible to start from New York, cross the Atlantic by steamer, and then continue by flying liner across the great African airway to Cape Town, or eastward to Karachi, Calcutta and Singapore, the return trip being made by a similar combination of air and sea travel.



For a LIMITED

Special Offer of Kit of Tools the WIRELESS CONSTRUCTOR

BY arrangement with our companion paper, "Practical Wireless," we are enabled to make this very Special Offer to readers of "Practical Mechanics." Naturally, the great majority of you are keenly interested in Wireless and we anticipate that this offer will meet with a ready and widespread response.

These Kits cannot be bought in the shops. They were designed by Mr. F. J. Camm, editor of "Practical Wireless," and expressly manufactured for the purpose of being supplied on special terms to readers of that paper, who were quick to appreciate their worth. The privilege accorded them we now extend to our readers, and we trust and believe the response will be equally satisfactory.

READ THESE SIMPLE CONDITIONS

All you have to do to obtain your Pocket Tool Kit is:—

(*a*) Complete the Acceptance Form and Address Label on right in ink and paste or gum Tool Kit Gift Token cut from the bottom left-hand corner of the inside back cover in the space provided on Acceptance Form.

(*b*) Post both, together with postal order for 3/6, to include registration, postage, packing, insurance, etc., to PRACTICAL MECHANICS, Presentation Department, 22 Tavistock Street, Covent Garden, London, W.C.2.

Applications will be dealt with in rotation, and your Pocket Tool Kit will be despatched to you in the course of a post or two.

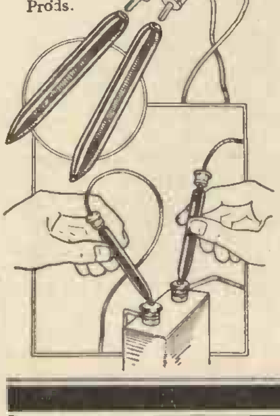
No reader may qualify for more than one Pocket Tool Kit.

This offer applies to persons residing in Great Britain and Northern Ireland. Readers in the Irish Free State must pay any duty imposed.

● The Case, which is made of stout stamped metal, measures 6¼ × 4 in. Recesses are provided for all tools, and when loaded the Kit slips easily into the pocket.

a 12/6 POCKET KIT at the PRIVILEGED PRICE of 3/6

The Test Prods.



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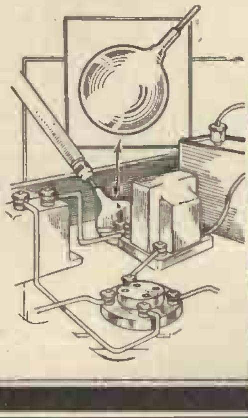

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EVERY detail of this handy and highly efficient Pocket Kit for the Wireless Constructor has been designed for the purpose by an Expert. It comprises in handy pocket form a complete battery of tools, all sound engineering jobs. As will be seen, they fit snugly into the limits of their 6¼ × 4-in. Pocket Case, which is of stamped metal.

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Please read the simple conditions on the opposite page, then complete and post the forms below. Immediately on receipt of your Acceptance Form with Tool Kit Gift Token and remittance and Addressed Label, a Pocket Kit will be despatched to you.

● **NOTE.—Delay is dangerous. Our stocks, though ample to meet the estimated demand, are not inexhaustible. Prompt application is therefore advised. *Why not write to-day and make sure of your Kit?***

TO ALL WHO ARE INTERESTED IN WIRELESS CONSTRUCTION THIS POCKET KIT OF TOOLS WILL PROVE OF LASTING SERVICE

LIST OF TOOLS IN THE "PRACTICAL MECHANICS" KIT

1. One 4-in. Spring Steel Chesterman Rule No. 300D-2.

2. One Special Steel Scriber with adjustable Chuck for scribing point renewal.

3. One pair of special Ebonite Test Prods with Wander Plug Socket Ends and Brass Test Points.

4. One special 4-in. Trammel with one Fixed and one Sliding Head, enabling circles to be scribed from 0 up to 3⅝ in. in radius. This tool may also be used for cutting holes in ebonite and baseboards too large to be drilled in the ordinary way.

5. One 60-degree 16-gauge Steel Set Square with finger Fret, for easy use.

6. One Special Viewing Mirror for inspecting obscure parts of the set. This Viewing Mirror fits into the Scriber Chuck.

7. One Steel Screwdriver with Brass Ferruled Handle, extremely useful for locking screws, securing components to baseboard, etc.

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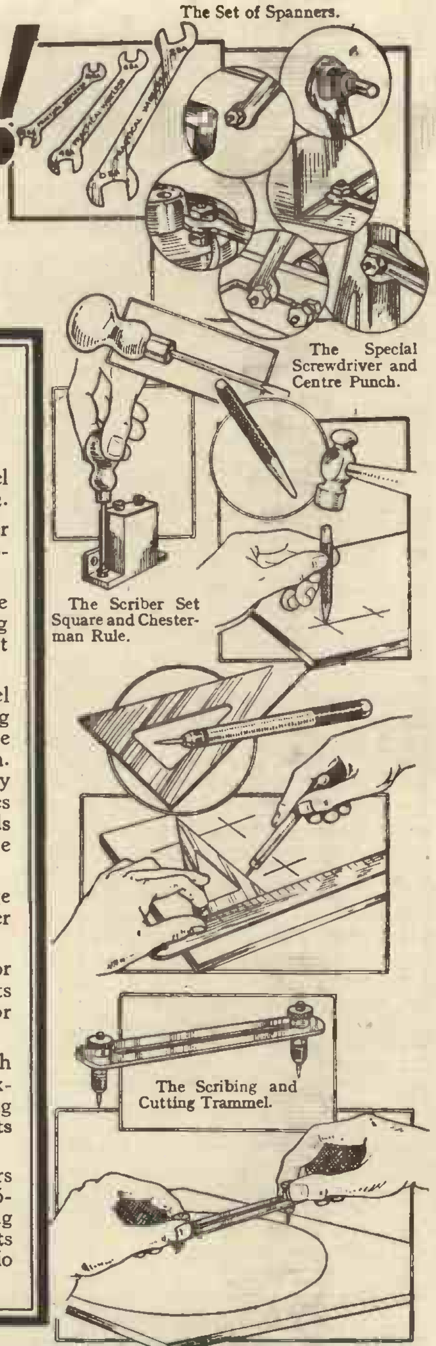

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In accordance with your special offer, please send me, post-paid, a Pocket Kit of Tools for the Wireless Constructor. I have affixed the Tool Kit Gift Token to this Form and enclose postal order, made payable to George Newnes Ltd., value 3/6, in compliance with the Conditions.

Name ....

Address ....

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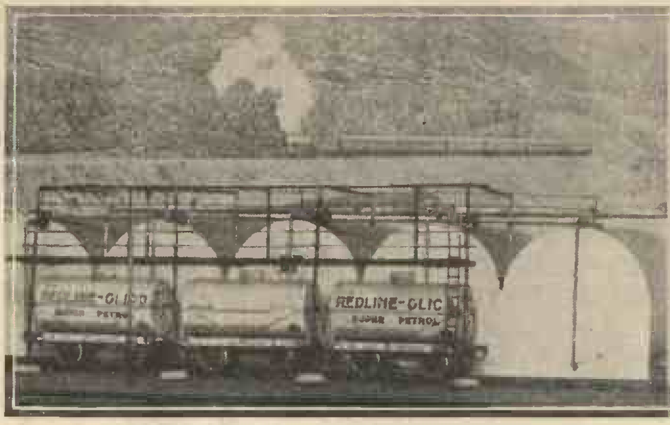
Postal Order No..............................

MODELLING PETROL WAGONS

The realistic model wagons shown in the photographs below are made from the simplest of materials, and can be constructed in a few hours.

By "THE PADRE"



Petrol wagons designed for a 00 gauge railway.

An effective tank wagon in 0 gauge

TANK wagons of all kinds are very characteristic and picturesque models, and may now, as the accompanying photos show, be built on very realistic lines. It may be well to preface a few remarks as to the procedure with regard to oil traffic on real railways. The mineral is, of course, brought to Britain in tank vessels from oil-producing countries like Russia, America, Venezuela and certain European States. On arrival at port, the tankers are relieved of their liquid cargo through pipes at the docks, the commodity being stored in stationary tanks to await redistribution by wagons to refineries or subordinate storage centres. Tank wagons engaged in this traffic are specially set apart for the conveyance of petroleum, crude oil, petrol, lubricants, creosote, tar oil and tar. Coal oil is a by-product of coal mining in Britain, and is used as a foundation for lamp oil, creosote, fuel oil and motor spirit. A medium-sized storage tank is thus part of the equipment of any considerable coal mine. It remains for the model railway enthusiast to instal on his layout a large oil depôt and several smaller tanks at way stations.

Petrol Tank Covers

Several of the better-known companies have most generously co-operated in the production of petrol tank covers in lithographed paper. The papers, which represent in each case the very latest practice in colouring and lettering of these vehicles, are the result of some months of experiment and investigation. A very novel manner of supplying them has been devised; they are sent out in a correctly-sized postal tube which cuts up into four tanks on which to fix the papers. The tube is exactly to scale for the purpose, and may be cut with a sharp tenon saw in a mitre box. The papers include tank side cover, solebars, two ends and the pieces to form the manhole projection on the tank top.

In Fig. 1 are given the details for the building up of the metal underframe or chassis, which has been kept as simple as possible in conjunction with scale appearance. The parts are a standard product and cost about 2*s*. for each wagon, exclusive of the papers, which are a few coppers more. The metal sides are soldered to two pieces of $\frac{1}{8}$-in. square brass strip, ready drilled with holes for the buffers. The soldering should be done on a perfectly flat piece of smooth board, the frames upside down, and the wheels on their axles in the correct position. It is well to leave, if possible, a little side play for the wheels when soldering the frame together. The tank may then be proceeded with, and the two metal retaining beams for the wagon ends. These may be made from radio busbar, which is square. They should be given a slight rake outwards, as indicated.

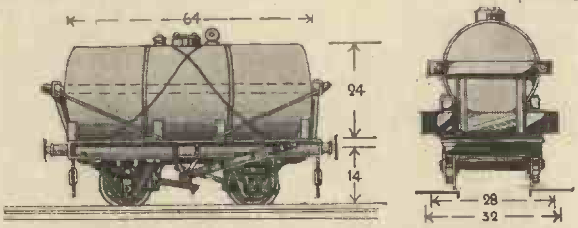


Fig. 1.—Details for building up the metal underframes of the wagon.

Fitting the Tanks into Place

The method of fitting the tanks into place is simple. But first see that the papers are carefully stuck on, and that the two ends correspond exactly with the red line on the sides. As these tanks are a good, robust size, it is suggested that all under supports be dispensed with. Let the tank simply rest between the chassis solebars and between the end retaining beams, and then fix in place with brown thread. The thread should first be tied to the side of one of the axle guards, then carried up and over the projecting end of the nearest retaining beam. It should then be carried across the beam, underneath, and out of sight, lapped over the end again and carried to the axle-guard corresponding on the opposite side of the wagon. Then repeat the process at the other end of the vehicle. A pair of additional trusses may be formed of the same thread directly over the ends of the tank as in sketch. The underframe of the wagons should be painted to match the tanks, and the solebar covers, with correct scale lettering, should then be stuck on the face of the solebars.

Fig. 2 is a sketch of a typical country oil storage depôt; in the case from which the drawing was taken the tank was used for crude oil to be supplied to small motor fishing craft. It does not therefore follow that every country oil storage is used for petrol. The substructure of the depôt, which forms a pump-room and store, is built of brick, and may be finished in the correct scale paper. Roof is of corrugated iron—cardboard lined out and painted aluminium. The tank, an empty carton studded with small sprigs, is painted dark grey or aluminium.

