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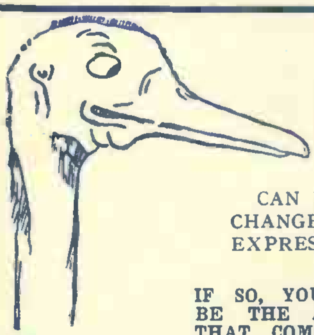

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Edited by F. J. CAMM

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Notes, News and Views

A Giant Telescope

THE new spectrum telescope, recently installed in Greenwich Observatory, has a mirror 3 ft. in diameter and 6 in. thick, weighing 500 lb. The room which accommodates the telescope has a dome 34 ft. in diameter, having a steel framing covered with papier mâché, and roofed with copper plates.

An interesting feature of this huge instrument is that the intersecting lines on the observer's lens are formed with part of a spider's web, and are used to keep the object in the centre of the field of vision. By means of a motor-driven clock the motion of the telescope can be regulated in accordance with the motion of the earth, so that the telescope can automatically follow a star in its course across the heavens.

An Electrical Train Indicator

A REMARKABLE train indicator, the first of its kind, was recently installed at Paddington Railway Station. On one side of it are given details of every train leaving the station, and on the other side details of train arrivals are indicated. The new indicator is operated in a similar manner to a totalisator. A girl sits in a control box, high up above the platforms, and is notified of all trains arriving. Each train has a number, and the girl operates a keyboard similar in appearance to a telephone switchboard. Above the keyboard is a model of the indicator on the platform so that she can see at a glance exactly what information is being given to the public.

A Mammoth Gear-wheel

WHAT is probably the largest gear-wheel of this type ever constructed in this country was recently completed at the works of the Power Plant Company, Ltd., of West Drayton, Middlesex. The wheel, which is of the double-helical type, is 19 ft. in diameter and has a face width of 50 in. It has 222 teeth in all, and has been designed for transmitting 16,000 h.p. at 28 r.p.m. in an Australian sheet mill.

An American Streamlined Train

THE Union Pacific Railway has just put into service the first of two articulated and streamlined three-car trains designed for speeds of 90 to 110 miles per hour. By the use of aluminium framing, and the articulated construction, a great reduction in weight is made possible, requiring only four bogies, instead of the usual six, to carry the three cars. The front car, which is 73 ft. long, has the driver's cab in the bullet-shaped front end, behind which is the engine room, postal compartment, baggage compartment, and air-conditioning and heating apparatus. The second car, 60 ft. long, has seats for sixty passengers, while the third car has seats for fifty-six passengers, two toilet rooms, and a kitchen in the projectile-shaped rear end. In the engine room is a twelve-cylinder 600 h.p. oil engine which drives a 500-kw. generator supplying current to two 300-h.p. motors geared to the axles of the leading bogie. All the bogie wheels are provided with roller bearings. The total weight of the train is about 80 tons.

THE MONTH'S SCIENCE SIFTINGS

New plant has recently been installed at Keighley for the manufacture of stout wire carpet beaters which are a decided advantage over the old cane type. The beaters, which are over 30 in. long, are constructed of the best-quality tinned spring steel wire. The retail price is 1s. 3d.

Twenty-five Admiralty buoys, each weighing 6½ tons, left the works of the Fairfield Engineering Company recently. They are each 40 feet in diameter and 10 ft. high.

A new type of spark arrester fitted to locomotives on the New Zealand railways is placed in the smoke-box, where a system of louvres imparts a rotary movement to the gases and pulverises the sparks as they are drawn into it, thus preventing them from escaping through the chimney.

A noteworthy feat, recently accomplished at the Royal Aircraft Establishment at Farnborough, Hants, was the launching of the "Supermarine Seagull V." by catapult. The machine, which has folding wings, is the first amphibian flying boat to be launched in this manner.

A new glass product consisting of curtains sandwiched between double-glass sheets has been placed on the market by Lancashire glass manufacturers.

A "flying" bicycle, the invention of a German policeman, is claimed to have three times the normal bicycle speed. Bird-like wings are mounted above the machine on a light framework, and a rudder and tail plane are also provided. There is no propeller, the machine being propelled along the ground by means of the rear wheel in the ordinary way.