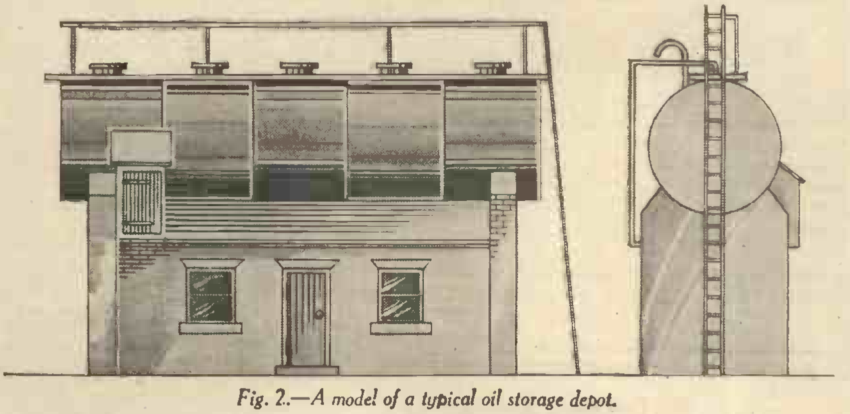


Fig. 2.—A model of a typical oil storage depot.

HINTS ON MECHANICAL DRAWING

By DRAUGHTSMAN

The several little points which are discussed here are concerned chiefly with inking in and with tracing in ink, their aim and object being to help the mechanical draughtsman, and especially the beginner, to do neater work and to overcome some of the little difficulties which crop up.

THE ability to produce a good drawing depends largely upon the condition of the drawing instruments and the observance of very definite rules regarding their treatment and usage.

All mathematical or drawing instruments worthy of the name are fitted with needle points. These points are made from ordinary sewing needles of such a diameter as will fill exactly the holes provided to receive them. If the case of instruments includes a pricker the needle intended for a compass should be placed in the pricker with a good length projecting, the pointed end laid at a very fine angle on an oil-stone and rubbed lightly backwards and forwards, at the same time revolving it. Fig. 1 shows the comparative forms of the needle point before and after this treatment. All the needles in the compasses and spring bows should be given a very fine point. Dividers do not matter so much, although it is an advantage to have them also fairly sharp.

The next matter is that of the relative lengths of the needle and pen and pencil points. This is shown in Fig. 2. To adjust the lengths, the pencil or the pen nib should be brought close to the needle by closing the compass, and the needle be allowed to project beyond the pencil or pen, an amount just sufficient to enable it to enter the paper. Usually $\frac{1}{32}$ in. or at the most $\frac{3}{64}$ in. is enough. With most good instruments the end of the electrum in which the needle fits provides a stop to prevent the needle entering too deeply.

Pencil and Pen Points

Many draughtsmen, for straight drawing, use a pencil sharpened to a chisel edge,

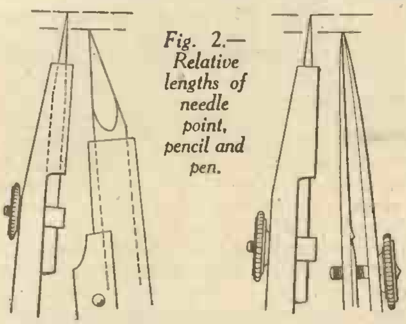


Fig. 2.—Relative lengths of needle point, pencil and pen.

and whether the reader uses such chisel edge or not on his ordinary pencils, he should certainly do so in his compasses. It will be found that the best grade for general work is 1H. Fig. 3 illustrates the shape to be given to the pencil, which shape is best obtained by using a small dead-smooth file. It is far quicker and more reliable than using a penknife. It seems a remarkable thing that the pen-points of most instruments, even of the best English make, have, when they are purchased, the two nibs much too curved, or if not both of them, the outermost next to the milled knob, as at A in Fig. 4. For rough work or heavy drawing this does not matter so much, but it is impossible to draw very fine lines with such a pen, when it is fully charged with ink. This criticism concerns not only the compasses but the ruling pens. If one charges such a pen with ink and commences to draw, the lines will become gradually thinner as the ink flows out, and, if care is not taken and too much ink is placed in the nibs, when the pen or compass is tilted vertically over the paper the whole lot will drop out with, of course, disastrous results. Another effect from over-charging with ink is that at the ends of the lines, both commencement and finish, there will certainly be a thickening up and probably a blob as at A, Fig. 5. In all cases where thick lines are required it is better to draw two lines and let them run one into the other as at B.

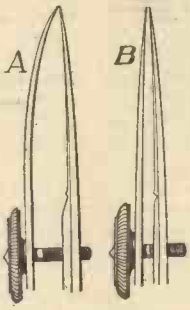


Fig. 4.—Pen points.

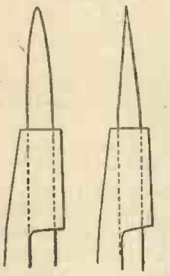


Fig. 1.—Needle points.

A Simple Remedy

The remedy is to open the nibs and straighten them to a considerable extent. This must be done very carefully, for if the steel is highly tempered it may be fractured in the attempt to straighten it. The safest plan is to draw the temper first, then straighten until the two nibs are nearly parallel, as shown at B, Fig. 4, and then re-harden and set the two nibs together on an oilstone. To do this screw the nibs together and rub them down on the stone, on the outside surfaces only. Those who are not used to hardening and tempering should get the job done for them. In setting the nibs the grinding on the oilstone should be done in such a way that the sides and extreme point of both nibs have exactly the same thickness at their edges, and that thickness should be practically *nil*: that is to say, the nibs should very nearly have a cutting edge. It is only by thus setting them that the nibs can be expected to draw the finest of hair lines.

It may be worth while explaining that the reason why the bow-shaped nibs will not hold the ink is that the weight of the fluid tends to overcome capillary attraction, whereas in closed or parallel nibs capillary attraction is practically constant and the same, whether the pen be full of ink or nearly empty.

Fig. 5.—Drawing heavy lines.

Drawing Fine Lines

I have many times been asked by those who have been looking at my drawings how I manage to draw such fine lines without the ink clogging in the pen. Waterproof ink *is* inclined to clog, especially in hot or dry weather. The secret lies in setting the nibs so that they almost, but not quite, cut the paper. When drawing, press very lightly with the pen, and above all keep the pen clean. This matter of cleanliness is very important indeed: lack of it is the source of most people's troubles. Keep by you on the drawing-board a few square inches of linen and make a rule *each time* before re-filling the pen to wipe it out, if necessary dipping it in water before wiping. If you have occasion to stop drawing, even for a minute or two, wipe out the pen. It is almost fatal to let the ink become dry between the nibs.

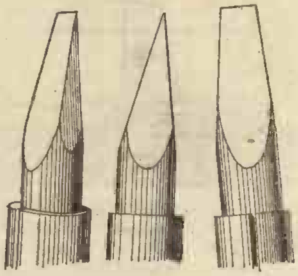


Fig. 3.—Pencil points.

Thick Lines and Thin

Quite a number of people admire drawings made with heavy, bold lines, but some of them forget that both heavy and fine lines have their particular uses. In a general way workshop drawings made to full size and fully dimensioned, especially

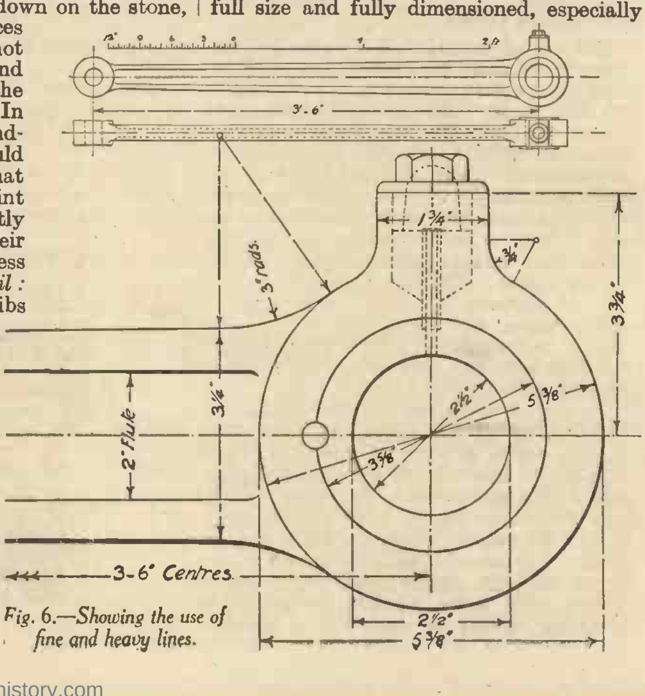


Fig. 6.—Showing the use of fine and heavy lines.

when they are to be blue printed, should be heavily drawn, but small scale drawings and general arrangements where many measurements have to be taken off with dividers and scale, should always be finely drawn, for it is obvious that accurate measurements between two lines cannot be taken when the lines themselves have a definite thickness. Fig. 6 illustrates this point. By means of the scale every measurement of the connecting rod shown can be taken off, whilst the big end, drawn below the complete rod, is big enough to fully dimension and therefore can be boldly inked in.

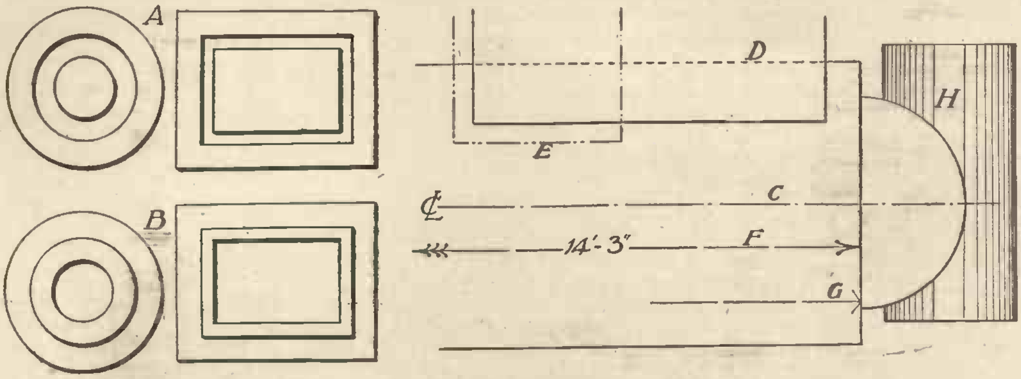


Fig. 7.—Back lining construction lines and shading.

Back Lining

With the introduction of what is known as "back lining" we begin to enter the field of drawing in relief. This matter of relief is seldom carried beyond the stage of the simple back line, but even this can be made very effective. I have devoted the left-hand side of Fig. 7 to illustrate this. At both A and B we have exactly the same lines drawn, three circles and three rectangles in each case symmetrically arranged one inside of the other, but they are differently back lined. Referring to the circles only for convenience, the two inner circles at A make it appear that the space between them is recessed, whilst at B the same two rings make the space appear to stand clear. This also applies to the rectangles, the recessing and relief being in the same order.

Construction Lines

In mechanical drawing certain lines have been adopted as standard for indicating definite meanings. The drawing of the object represented which is intended to be visible is, of course, shown in full and complete lines. Centre lines of symmetrical objects are drawn with one dot and one dash as at C, Fig. 7, and sometimes marked with a monogram CL. The outline of the portion of an object which passes behind another object is shown by short dots as D. If the object is in section and it is desired to show some portion of it which is removed by the sectioning, that portion is indicated as at E with a dash and two dots. Thus, suppose we were drawing a locomotive in section looking towards the right-hand side and we wished to indicate the position of, say, an injector which is on the left-hand side we should show it by this dash-and-two-dot line.

Dimension lines are shown as at F by a series of dashes with no dots. Dimension figures should be placed as nearly as may be convenient in the middle of the line and the lines should terminate with arrow heads. Some inexperienced draughtsmen make their arrow heads after the manner shown at G: this looks bad and indicates the novice. The shape shown at the right-hand end of the line F is much neater and occupies less room. Where a dimension extends to a point beyond the limits of the drawing it is usual to draw three arrow heads one behind the other in the manner shown.

The shading of round objects in ordinary mechanical drawing is added to Fig. 7 at H, approximately the same number of lines being drawn on each side of the centre, which lines become closer together as they reach the limits of the diameter.

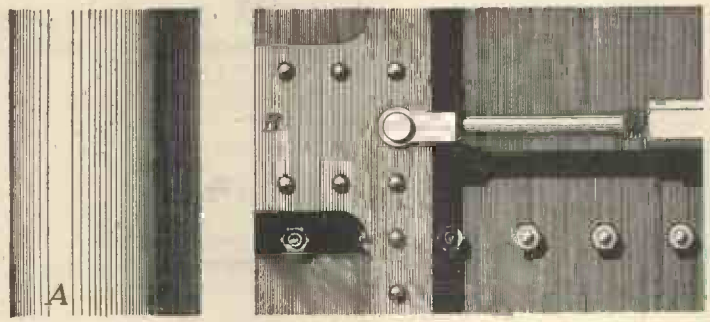


Fig. 8.—Shading and flat toning.

Greater Relief Effect

I now come to a class of drawing which goes rather beyond the limits of ordinary mechanical drawing; in fact, although the outline of the object may be of a mechanical nature, the result may be termed semi-pictorial. The process includes tone shading by hatching, the projection of definite shadows from the portion in relief and the representation of high lights, shadow and reflected lights on round objects. Fig. 8 illustrates at A the method of treating a cylindrical object. Here it will be seen how the treatment differs from H in Fig. 7. The high light, that is to say, the point where the light is striking the cylinder, is where I have placed the letter A, whilst on the opposite side of the cylinder the deepest shadow is reduced by some light being reflected upon it.

At B I have drawn an imaginary bit of steel plate structural work having rivets, the ends of bolts with nuts and a tie rod with a turnbuckle. The making of drawings of this class calls for not only a definite consideration of the angle at which the light is striking but the amount of projection of one part beyond another: thus the plate holding the rivets is standing out clear of the main plate by a distance considerably greater than the height of the hexagon nuts. This is evidenced by the length of the shadows cast respectively.

Some little practice is required in ruling the vertical hatching. It does not follow, by the way, that the hatching need be vertical. Horizontal lining is equally effective and frequently in combination with vertical, and cross hatching is permissible to give a greater depth of tone. The spacing should be perfectly accurate, and that is why I say that some little practice is required, for it will be obvious that the lines must all be quite uniform in thickness and spaced exactly the same distance apart. It is particularly in doing such work as this that fine setting of the pen and cleanliness in working is called for.

SCIENCE NOTES

A heating system has been invented by Mr. J. H. Taylor, a Huddersfield electrical engineer, who has harnessed the infra-red ray in a way which he claims will revolutionise the heating of buildings. Lengths of specially prepared cable run the width of the room above a false ceiling. When the current is switched on, the rays pass through the false ceiling and warm the air in the room below. The temperature can be regulated by means of thermostatic control.

A remarkable aeroplane, the Crouch-Bolas "Dragonfly," fitted with two Menasco engines, has recently made its first test flight. It is designed to possess the landing qualities of an Autogiro, while retaining the performance and handling characteristics of a conventional aeroplane.

A new gas, known as "Cyclopropane," has just been introduced for use as an anæsthetic. It is claimed to produce an anæsthesia as deep as that produced by ether, and the induction and return to consciousness are as quick as in the case of nitrous oxide.

U.S. Train's 112 Miles an Hour

WHAT is probably the fastest and longest non-stop run in railway history was recently accomplished by the Burlington Railway's streamlined train, the "Zephyr," when it made the journey from Denver to Chicago, 1,015 miles in thirteen hours five minutes. The average speed during the run was just over 77 miles per hour, and over some sections of the track reached 112½ miles per hour. The train is driven by Diesel engines, which run on crude oil costing only twopence a gallon, and about 500 gallons were consumed. The total fuel bill for the trip was therefore not more than £4 5s.

DIESEL OIL ENGINES

By S. J. GARRATT

The history of the internal combustion engine has been one of continuous improvement ever since the introduction of the first gas engine about the middle of last century, the highest development being reached in the modern Diesel oil engine.

This impressive-looking saloon was built experimentally to test out the possibilities of the Diesel engine for high-speed purposes. Driven by Captain G. E. T. Eyston, it achieved a speed of over 100 m.p.h. on Brooklands.

THE first gas engine, the "Lenoir," put upon the market in 1860, did not compress its combustible charge, which was ignited at atmospheric pressure. The engine was in consequence very extravagant in fuel consumption. It was soon realised, however, that the thermodynamic efficiency—and consequently the fuel consumption—could be improved by compressing the charge before ignition, thus enabling higher initial pressure to be obtained on the working stroke, together with a greater ratio of expansion. The introduction of the now common four-stroke cycle solved many problems, including that of compression, for compression could be carried to any desired extent by suitably proportioning the clearance volume at the end of the stroke.

Brake thermal efficiencies of the order of 25 per cent. then became an accomplished fact. This means that 25 per cent. of the energy contained in the fuel is converted into useful work. At first sight this may appear very low, but it was really about the best obtainable until the advent of the Diesel engine which can give overall efficiencies up to 35 per cent., the highest figure yet obtained from any kind of heat engine.

There are several reasons why one cannot hope to convert anything like the whole of the energy of the fuel into mechanical work. One of them is that it is impracticable to expand the working charge sufficiently with the result that about 40 per cent. is lost as heat in the exhaust gases. The other chief item is loss of heat to the cylinder walls, etc., which accounts, roughly speaking, for another 30 per cent. of the fuel energy. We cannot by any conceivable means prevent heat being absorbed by the metal forming the cylinder, cylinder head and piston, so there appears to be no alternative but to accept this second source of loss as unavoidable.

The loss of heat in the exhaust can, however, be curtailed to a useful degree by increasing the difference between the initial and final temperatures of the power stroke. An increase in the compression ratio produces higher initial temperatures, and at the same time provides a higher expansion ratio, since the expansion and compression ratios are of course the same. The curve shown in Fig. 1 indicates the theoretical maximum efficiency for different compression ratios, but as this curve makes no allowance for losses, the efficiency figures are not attainable in practice.

Doubling the Compression Ratio

It will be seen from Fig. 1 that by doubling the compression ratio from 6/1 to 12/1 the theoretical maximum efficiency is increased from 51 per cent. to 62 per cent., which corresponds to an increase of nearly 24 per cent. in the power obtainable from equal quantities of fuel. There is, however, a definite limit to the compression ratio in a petrol engine owing to the danger of pre-ignition, which may occur owing to the rise of temperature when the charge is compressed.

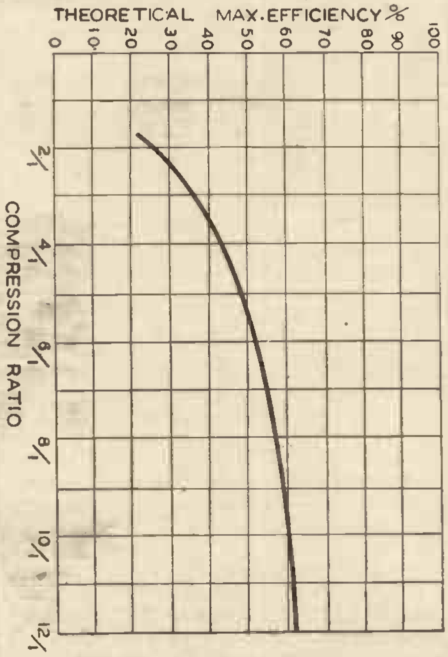


Fig. 1.—Showing how the efficiency depends upon compression ratio.

In the case of the Diesel engine, however, this limitation of compression ratio does not apply, for air only is compressed and the fuel added when compression is complete. The Diesel engine can therefore use a very much higher compression ratio, and it actually does so with a corresponding increase in thermal efficiency.

The Diesel engine, in common with the usual form of petrol engine, has one or more cylinders, together with the necessary piston, connecting rod crankshaft and flywheel. The valve arrangement is not quite the same for, in addition to the inlet and exhaust valves, there is a fuel injection valve and an air starting valve, all four valves being arranged in the cylinder head so that the combustion chamber may be kept as compact as possible. All valves are operated by an overhead camshaft and rockers, but there is an arrangement for throwing the starting valve out of operation as soon as the engine is running, for as its name implies it is only used for starting up, during which operation the engine is turned by the pressure of air stored in a special container.

The Sequence of Strokes

This is the same as for any ordinary four-stroke engine :—

(1) Suction stroke (outward).
(2) Compression stroke (inward).
(3) Firing stroke (outward).
(4) Exhaust stroke (inward).

On the first stroke the cylinder sucks in a charge of air only; the inlet valve then closes and the air is compressed to a much greater extent than in a petrol engine. The compression pressure on a Diesel engine is generally about 500 lb. per square inch, and at this pressure the temperature rises to over 1,000° F. A piece of metal at this temperature would be white hot, so it will be readily perceived that when oil is injected into this heated charge of air in the form of a fine spray it ignites immediately.

At the moment of maximum compression the oil is sprayed into the cylinder through the fuel injection valve and the burning charge (it does not actually explode) forces out the piston and provides the power stroke. Near the end of the stroke the exhaust valve opens and on the exhaust stroke the piston pushes out the exhaust gases in the usual manner.

No Carburetter required

It will be seen from the above that no carburetter is required and further, the ignition being automatic, such things as magnetos, sparking plugs, batteries, coils, distributors, contact breakers, etc., are all dispensed with. The only auxiliaries required are a fuel pump for delivering the correct quantity of fuel to the injection valve and an air pump for providing high pressure air for spraying the oil into the cylinder. Another air pump is also needed to pump up the supply of compressed air for starting purposes, but this does not run continually; it is put out of operation as soon as the storage reservoir is replenished.

Although the sequence of operations is similar to a petrol engine, there is a difference in the manner in which combustion takes place inside the cylinder which is illustrated by the indicator diagrams shown in Fig. 2.

In the petrol engine when the charge is ignited there is a sudden rise of pressure from B to C (Fig. 2). Ignition is usually timed to occur slightly before the end of the stroke so that maximum pressure is reached at the same instant that the piston reaches the end of its stroke.

In the case of the Diesel engine the compression pressure becomes the maximum pressure, and there is no sudden increase, because the fuel oil is injected comparatively slowly at the top of the stroke and at such

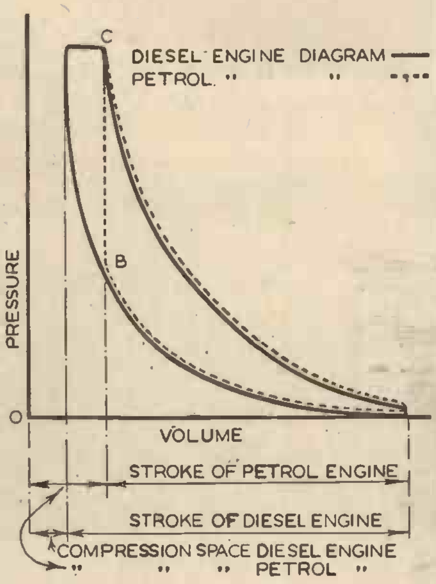


Fig. 2.—Showing the essential difference between indicator diagrams and Diesel and petrol engines.

a rate that the pressure is maintained for a short period after the piston has commenced its outward stroke. This indicator diagram, therefore, has a flat top, something like a steam engine diagram with early cut-off. There are certain advantages in this principle of combustion, one of them being that excessively high peak pressures and temperatures are avoided.

The Amount of Fuel injected

This is varied to suit the load, and there is no danger of misfiring through making the mixture too weak, the excess of air simply remains unused and is expelled with the exhaust.

Diesel engines seem to work well on any kind of oil that is liquid enough to be got into the cylinder—crude oil from wells, tar oil from coal, mineral, vegetable and fish oils have all been used successfully.

Originally Diesel engines were used only for large power outputs on land or in ships, but much research work has been carried out with the result that this type of engine is now being used on motor vehicles. Aero engines, too, have been made, and although for this purpose the engines themselves are heavier than petrol engines, the extra weight is more than made up by the reduction of weight of fuel required for long flights. It is for this reason that the Diesel type of engines is more suited for airships than aeroplanes.