A Steam-driven Aircraft

IT is reported from Germany that a steam-driven aeroplane is under construction at an aeroplane works near Berlin. The designer of the machine is Herr Huettner, who claims that he has succeeded in obtaining a satisfactory power/weight ratio by using a revolving boiler combined with a steam turbine. The fuel used will be oil gas. The machine, which will be driven by two propellers, will have a range of sixty to seventy miles non-stop flight, and the speed will be approximately 230 m.p.h. The aeroplane will have a span of 108 ft. and a length of 66 ft.

Automatic Machine for making Waterproof Fabric

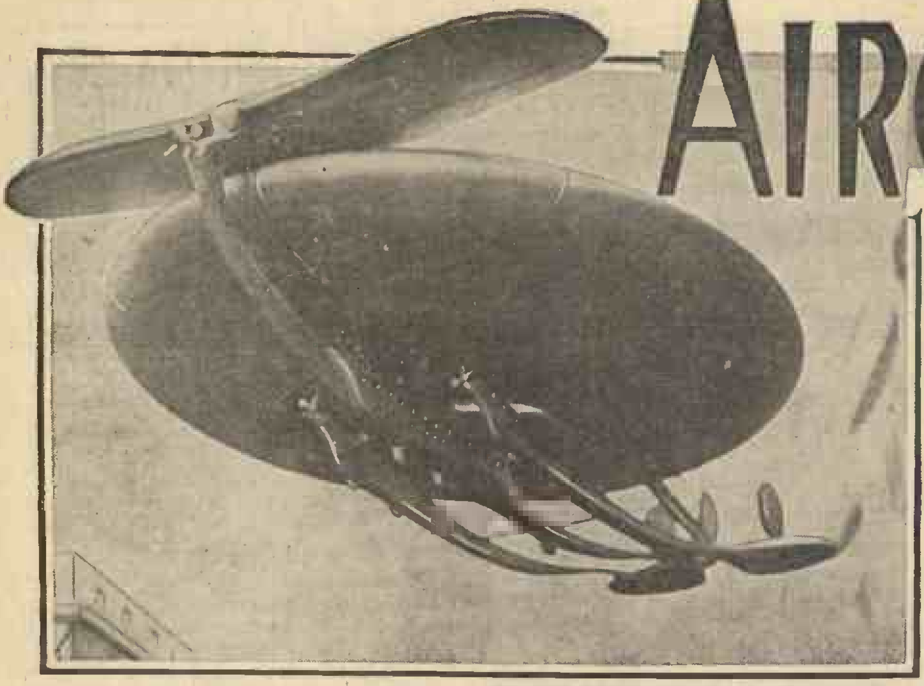
ELECTRICITY is used to supply the heat and motive power in a remarkable machine for making a new waterproof fabric in a large rubber plant in Kansas City, U.S.A. Six electric motors, the largest being 2 h.p., are used to drive the machine, and there are eight large steel drums, each of which is equipped with two 500-watt strip heaters and an automatic temperature controller. The material being treated, which consists of silk cloth, travels over rollers, is impregnated with liquid rubber, dried in a first drying chamber, washed in a water tank, and then dried in a second drying chamber. It is then coated with mica dust in a dusting box, tempered by passing over electrically-heated rollers, brushed in a finishing chamber, and delivered in rolls at the end of the machine.

A New 134-ft. Thames Passenger Vessel

THE motor ship *New Dagenham*, which has accommodation for 450 passengers, has recently been placed in service on the Thames, and will be engaged largely in taking visitors from London to the Ford Motor Works at Dagenham. Built in Holland, the vessel has a length of 134 ft., a breadth of 22 ft., and depth of 9 ft. 6 in. The twin propellers are each driven by a 200-b.h.p. eight-cylinder Diesel engine running at a maximum speed of 900 r.p.m. Reverse gear and a 3 to 1 reduction gear are employed so that the propellers run at 300 r.p.m.

An auxiliary engine drives a 100-volt 15-Kw. dynamo, which can also be driven by a series of belts from one of the main engines to ensure that illumination shall always be available. The excellent accommodation for passengers includes three large dining saloons. It is stated that the speed of the *New Dagenham* is 14 knots.