The Diesel self-ignition principle is also used on two-stroke engines. This type of engine is mostly favoured for ship propulsion on account of its saving of space and weight, though this is not so great as might be thought because it is necessary to provide large pumps for the scavenging air. The two-cycle engine is also easier to reverse, a consideration in marine work. Double-acting two-stroke engines for ships are now in use, developing several thousands of horsepower per cylinder.

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stern post. The bulkhead fits into an opening in the front of the fuselage in a similar manner to the nose piece of the average rubber driven model. The under-carriage is a much simplified affair, made out of exceptionally stout spring steel wire, also on the usual lines employed on rubber driven models. I have now appreciated the fact that both I and most other petrol model builders have been working on the wrong principle in the case of under-carriages.

A petrol model glides in rather steeply, and the under-carriage requires to give backward followed by an upward movement, whereas most constructors have allowed for an upward movement first, as in the case of a full-sized machine. Reference to a photograph of the next model will make quite clear the details of this new type under-carriage. The weight of this little biplane is 6 lb., and the model is quite lightly loaded with a very slow flying section.

Fig. 6 shows the "Drone" model at rest, whilst Fig. 7 shows the under-carriage details and method of cut-out fuselage for the location of the low wing. As already stated, this model is the result of experience gained on the "Gull." The model is a low wing cantilever monoplane of 8 ft. span, with tapered wing divided in the centre for portability. The chord is 16 in. in the centre, tapering to 6 in. near the tips. There is a pronounced under-surface camber.

The fuselage is shaped out for the wing location at the correct angle of incidence, the wing being kept in position for flying by the usual stout elastic bands.

The engine and tail unit are both detachable as in the case of the engine on the small biplane. The tail unit comprises fin and tail plane and tail of fuselage built into one unit. A wire and coil spring, with a hook

PETROL MODEL AEROPLANES

Continued from page 508.

at each end, passes through the fuselage and hooks on to the detachable engine mounting and tail unit.

It will be appreciated that to obtain slight alterations of engine thrust line or tail and fin setting, all one has to do is to pack these components with slips of balsa wood where they join the fuselage proper. This system also allows either unit to be knocked out in a rough landing. The petrol pipe is of rubber tubing to allow of the necessary flexibility. Rubber tubing is quite satisfactory provided benzole or ethyl is not used in the petrol. The under-carriage is made of heavy gauge spring steel piano wire, as in the case of the biplane "Roo," with two legs reinforced with further pieces of wire. The ends of the legs are turned out to form stub axles. Two large coil springs, one from each leg, are carried back to the fuselage from half way up the legs. The legs are paired off with balsa wood pairings, bound with silk and doped.

The model carries an Ever-Ready battery, weighing 14 oz., and relies upon this for starting and flying. This extra weight is made possible by the lower wing loading. There are two large rubber-tyred wheels to help keep weight low in the low wing design. The whole model with battery weighs 7½ lb. and glides very slowly.

The Bowden Bullet III. is a speed model and is a pure experiment, and probably the first petrol model to be designed especially for this somewhat tricky purpose. The model is completed but has not been flown yet owing to the difficulty of finding a suitable ground where I am situated at the moment.

The whole model is very much of a gamble, and is to see how petrol will work in a speed model. As every one knows, a rubber-driven speed model is a touchy thing. This model is a descendant from my rubber speed model Bullet II. that came in second in the S.M.A.E. Speed Trials in 1933.

Fig. 8 shows the model before it crashes its way through life !

I hope these notes may have proved of interest to readers, and may be of use to those contemplating the fascinating business of building a petrol model for the first time.

LATHE WORK

(*Continued from page* 500.)

opposite to it has jaws which are reversible. Such a chuck is essential to properly hold irregular-shaped castings and plates for facing. No provision is made in the form of threads in the chucks themselves for the purpose of screwing on to the lathe nose. A fairly representative group of holder-type tools is seen in Fig. 3. These holders hold short lengths of square high-speed steel, three of these "tool bits" are seen in the front of the photograph. They are supplied in a hardened condition and may be quickly ground to any shape. The tool on the left is a spring screw-cutting tool, and the holder can be rendered rigid by tightening the large screw with the hexagonal key. Next to it is a parting tool, the blade being sectioned so that grinding on the front only is necessary. Boring bars which employ tool bits are seen in Fig. 4, and it is hoped to say more about them, and tools in general, at a later date.

GAS-FILLED RELAYS

By H. J. BARTON CHAPPLE,
Wh.Sch., B.Sc.(Hons.), A.C.G.I., D.I.C., A.M.I.E.E.

Although gas-filled relays are coming to the fore now in time bases for cathode ray television, their use is not confined to this purpose. The following article describes their principle of operation and their applications.

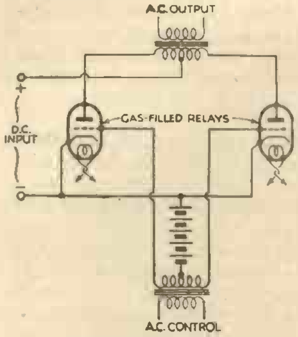
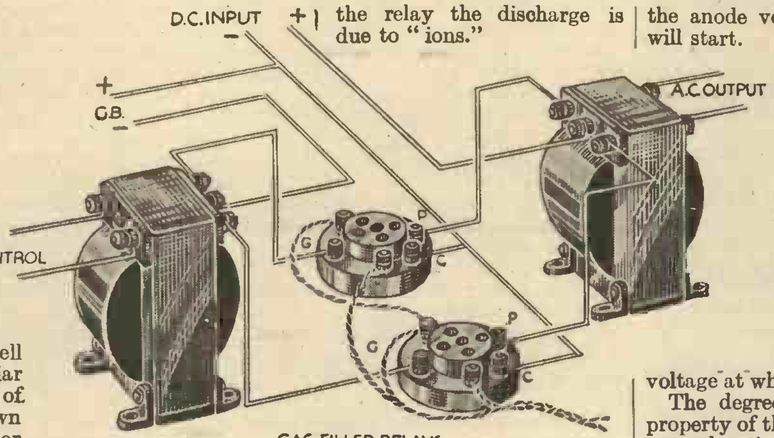


Fig. 3.—A theoretical circuit with the pictorial shown on the right for a D.C. to A.C. "inverter" using two relays.



GAS-FILLED RELAYS

TO the student of radio who is accustomed to the properties of the ordinary high vacuum or "hard" valve, there is much that is unfamiliar as well as something that is familiar in the newer types of "tube" which are known variously as "gas relays" or "mercury vapour discharge tubes with grid control."

The gas-filled relay resembles the ordinary receiving valve in that it is a triode and that the behaviour of the anode current is controlled to a certain extent by the charge applied to the grid. Unlike the ordinary valve, however, the bulb is not exhausted, but is filled with a gas—usually mercury vapour. Moreover, the type of control exercised by the grid differs greatly from the control in an ordinary valve, as will be explained later. A long cathode is indirectly heated, being completely enclosed by the control grid, the cylindrical anode being a little less than half the grid length.

Electrical Discharge through Gases

In order to understand the action, it must be remembered that the development of the high vacuum valve was largely the outcome of a long series of experiments and researches into the behaviour of electric discharges through gases at low pressures. When valve action became better understood, and practical application was made of their properties, developments proceeded on the lines of high vacuum valves, and, indeed, for the purposes of radio reception the high vacuum phenomena were those which gave the best results.

But scientists continued to experiment with tubes containing considerable quantities of gas, recording the various effects observed and trying to connect the effects with working conditions, that is to say, with gas pressure, applied voltage, and so on. Space precludes setting down all that they discovered, and it must suffice to say that the discharge of electricity through gases takes many different forms according to conditions. Some of the principal forms are the disruptive spark, the brush discharge, the corona, the glow discharge (as in a neon lamp) and the arc.

It is the arc discharge which is utilised in the gas-filled relay—a discharge between a heated cathode and a positively charged anode, through mercury vapour. There is one fundamental difference between the passage of electricity through this device and through an ordinary valve, namely, that in a valve the current is due entirely to the movement of electrons, while in the relay the discharge is due to "ions."

Ionisation

Ions are molecules of gas which have been deprived of an electron. What occurs in the case of a gas discharge tube is that electrons, emitted by the cathode, collide with the gas molecules and "knock" an electron from each. The resultant molecule-less-one-electron is called an "ion" and the gas is said to be "ionised." As a matter of fact, not only the emitted electrons but also the electrons removed from the gas molecules continue to collide with other gas molecules, so that the effect is cumulative.

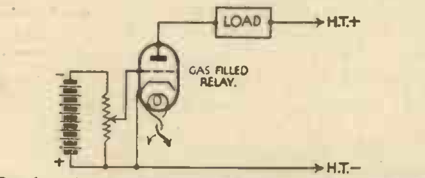


Fig. 1.—A mercury vapour discharge tube employed as a sensitive trigger relay.

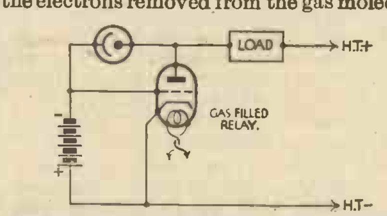


Fig. 2.—Employing the tube as a relay actuated by light falling on a photo-electric cell.

For a given set of conditions of gas pressure, distance between electrodes, and so forth, there is a definite minimum voltage which must be exceeded before the arc will "strike," or, in other words, before the discharge will pass.

The next fundamental difference between this discharge tube and a receiving valve is in the action of the grid. As every reader knows, the variations of voltage applied to the grid of a receiving valve cause corresponding variations in the value of the anode current. In the case of the relay, however, the voltage applied to the control grid does not cause a variation in the strength of the anode current. What it does do, however, is to alter the value of the anode voltage at which the discharge will start.

Degree of Control

For example, a negative voltage on the grid will prevent the discharge from commencing until the anode voltage is considerably greater than that at which discharge would take place if there were no negative charge on the grid. This can be stated in another way by saying that the voltage applied to the grid of a gas-filled relay controls the value of anode voltage at which discharge commences.

The degree of control depends upon a property of the gas relay known as its "grid control ratio," which is something similar to the "amplification factor" of an ordinary receiving valve. For example, a discharge tube having a "grid control ratio" of 25 and given a grid potential of 10 volts, would require a voltage of $25 \times 10 = 250$ volts in excess of normal before the discharge would commence.

When, however, the anode voltage has reached a value great enough to overcome the control exercised by the grid potential, and the arc has started, the grid has no further control, and the discharge can be stopped only by interrupting the anode circuit. If this is done, however, the grid immediately regains control and the discharge cannot again be started until the anode voltage is once more great enough to overcome the grid control.

Once the discharge is started, the internal resistance of the tube is comparatively low—it accounts for a voltage drop of only some 15 volts at maximum rated anode current. The value of the anode current, therefore, is governed solely by the impedance of the external load, and it is very important to ensure that this current does not exceed the value recommended by the maker. It is usual, therefore, to include some form of limiting resistance in the circuit.

Practical Applications

It is obvious from the foregoing that the device is one in which a very small amount of energy—merely, that required to charge the grid—may be used to hold up or release at will the much larger amount of energy represented by the anode current. It can thus be used as a very sensitive relay, and a

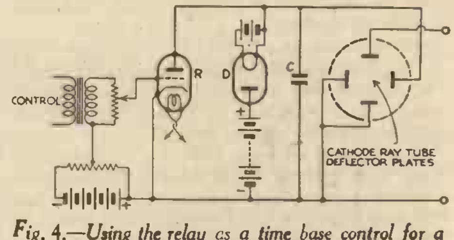


Fig. 4.—Using the relay as a time base control for a cathode ray tube.

circuit for this application is given in Fig. 1. Here it will be seen that a high tension supply is connected between the anode and cathode, with some form of load in series. The negative charge on the grid can be varied by adjusting the slider of the potentiometer connected across the biassing battery.

Several methods of employing such a relay present themselves. For example, by setting the grid voltage at a certain value the relay will prevent the flow of anode current unless the anode voltage rises above a certain figure. The relay would thus record the existence of a sudden rise in voltage. Alternatively, some device could be included in the grid circuit to render the grid positive under some predetermined conditions, thus starting the current in the anode circuit.