AIRCRAFT



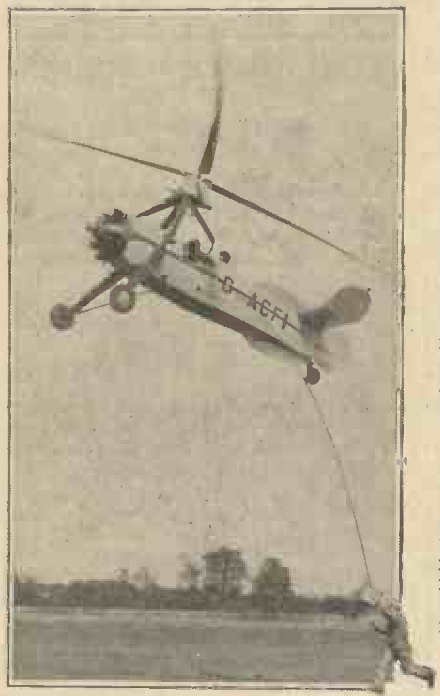
ALTHOUGH the practical development of the aeroplane really commenced with the experiments of Orville and Wilbur Wright in 1904 at Kill Devil Sands, Kittyhawk, when their now historic tail-first biplane, fitted only with landing skids, was crudely launched into the air along a rail track by means of a falling weight, the earliest records of civilisation show that man had always dreamed of the ultimate conquest of the air. The first practical experiments probably started with the Chinese, who developed fearsome-looking kites which were capable, although captive, of attaining great altitudes. But even in the Grecian legends we read of Icarus, the Son of Dædalus, who soared too high on wings made by his father so that the sun melted the wax that held the wings to his body, and Icarus was drowned in the sea. The Icarian Sea takes its name from this legend. It was natural that the first real experiments in mechanical flight should be made on machines which sought to imitate the flight of birds. None of such experiments was even moderately successful, and it was not until about the fifteenth century that *'planes* as we know them to-day came to be used for supporting surfaces.

Lighter-than-Air Craft

Experiments from then on were devoted almost entirely to lighter-than-air craft, but it was not until 1783 that the Montgolfier Brothers succeeded in making a large balloon ascend by means of hot air. Full-size gliding experiments followed, the most successful being Chanute and Lillienthal. The Wright Brothers collected up the scraps of practical information which earlier experimenters had left behind and built their first successful gliders which formed the basis of the design of their first biplane.

Forging the Missing Links

As in every other field of human endeavour so with aviation, it was necessary for many allied sciences to be developed before success could be achieved. No one really foresaw, when Gottlieb Daimler invented the internal combustion engine, that he had forged one of the missing links in the chain of heavier-than-air flight. Yet such is the case, although it was many years before it was brought to such a state of perfection that it could develop sufficient power in relation to its weight to lift the additional load of a pilot and his machine. Nor did anyone realise, upon the accidental discovery of petrol, that an entirely new era in land, sea and air travel had been revealed. The Wrights were not slow to realise that the steam engine would not provide the ultimate source of power for aircraft. They built their low-powered petrol engine, installed it in a strengthened version of their most successful glider, and as all the world knows, made their epoch-making ascent of a few minutes into the air.



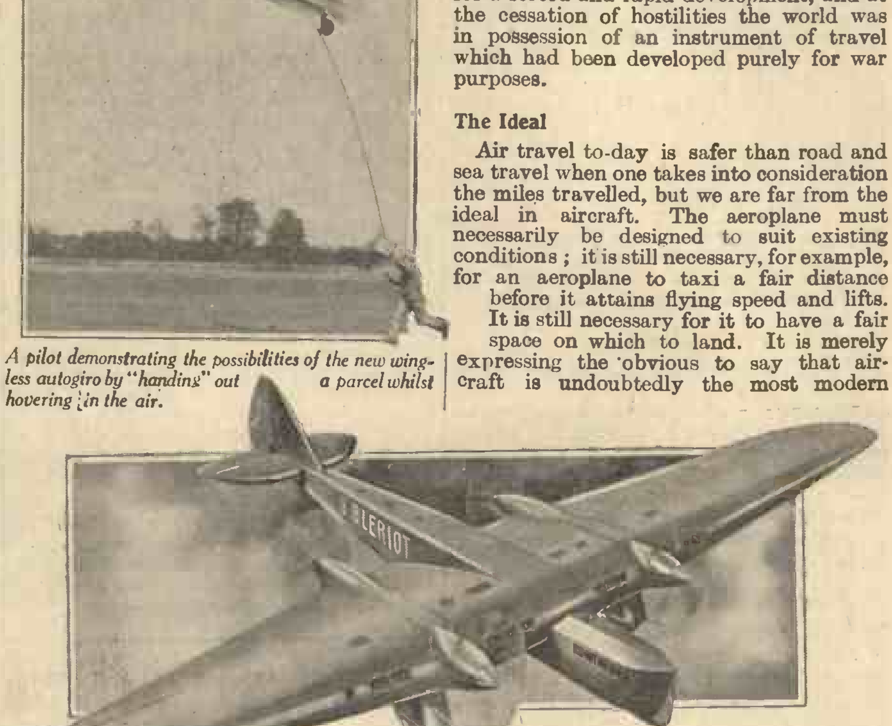
A pilot demonstrating the possibilities of the new wingless autogiro by "handing" out a parcel whilst hovering in the air.