An example of this application is shown in Fig. 2, where, under normal conditions, the grid is biassed negatively by the battery shown and no anode current flows. A photo-electric cell connected between the anode and grid neutralises the negative grid charge when light falls upon the cell, and allows current to pass through the relay.

D.C. to A.C.

Another interesting application is as a so-called "inverter" for producing an alternating current from a direct current supply; just the opposite of the well-known rectifier. One circuit arrangement for this purpose is given in Fig. 3. Here two relays are used, their anodes being connected to the two ends of the primary winding of a transformer, the centre tapping of which is connected to the positive terminal of the D.C. supply, while the negative terminal of the supply is joined to the cathodes.

The grids are given a permanent negative bias by the small battery shown, but an alternating current control voltage from a small subsidiary supply is also applied to the grids through the secondary of the control transformer. It will be seen, therefore, that while the grid of one of the gas-filled relays has its permanent negative bias neutralised and its grid made positive by the A.C. control voltage, the second tube grid is made still more negative. The two relays will therefore work alternately, the flow passing first through one and then through the other tube.

The voltage drop across the primary of the transformer in the anode circuit will therefore be alternating, and an alternating current output can be taken from the secondary of this transformer, its voltage depending upon the turns ratio.

The full possibilities of the practical application of these devices have not yet been exhaustively explored, but additional uses are being developed rapidly. One of the latest is in conjunction with cathode ray tubes when employed as an oscillograph or for television. As readers are aware, an essential part of such an apparatus is a "time base," that is to say, a device for controlling the movement of the cathode ray vertically and horizontally at absolutely synchronous speed. The action of such a time base depends upon the building up of a voltage to a certain value in a certain period of time and then suddenly destroying that voltage.

A time base employing a gas-filled relay is shown in Fig. 4. The condenser C is charged gradually through the impedance of the diode D until the voltage across C, and consequently across the relay R, is sufficient to ionise the gas in the relay, when the condenser is discharged rapidly. The voltage at which discharge occurs is governed by the negative charge on the relay grid, while the A.C. control voltage applied to the grid is obtained from the signal being examined by the cathode ray tube, and is needed merely to obtain synchronism.

THE MAGIC EGG

HOW IS IT DONE?

Solution next month.

ALL that is seen by the audience is a paper bag containing confetti, a glass tumbler, a fan and an egg. The tumbler is filled with confetti from the bag and covered with a handkerchief. The egg is taken in one hand and gently fanned with the other: it changes to a shower of confetti and the glass being uncovered is seen to contain, in place of the confetti which has disappeared, an egg, ostensibly *the* egg.

The paper bag is not without guile. The lower part of it is reinforced with cardboard and is divided into two compartments. It will be convenient in order of construction to make a cardboard container and form a paper bag round it. Let the box be 7 in. by 5 in. and 7 in. deep or thereabouts. At a distance of 3½ in. from one end set up a partition 5 in. high, and to the top edge of this, hinge with a strip of calico or tape a flap equal in length to the width of the partition and 3 in. wide, or, in other words, a folding extension of 3 in. to the height of the partition. Line the inside of the smaller compartment of the box with cotton wool and put a pad of the same material at the bottom so that a tumbler my be dopped into it noiselessly.

This done make up a paper bag of stout brown paper of such size as to take the cardboard box easily, and 9 to 10 in. deep, and fix the compartment box in the lower part of it.

The Construction of the Box

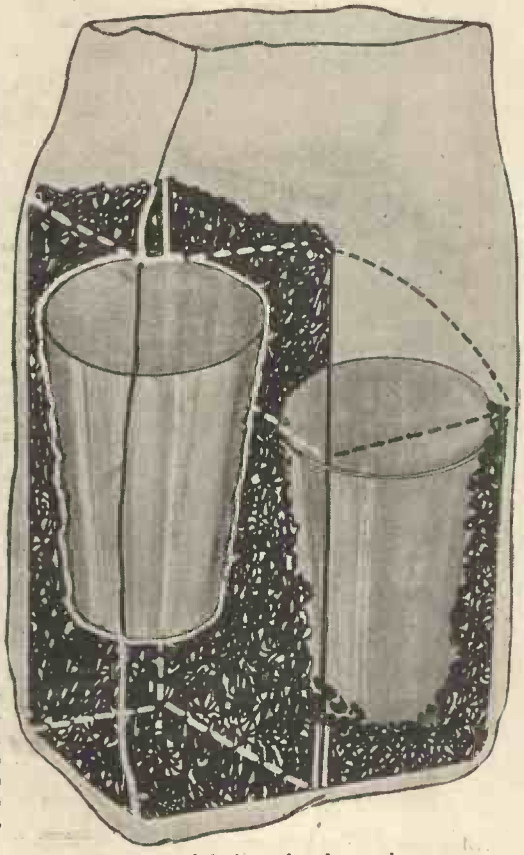
The bare essential of the box construction has been described, but it is worth a little extra trouble to eliminate all sharp angles and make it with rounded edges and corners, so that the finished bag shall not present a stiffness of appearance that might suggest it to be a fake. The more casual its appearance the better.

The next thing is to prepare an egg. Make a hole in one side of the shell about 1 in. in diameter, and with the aid of a tube blow out the contents. Well wash the empty shell and set aside to dry. When dry, pack closely with confetti and cover up the opening with two or three layers of white tissue paper pasted into position. It will save time to make up several at a time, for stock, as one is used for every performance. If the shells are properly washed and dried they can be stored indefinitely for use as required.

Other Equipment

To complete the property list, two glass tumblers, alike, a fan and a handkerchief are necessary, and an additional fake to fit one of the tumblers. This takes the form of a truncated cone, shaped like an inverted tumbler, which it fits loosely inside, covered with confetti. First make the wall of the shell by rolling several thicknesses of thick pasted paper round the outside of the tumbler. Don't stick it to the tumbler, of course, and let the smaller end protrude an inch or two beyond the bottom of the tumbler. When set, trim off the top and bottom edges to leave a loose-fitting lining to the tumbler extending from the inside bottom to within ½ in. or so of the rim. Cut a cardboard disc to fit in and close the larger end. Strengthen the join by sticking a strip of muslin or calico round the edge and cover the whole with thin paper of any colour approximating to one of the colours prominent in the confetti. Then divide the entire shell longitudinally into two halves and reconnect by a calico hinge across top. Cover it with paste and sprinkle confetti over the entire surface. Placed inside the tumbler it will present the appearance of a glass filled with confetti. A 3-in. length of thread attached to the top and terminating in a substantial knot or small ball cut from a bottle cork and a facility in handling furnishes the means of withdrawing this fake at the proper time. The division is to ensure free passage of an egg in and out, but more particularly out.

To set the properties for the trick, place an egg (a real egg) inside the confetti-covered shell, and the shell inside one of the tumblers. Partly fill the larger compartment of the prepared confetti bag with confetti, stand the loaded tumbler upon it and pile more confetti around and on top of it, raising the partition flap to form a temporary wall to retain the whole. The duplicate tumber, a fan, a handkerchief and an egg prepared as described are placed ready to hand.



Appearance of the bag referred to in the text.

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.*

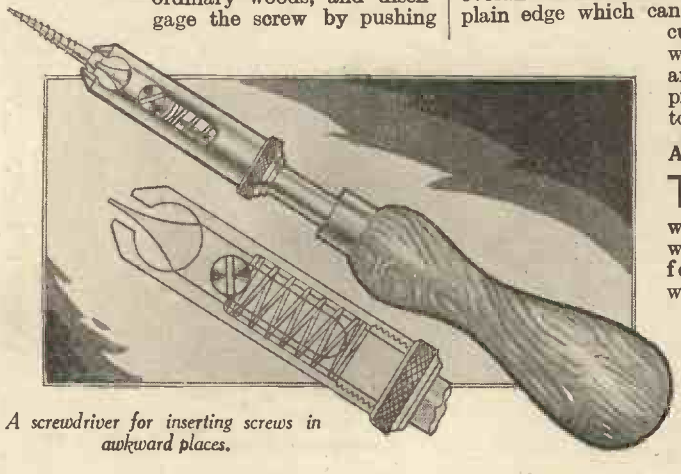
An Improved Saw

WE show on this page one of the latest types of saw which can be used for cutting sheets of metal of any width or length. The frame is strongly constructed of steel, with a cast steel blade sufficiently thin to follow the cut of an ordinary 12-in. hacksaw blade. The angle at which the hacksaw blade is held in the frame enables it to cut through any length or width of material. With this frame, you can use an ordinary hacksaw blade for cutting corrugated iron and other sheet metals, ebonite, vulcanite, asbestos sheet, etc. The frame is made in two sizes: 12 in. for ordinary sheet iron or light asbestos, and 16 in. for deep corrugated asbestos sheet, tubes and thick material. Its principal features are an unbreakable handle, a tubular back, giving more rigidness, a rustproof blue finish and a new cutting angle with finger-adjusting screws. The price is 5*s.* 9*d.* for the 12-in. frame and 12*s.* 6*d.* for the 16-in. [72.]

A new improved type of saw for cutting sheets of metal of any width or length.

Difficult Screwdriving Made Easy

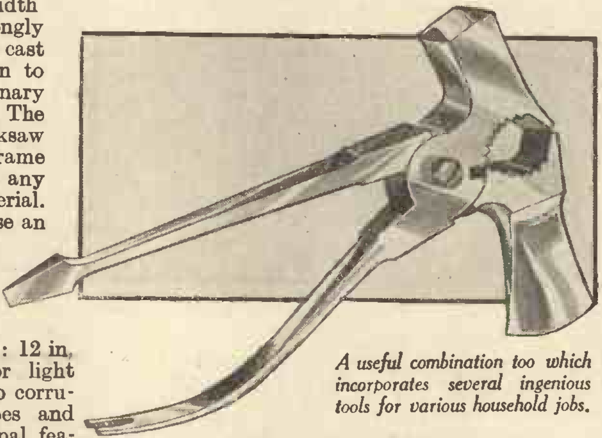
MOST handymen know how difficult it is to start a screw with the ordinary type of screwdriver. This difficulty can easily be overcome by using the screwdriver shown at the bottom of this page. You simply push up the sleeve, which is shown in section in the illustration, and insert the screw. Drive the screw nearly home. No preliminary hole is needed in ordinary woods, and disengage the screw by pushing the sleeve forward. The screwdriver may then be used as an ordinary driver for the last few turns. It costs 3*s.* [73.]



A screwdriver for inserting screws in awkward places.

A Combination Tool

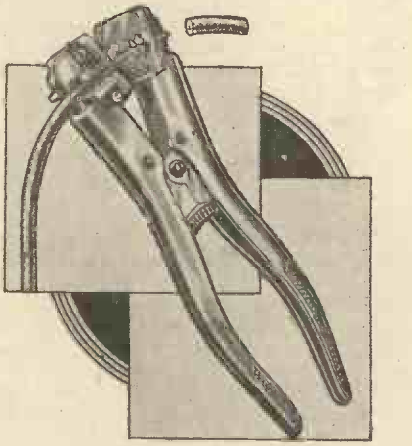
WE have dealt from time to time in these pages with various types of combination tools, which have proved of considerable use to the handyman, and the one shown on this page proves no exception. As can be seen, this tool can be used as a hammer, screwdriver, chopper, pincers, cutting pliers, floor nail extractor, and pipe grip, which makes it very handy for the garage or house. This seven-in-one tool costs 3*s.* 9*d.* [74.]



A useful combination too which incorporates several ingenious tools for various household jobs.

An Ingenious Wire Strip

THE wire stripper shown herewith will prove a boon to the constructor of wireless sets, electrical engineers, etc. The action of the tool is triplicate. As you squeeze the handles together the grippers close first to hold the wire in position; then the blades close, cutting through insulation; lastly the jaws open outwards stripping off the insulation. For fine flexible wires a rather exact size hole in the blades is necessary. The size of any of the holes can be increased with the point of a small round file. Each of the holes will strip solid wire several sizes smaller than the hole, but not larger. The stripper should be kept clean, washed in petrol occasionally to remove insulation refuse and lint. All working parts should be kept oiled and all screws kept tight. All the parts are renewable, being assembled with screws, not riveted together, except the slide studs, which are held by small split rings. Blades of three different sizes which are interchangeable, can be supplied for the wire stripper as follows: No. 1 for Nos. 14 to 22 S.W.G., No. 2 for Nos. 12 to 19 S.W.G., No. 3 for Nos. 10 to 13 S.W.G., or equivalent overall sizes of stranded wire. There is a plain edge which can be used as a wire-cutter for small copper wires on the Nos. 1 and 2 blades. The price of this ingenious tool is 9*s.* [75.]



These ingenious wire strippers should prove a boon to the constructor of wireless sets, etc.

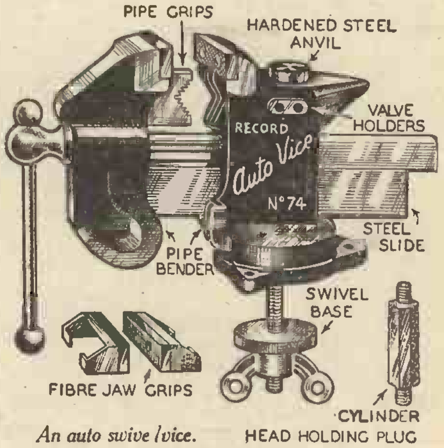
A Useful Wood Cutter

THE unique tool shown on this page will cross cut rough wood, crate wood, fencing matching, weatherboard, etc., up to 6 in. wide by 1 in. thick by hand. It is many times faster than the ordinary hand saw. Made from Admiralty standard black malleable iron with best quality Sheffield steel blade, the price, complete with packing strips, mitre and angle gauge and coach screws for fixing is 60*s.*, extra blades costing 7*s.* 6*d.* each. [76.]

A useful tool for cross cutting all kinds of wood by hand.

An Auto Swivel Vice

THE vice shown at the foot of this column will prove very useful to the handyman. It has an unbreakable steel slide, and off-set jaws to enable the vice to hold long and wide work. Other features are a pipe-grip between the jaws, a hardened steel anvil, and an adjustable pipe and rod bender. It has a swivel base which enables the vice to be swivelled in a complete circle, and can be locked at any point. The vice weighs 26 lb. and is priced at 29*s.* 6*d.* [77.]



An auto swive lvice.

THE CONTROL SYSTEM OF AN ELECTRIC MODEL RAILWAY

The fascination of an electrically-driven model railway lies in the fact that the operations of starting, stopping, speed variation, shunting, etc., can be carried out from one point without touching the locomotives or the rolling stock. For shunting purposes it is necessary to have automatic couplings, but these are not a very difficult matter, and several makers already have couplings fitted which will couple together themselves, although most of these have to be uncoupled by hand.

WHERE reversing and shunting is required it is practically essential to use direct current (D.C.) and to use locomotives which have permanent magnet mechanisms. All the makers can supply this type, but there is also the alternating current (A.C.) mechanism which is driven from the mains through a transformer. This type will not reverse from the track, but is reversed by moving a lever on the loco. There are certain systems by which an A.C. loco can be reversed from the track, but, so far, these are somewhat complicated and expensive.

It will, therefore, be assumed that D.C. will be used, and in most cases the power will be supplied from an accumulator. Dry batteries are not very satisfactory for this purpose and an accumulator is the best solution, although there are several types of rectifiers now available which give D.C. from the mains. The diagrams used here will show the connections to accumulators, but no alteration is necessary where a rectifier is used. The rectifier is simply put in the place of the accumulators.

The "live" rail can be either of the "inside" or "outside" systems. Most layouts use the inside third rail and this will be used in the diagrams, although the connections are identical in every way for the outside system.

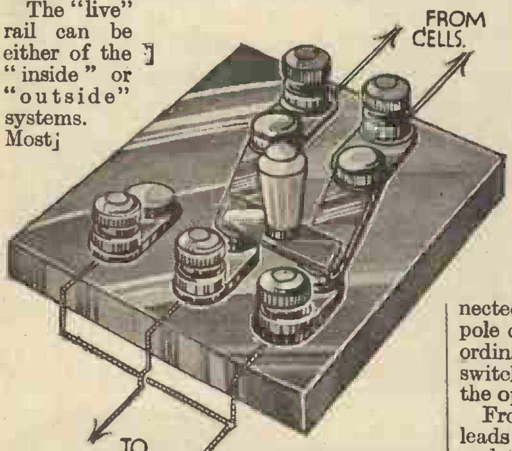


Fig. 2.—Another form of reversing switch.

To get smooth running over points, etc., the third rail should be raised above the running rails (about $\frac{1}{8}$ in. is right for Gauge "0"). If this is done and the collectors adjusted so that they do not touch the running rails, the loco will pass over points without any stop and without short-circuiting the battery. All locos should have double collectors in order to bridge the gaps between the sections of live rail.

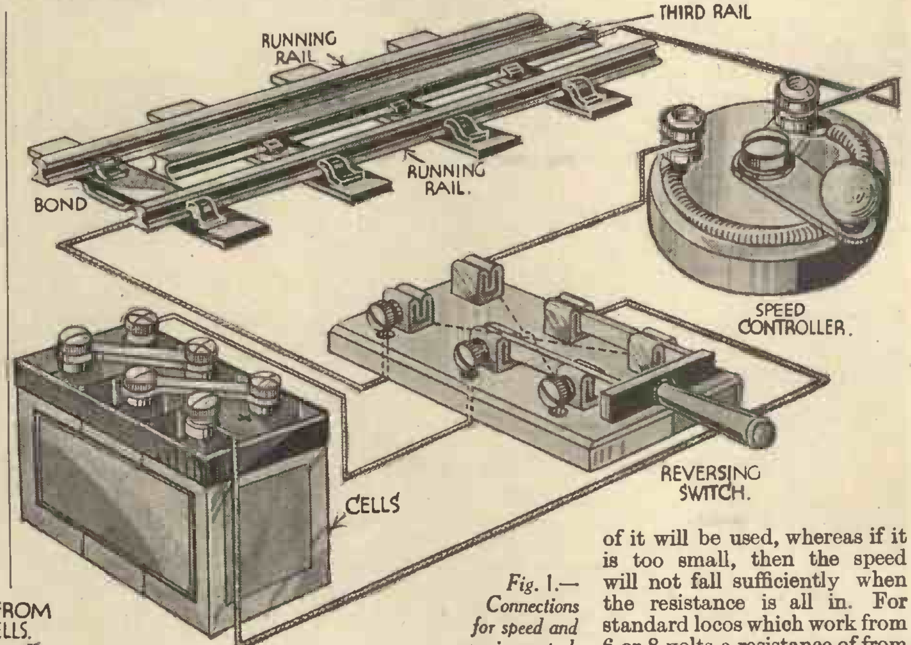


Fig. 1.—Connections for speed and reversing control.

The Controls Required

The controls are for *direction* and *speed*, and a simple arrangement to give these controls is shown in Fig. 1. It will be seen that the battery connections are first taken to the centre terminals of the reversing switch. This switch can be a ready-made reversing switch in which the cross-over wires are already connected under the base or an ordinary double-pole change-over switch can be used. The ordinary double-pole aerial-earth wireless switch can easily be adapted by wiring up the opposite contacts as shown in Fig. 1.

From the reversing switch, one of the leads is taken direct to the running rails, and the other is taken to a rheostat which acts as a speed controller. These rheostats can be obtained in a number of different forms, but the one shown is the type usually stocked by electricians and is not expensive.

Some care must be taken, however, to get a rheostat having a suitable resistance and able to carry the necessary current. If the resistance is too large, only a portion of it will be used, whereas if it is too small, then the speed will not fall sufficiently when the resistance is all in. For standard locos which work from 6 or 8 volts a resistance of from 4 to 8 ohms is about right when a 6- or 8-volt battery is used. If a 10- or 12-volt battery, is used, is connected as in Fig. 1, then the resistance must be increased to about 12 ohms.

The current taken by an ordinary loco is from 1 to 3 amperes, and so the rheostat must be made of sufficiently heavy wire to carry more than 3 amperes. If the wire is too thin, then the rheostat may burn out. A satisfactory resistance should be able to carry 4 or 5 amperes continuously without getting too hot. For this reason wireless rheostats will not do, as they are only designed to carry 1 ampere at the most.

Another Form of Reversing Switch

This switch is shown in Fig. 2, and has a quicker action than the change-over type, since it does not have to be moved so far, and if the switch is to be home-made, this is the easiest type to make. Two strips of brass or copper, some contact studs and terminals are all that will be required. The reversing action is obtained by joining the two outside terminals as shown in the sketch.

(Further details next month.)

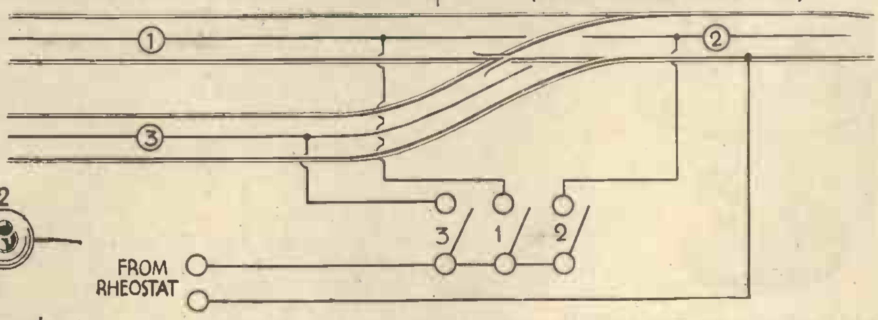


Fig. 3.—Section control for a simple siding.

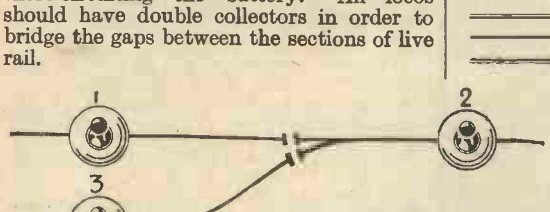


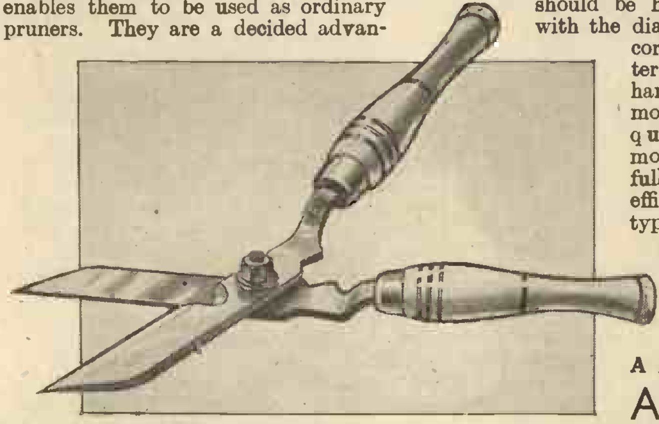
Fig. 4.—The key plan on the control board for Fig. 3.

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 St., Strand, W.C. 2. Quote number at end of paragraph.

Adapting Garden Shears

THERE is no novelty in a pair of garden shears, but those shown in the sketch are both ingenious and new. As can be seen, a niche is cut out of the blades, which enables them to be used as ordinary pruners. They are a decided advantage when pruning and cutting hedges or bushes, etc., as the niche easily cuts through thick branches. They cost 3*s*. 9*d*. [69.]



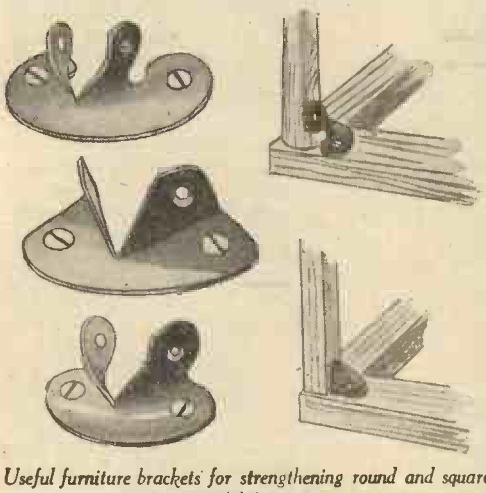
The feature of the shears shown above is the niche in the blade, which enables them to be used as ordinary pruners.