Light Metals

The problem of making parts sufficiently light to withstand the enormous stresses imposed upon them in the air was not easy of solution, and here again another link was forged in the production of light metal such as aluminium, duralumin, magnalium and many of the light high-tensile steels which we use to-day. New processes of working these metals such as extrusion, oxy-acetelyne welding and rolling, contributed to the aeroplane as we know it to-day. Twenty years ago, that is to say at the commencement of the war, the aeroplane industry was practically non-existent, save for a few pioneers like A. V. Rowe, Colonel Cody, Bleriot, Caudron, Sopwith and Handasyde. The war, of course, was responsible for a forced and rapid development, and at the cessation of hostilities the world was in possession of an instrument of travel which had been developed purely for war purposes.

The Ideal

Air travel to-day is safer than road and sea travel when one takes into consideration the miles travelled, but we are far from the ideal in aircraft. The aeroplane must necessarily be designed to suit existing conditions; it is still necessary, for example, for an aeroplane to taxi a fair distance before it attains flying speed and lifts. It is still necessary for it to have a fair space on which to land. It is merely expressing the obvious to say that aircraft is undoubtedly the most modern



L. Bleriot has considered the possibility of constructing a powerful 'plane for passenger transport incorporating a lifeboat fitted with an engine which will automatically be released as soon as the 'plane strikes the water.

OF THE FUTURE

means of travel and transport. It is here to stay, and just as the train, the motor car and the motor coach replaced the stage coach, so assuredly will the aeroplane in a century to come take their places.

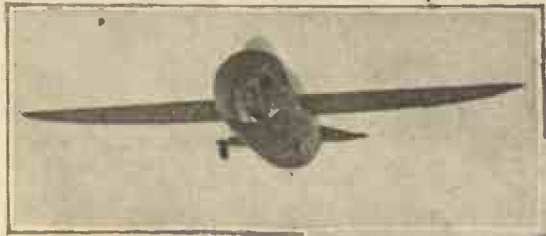
The Difficult Conditions

If we concede that this state of affairs will eventually come to pass, we must agree that the design of aircraft must undergo a radical change. We cannot, for instance, rebuild London, so that aeroplanes can land, pick up their passengers and ascend again in the same way that a 'bus can now stop, pick up its passengers and continue on its journey. To be of material advantage to commerce, it would be necessary for aircraft to be able to land and to ascend from a spot adjacent to every business house. There would be no saving in time over present means of travel if one lost in getting to an aerodrome the time saved by air travel.

Now the speed of aircraft is largely controlled by its load; the more weight carried per square foot of wing area the faster must the machine fly in order to lift. A little thought will show why this must be so. A sheet of ordinary notepaper, if balanced with a few paper fasteners, will glide steadily to earth. If a load is now placed on this piece of paper, it will glide forward (provided the load has been correctly placed over the centre of gravity) at a steeper angle and at a higher speed. It will be obvious, hence, that to maintain horizontal flight the speed must be increased as the load increases. If we wished the speed of an aeroplane to remain the same when the load is increased as it was *before* the load was increased, the wing area must be increased to a point where each square foot is carrying the same amount of weight in both instances. Without going into technicalities, it will be clear that if the aeroplane of the future is to carry a passenger load equal to a modern train, speeds must increase enormously or the size of the planes will be such that our present Goliath planes seem like toy gliders.

By F. J. CAMM.