Useful Furniture Brackets

THE brackets shown in the sketch at the foot of this column will be found a definite advantage to the householder. Wobbly chairs and tables can be made rigid by fitting these brackets as shown, which are designed for strengthening round and square furniture joints. They are made in three different sizes, costing 2½*d*., 3*d*. and 4*d*., respectively. [70.]

An Efficient Glass Cutter

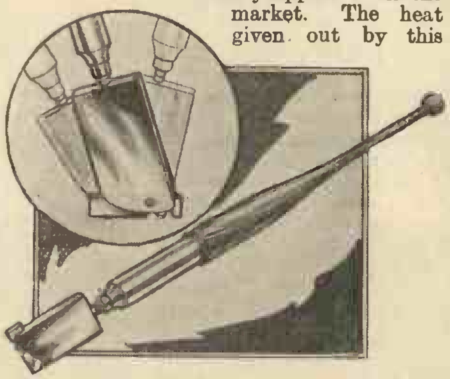
FOR cutting sheet and plate glass nothing equals the diamond, for it outwears hundreds of steel wheels. It can be used at a greater speed than the latter type, needs less pressure, and makes a clean continuous cut. The diamond cutter shown is ideal for cutting sheets of bent plate glass, opal glass, old plate, or any glass-cutting operation in which the user is doubtful as to the correct angle at which the diamond should be held, since the carrier, with the diamond, is always in its correct position, no matter at what angle the handle is held. The diamonds fitted are of finest quality, selected and mounted by experts, and fully guaranteed to give efficient service. This type of cutter is obtainable for thin or thick sheet glass, or for plate glass, and the prices range from 15*s*. to 45*s*. [71.]



Useful furniture brackets for strengthening round and square joints.

A Handy Camp Stove

A VERY complete and highly efficient stove, suitable for use by campers or picnic parties, has recently appeared on the market. The heat given out by this stove is equivalent to that supplied by a full-size gas ring, and the size of the flame can be regulated between wide limits. An additional feature is the provision of a new type of petrol-gas igniter. The stove is obtainable in two types, the first one measuring 4¼ × 8½ × 8½in., and weighing 5 lb.; the second size measures 4¼ × 9¼ × 16¼ in. and weighs 8 lb. Both burners pack up to form a case similar to a small attaché case, and the respective prices of the two models are 32*s*. and 41*s*. [72.]



An efficient diamond glass cutter.

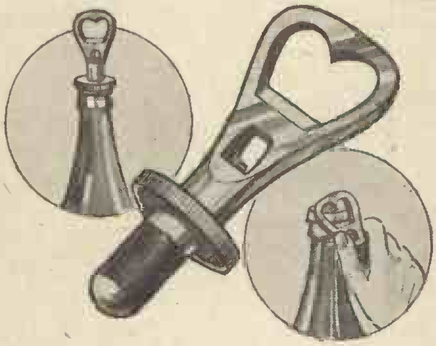
Combination Stopper and Opener

THE stopper and crown cork opener shown on this page will prove a useful gadget for picnickers, campers, etc., to take with them. By reason of its adjustment it fits a wide range of bottle necks, and the rubber, not being porous material, makes the stopper most suitable for sealing bottles originally sealed with crown corks.

Made of polished aluminium, it costs 2*s.* 11*d.* [73.]

A Home Paint-spraying Outfit

OLD methods are gradually giving place to new, and although the paint brush and paint pot can never entirely be superseded, there are many jobs where paint-spraying, the modern method, gives a result far surpassing that obtainable with a brush; for not only is one able to get an even surface, free from brush marks and indistinguishable from that of the professional painter, but a considerable economy is effected in the quantity of paint used.



A combined stopper and crown cork opener.

Also, the spray penetrates crevices which cannot be satisfactorily reached with a brush. The paint-spraying outfit illus-

The paint-sprayer shown is very light and portable, extremely compact, and neatly designed, but in spite of its small dimensions, it is capable of covering large surfaces with speed and efficiency.

trated here has a reservoir which is inflated by means of the 2½-in. diameter brass foot pump to about 20 lb. to the square inch. The pistol is fitted with a trigger which controls the air supply, and two extra glass containers are included in the outfit. They are provided with airtight lids so that they may be used to store the paint. The air and fluid nozzles of the pistol are adjustable, so that they may deal with liquids of various consistencies. The price of this sprayer is 45*s.*, which includes two spare containers. [74.]

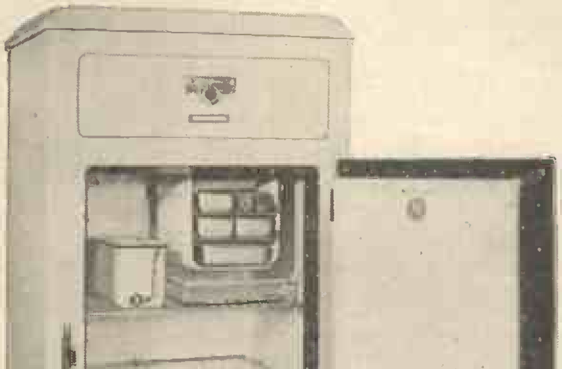
DOMESTIC REFRIGERATORS AND HOW THEY WORK

(*Continued from page* 505.)

The gaseous refrigerant is then conducted to the compressor where the vapour is compressed. This causes it to resume its liquid form, and in doing so it releases the heat previously absorbed from the evaporator. The liquid refrigerant is then ready to be pumped to the evaporator again to commence another cycle of operations, which continue as long as the motor is running.

The "Electrolux" refrigerator operates in a different manner. No motor-driven compressor is used, and there are no other moving parts. The unique system by which it operates comprises the use of hydrogen in addition to water, and ammonia, which is the refrigerant used. The refrigeration unit consists of three steel chambers connected by welded steel tubes, and the necessary chemicals are permanently sealed up in the containers at the works, like the Genie in the Bottle. All that is required to start the cycle of operations in an "Electrolux" refrigerator is a supply of heat, which can either be electric, gas or oil. Briefly, the cycle of operations is as follows: the ammonia in the apparatus is in the form of a solution in the water before the refrigerator is put into operation. The application of heat releases the ammonia from the water, after which the ammonia gas so formed is liquefied by cooling in a condenser. It is then made to evaporate at a low pressure in an evaporator, so absorbing heat from the interior of the refrigerator cabinet and producing a low temperature.

Rapid evaporation of the liquid ammonia is brought about by the hydrogen with which it is diluted on entering the evaporator. The gaseous ammonia is then again absorbed by the water from which it was expelled, thus completing the cycle of operations, which continues while the heat is applied.



A Westinghouse domestic refrigerator with the compressor unit mounted in the cabinet above the food storage space.

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.

A Copper Plating Query

"I WANT to copper plate direct on plaster of Paris. I have obtained some commercial 'black lead' called 'Leiterit' for the metallic foundation for the copper. But how am I to make the 'Leiterit' stick to the plaster. If I try wax, the model becomes waterproof and consequently won't plate. What ought I to use?

"Also can you tell me something to harden plaster? I have tried silicate of soda, but it forms a crystalline fur on the outside of the plaster and the latter is no harder." (J. D. H., Oxford.)

You should use ordinary blacklead well brushed on to the plaster of Paris. It should first be mixed with water and then allowed to dry. A mixture of vinegar and seccotine is useful to harden plaster of Paris.

Spraying with Whitewash.

"I have read with interest the article in your paper on making a paint sprayer, and would like to know what size of nozzle, also size of air tank to use with whitewash. Would a steel 40-gallon cask do? Also what sort of pump would be required and what kind of paints are most suitable? I am afraid that in spraying whitewash only two-thirds approximately of liquid could be used, as the sediment at the bottom would stop up the supply pipe. I assume that distemper, etc., would need about $\frac{3}{32}$-in. nozzle." (M. C., Shetland.)

The hole in the nozzle should be drilled with a 70 drill. An ordinary feed pump should be suitable, and spraying cellulose is the most effective.

A French Correspondent Wanted

Stanley C. Harrison, 39 Fawcett Road, Southsea, Hants., England, would like to correspond with a reader fourteen or fifteen years of age living in Paris, Marseilles, Nantes, Bordeaux, or Cherbourg.

Colonial Correspondent Required

N. Mathews, 10 Harvey Street, Carlisle, Cumberland, would like to get into touch with a reader about fifteen years of age living in the Colonies.

Formula for Power Factor

"Would you be good enough to give me the formula for power factor, also if the formula is adaptable for single, two or three phases? The particular load I am interested in is a three-phase with a load of 215 a at 400 volts. The wattmeter is calibrated at 10 R.kW.H. and revolves twenty-two to the minute." (S. W., Lurgan.)

Power factor for single-phase A.C. equals :—

$$\frac{\text{H.P.} \times 746}{\text{E} \times \text{I} \times \text{V}}.$$

When H.P. is power output of motor in horse power. V is voltage across motor terminals when on load. Current in wires of motor is I. E is efficiency of motor when expressed as a decimal.

For 2-phase

$$\frac{\text{H.P.} \times 373}{\text{V} \times \text{I} \times \text{E}}.$$

For 3-phase

$$\frac{\text{H.P.} \times 430{\cdot}7}{\text{I} \times \text{E} \times \text{V}}.$$

Where V is the voltage between any two wires in the balanced system, other notation as above.

Power from a Reservoir

"Would you please inform me what h.p. I could get from a reservoir 18 ft. × 9 ft. × 9 ft. deep, with a fall on the outlet pipe of 3 ft. which gives a head of 12 ft. The inlet pipe to the reservoir is 3 in. Which would be the most suitable, a water turbine or Pelton wheel?" (J. S., Salop.)

The power obtainable depends not upon the size of the reservoir but upon the rate at which it is supplied with water. If the water comes in fast enough to fill the reservoir in one hour you can get about $\frac{1}{2}$ h.p. from it with a 12-foot head. If the flow is less the h.p. will be reduced in proportion, *i.e.*, if the flow fills the reservoir in two hours you can get $\frac{1}{4}$ h.p., and so on. We do not think either a turbine or Pelton wheel would be very efficient with such a small head.

Testing Types of Blood

"To decide a point in some experiments and tests with various blood types it is necessary that I treat some specimens to produce rather rapid coagulation.

"I should be pleased to learn of various simple methods by which I can do so." (E. R., Northants.)

Allow the blood to react with the following agents and time the period necessary for complete coagulation.

(1) Calcium Chloride Solution.
(2) Tincture of Iron Perchloride.
(3) Solution of Potash Alum.
(4) Solution of Tannic Acid.
(5) Solution of Hydrogen Peroxide.

These tests will give a rough idea of comparative coagulability. (1) should be the quickest, as it is due to deficiency of calcium in the blood that coagulability is delayed or does not take place.

"A well-known book of recipes dealing with a description of vulcanising, mentions in one process the following passage :—

"'Steam for some hours under hydraulic pressure at 4 atmospheres.'

"As no description of any heating apparatus is given, I am at a loss to understand what is meant by this.

"It also mentions various heats of 80° F. up to 352° F.

"Could you give me a meaning of the above and of any apparatus necessary to obtain these heats?

"Could you also inform me where I could obtain any books dealing with the treatment of rubber?" (J. B., Sth. Woodford.)

The article to be vulcanised is inserted in a mould, and this is subsequently placed between the platens of a press operated by hydraulic power (giving a pressure of up to 2,000 lb. per square inch). Steam is then admitted into the platens, temperature being controlled in this manner. There are wide limits to the temperatures employed. It is rarely less than 138° C. (steam at 35 lb. pressure) and seldom more than 167° C. (steam at 90 lb.).

There are dozens of volumes on the subject in most libraries. It is usually treated fully under the "Chemistry of Rubber."

MODERN WATER BORING METHODS

(Continued from page 498.)

deep. A large industrial concern might even need 40,000 to 50,000 gallons per hour, necessitating a boring 30 in. to 40 in. or more in diameter. A private house, needing perhaps 500 gallons per day, would expect to obtain such a quantity from, say, a 6-in. well, perhaps 100 ft. to 150 ft. deep.

The Principle Advantages of a Borehole Installation

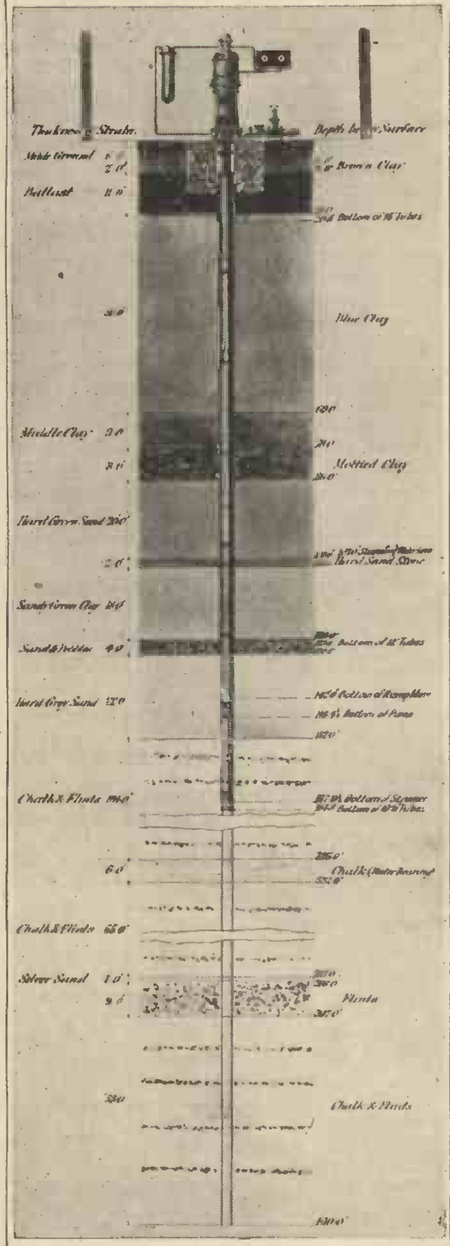
The reader will probably ask: "What are the advantages of a deep borehole, and what are the chances of success in this or that part of the country?" These questions may be answered as follows:

(*a*) It is possible, with a modern pumping plant, to obtain water from a boring at anything from ½*d*. to 4*d*. per 1,000 gallons, according to the actual conditions at the site. Where large quantities are used, this may mean an actual saving of several hundreds of pounds sterling per annum.

(*b*) In very many instances, deep well water is much less hard than that supplied by the companies' mains, and even when some form of treatment is necessary, the cost per 1,000 gallons still works out at a lower figure than that charged by the water company, thus still permitting a substantial saving.

(*c*) There is complete independence and freedom from interference by outside sources.

(*d*) Uniformity of temperature throughout the year.



A sectional drawing of a boring.

Testing Boreholes

Immediately a boring is completed it is usual to install a temporary pumping unit to test the supply. Careful records are made of water levels, pump speeds, etc., and upon the results of such a test the permanent plant is designed. The advantage of this procedure is that being made to suit that particular well, the pump is capable of giving much greater satisfaction than might otherwise be the case.

Increasing Supplies from Borings

Occasionally a borehole installation fails to produce its original supply, and this may be caused through silting up at the bottom. This difficulty may soon be overcome by carefully shelling out to a hard bottom once more. Most wells silt up in course of time, and sooner or later will require shelling out, but actually the operation is not often necessary, and when carried out permits the water to flow more freely.

Another cause of failure is that perhaps the water level has gradually fallen to a point below the actual pump suction. This is remedied by either deepening the borehole to give greater submergence, or by deepening the pump a few feet. Falling water level is due to an excessive drain upon the underground sources.

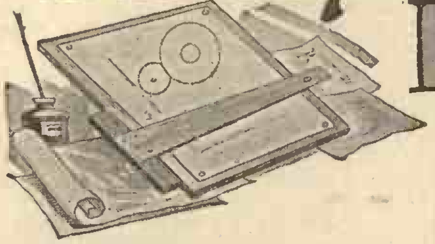
Recently successful experiments have been made in connection with what are termed "deflected" boreholes, that is, branch boreholes which are drilled at selected points from the main boring. A tool is lowered into the well to an agreed point, and by means of a patent apparatus, is caused to drill at an angle. Deflections are usually drilled about 50 ft., and greatly increased supplies have been obtained, especially in the chalk. One large water company in this country relies almost entirely upon several wells, each with two or three deflections. These, made some time after the boreholes themselves had been completed, increased the supply by nearly 100 per cent. Such an operation requires great skill in boring.

Headings and Adits

It is interesting to record that in several cases recently there has been such a demand for increased supplies that several well-known manufacturing concerns have been compelled to seek still more water by tunnelling under their property. These tunnels are usually excavated from the bottom of an existing shaft, and run for many hundreds of feet horizontally.

Headings are usually 6 ft. high by 4 ft. wide, and when left unlined, permit greatly increased supplies of water to become available by exposing larger surfaces of saturated strata. These operations are more expensive than normal well drilling, but the ultimate saving is so great that the capital expenditure is recovered in a reasonable time, and the underground storage provided is a very great asset.

Money Making IDEAS



ADVICE BY OUR PATENT EXPERT

Adapting the Wringer

"I HAVE an idea whereby the small rubber roller wringer can be attached to the ordinary metal dolly-tub. It is a small attachment, very firm in use, yet easily and quickly detachable.

"I should very much like your opinion on this idea." (H. D., Lincolnshire.)

As the applicant has not given any particulars of his invention for attaching a wringer to an "ordinary metal dolly-tub," it is not possible to express any opinion on the device.

Provided the invention is novel and contains subject-matter, it might be protected by Patent.

(*This reader omitted to give his full name and address. This must be given as evidence of good faith.*—ED.)

Internal Combustion Engines

"Would the following appliance be of any commercial value? If so, what steps should I take?

"I have devised a method which makes it possible for an internal combustion engine, working on the Otto four-stroke cycle, to have an impulse per revolution for every firing cylinder. This would be of use in a small single-cylindered engine, as it would give more uniform power than is now usually the case." (K. C., Jersey.)

Since no particulars are given of the proposed construction of the improved internal combustion engine, it is not possible to give any opinion as to its probable commercial value, which will naturally depend on whether it is possible to obtain protection for the idea.

It is, however, not understood how an internal combustion engine working on the "Otto four-stroke cycle" (which, by the way, was actually the four-stroke cycle proposed by A. Beau de Rochas in 1862, some fourteen years before the invention of the Otto gas engine) can have an impulse every revolution of the crank shaft. The first gas engine made by Lenoir in 1860 was a double acting gas engine, but this and subsequent gas engines prior to the "Otto" engine in 1876 were non-compression engines and, therefore, uneconomical in use and are now obsolete.

An Anti-skid Device

"I have invented an anti-skid device to prevent motor cars from skidding. It is worked by spiral springs and spikes in tubes. These spikes, which are all round the wheel, are ½ inch above the tyre and can be regulated to any pressure by turning a screw in the centre. I have taken out a Provisional Patent for twelve months and would like to know what you think about my idea." (J. S., West Lothian.)

The proposed anti-skid device for motor road vehicles should probably be effective in use, but it is feared that some trouble may be expected from the road authorities, since it is thought that the surface of the roads would be damaged should the use of such devices become common. It is possible that the proposed arrangement for regulating the strength of the springs controlling the spikes may be novel, but it is not thought that the broad idea of using projecting radially arranged spikes is novel. It is believed that something very similar was proposed some years ago for agricultural tractors driven by internal combustion engines. The object in such case was not for preventing side slipping on the highway, but to enable the driving wheels of the tractor to get a grip of the ground when used for ploughing, etc. The applicant is advised to make a search amongst prior Patent Specifications before proceeding further.

Self-drying Razor

"Can you advise me on the novelty and validity of the following idea?

As a result of the bother experienced in drying certain makes of razors I have evolved a scheme by means of which this could be obviated.

"In the bottom of a canister there is placed a dehydrating agent (calcium chloride). The razor rests on a grill at about ¼ in. to ½ in. above the calcium chloride. There is as little clearance as possible between the razor and walls of the container, so that the volume of air in the container is as small as possible. The lid is a good fit and has a spring hinge of the type shown in the diagram, so that when the catch is released the lid will fly open of its own accord.

"The actual external design of the canister does not enter into the matter?" (V. K., Liverpool.)

The suggested arrangement for drying safety razor blades is fit subject-matter for protection by Letters Patent and so far as is known from personal knowledge, is novel, but a definite opinion could only be given on this point after a search has been made amongst the prior Patent Specifications covering the subject.

The broad idea of using a dehydrating agent (*e.g.*, calcium chloride) in a container for absorbing moisture is, of course, old, but the specific construction of container for the present purpose is probably novel and the inventor would not be confined to the external design of the receptacle. Many years ago, a canister adapted to contain calcium chloride was on the market for hanging inside the case of a piano to protect the strings from rust and absorb moisture. Such containers have also been used for placing in show cases, particularly show cases for cutlery, to prevent moist air from damaging the contents of such cases. It may be of interest to the inventor to know that an apparatus was also on the market some years ago having for its object to protect safety razors from becoming rusty when not in use, but this arrangement consisted of a container filled with a liquid or a solution into which the razor was placed after use and kept there until again required.

A Marketing Difficulty

"Being the manufacturer of a certain proprietary article, I was asked by a firm to whom I have supplied my standard lines for some years, for an article which would match or be an improvement on one or two lines which are on the market.

"I went into the matter, and duly improved on these other articles, to my clients' entire satisfaction. Being very satisfied with my efforts, I applied for a Patent, on Forms Nos. 1 and 2, and have received acknowledgment from the Patent Office, and accordingly marked my goods 'Patent Applied For.'

"Upon seeing that I had covered it, and although verbally agreeing that it was my idea, my clients said they thought they were entitled to retain the idea for themselves, as it was at their request that this was evolved. Incidentally, they supplied no data, and the idea was carried further than they anticipated.

"I am quite agreeable to concede to their request, that is, not to supply other firms, but they now state that they do not wish to tie themselves to one source of supply, and suggest that they should split the order with another firm who have also been supplying them with a similar standard article.

"Naturally, I wish to make the most of my idea, and can only get remuneration on orders for large quantities, as the price has not been increased.

"I am now wondering if, as I must refuse their suggestion, they can evade my patent by bringing action on the grounds that, although I am an entirely separate firm, they employed me to provide the idea. If so, what is my line of defence? Do you think I should suggest my competitors making under licence? Again, if so, what is the usual procedure in this case? Ought I to claim my usual manufacturing profits?" (A. H., Lancs.)

The fact that a customer asked a manufacturer to supply him with a certain article, and as a result of such inquiry the manufacturer invented an article to supply the customer's wants, which met with the customer's approval, does not give the customer any exclusive right to the article or to any Patent which may be granted for the said article. The manufacturer is entitled solely to all rights in the invention. If the customer had stated that the article was to embody certain features, had suggested means whereby the article could be so produced and employed the manufacturer to carry out his suggestions, then the position is different. In such case, the customer might be held to be in the position of an employer and the manufacturer in the position of an employee, in which case the invention would belong to the customer. As to whether the customer can evade the Patent, if and when granted to the manufacturer, must depend on a variety of facts, on which it is not possible to express an opinion on the particulars supplied. On the supposition that the manufacturer obtains a Patent for the invention, then anyone, including the customer or any person he may employ to manufacture for him, making the Patented article will be infringing the Patent and can be stopped. It is, of course, open to the manufacturer to grant a licence to manufacturers under his Patent, and the royalty to be paid for the licence is a matter for the manufacturer, it should certainly be more than the manufacturing profit. There is a provision under the Patent Act whereby in certain cases the Comptroller may order a Patentee to grant a licence to manufacture under a Patent.

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