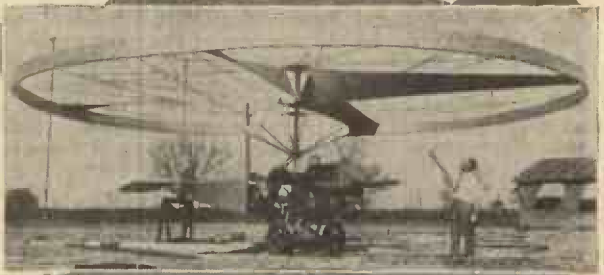
This fact encourages the thought that the present aeroplane is but a phase in the development of the ultimate aircraft in just the same way as the Wrights' gliders were but the introduction to the aeroplane which we have to-day. I do not consider that the size of planes will greatly increase, for there is a limiting size in aircraft, in just the same way as there is a limiting size to a train. As I have remarked, we cannot rebuild the world to suit aircraft, and I believe that the aeroplane of the future will be so contrived that it will be able to fit in with the present structure of civilisation. The need has always produced the device. Already we have wingless autogiros, which can take off after an incredibly short run and land almost vertically. The autogiro is without doubt the most modern of all aircraft. It is entirely satisfactory in every way, and as safe as an ordinary aeroplane, but it is only one means which has been evolved towards the production of the ultimate. The illustrations to this article show some of the other efforts (most of them successful) which have been made.

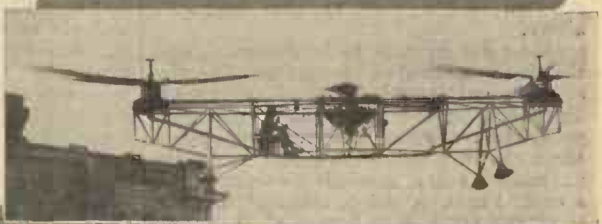


An aeroplane which employs a tubular fuselage which it is claimed has great stability and speed. The two photographs show the 'plane in the air and on the ground.

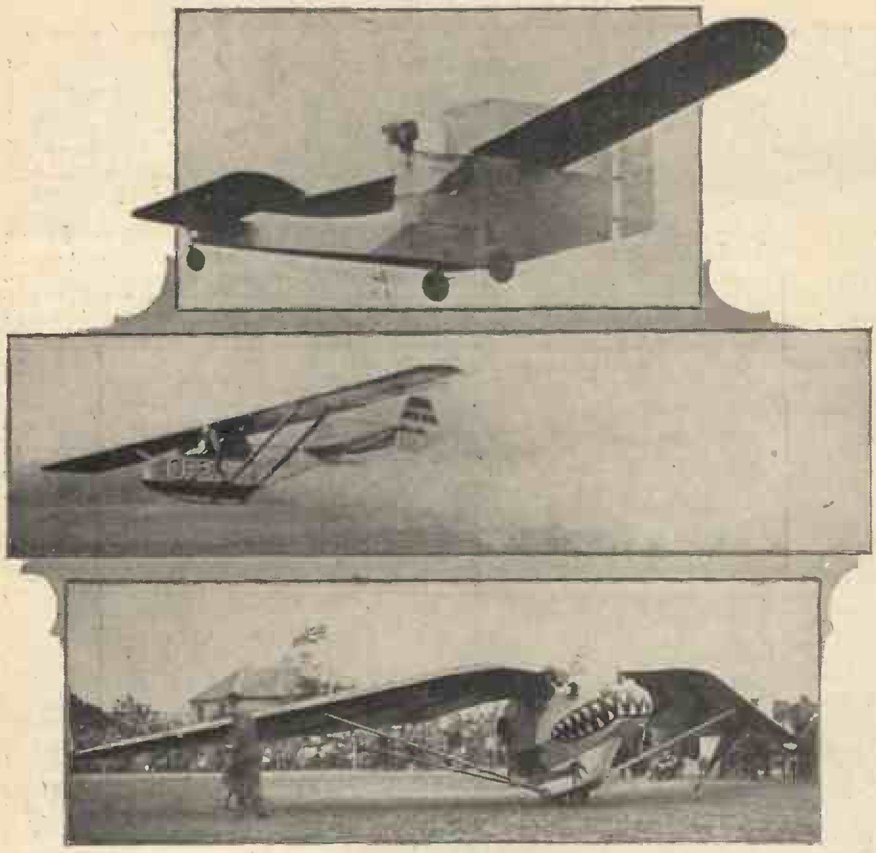
A New Fuel ?

Our scientists are doing their best with the material available to bring the aeroplane more in line with present conditions and to make it a worthy competitor to its long-established rivals. But to-morrow someone may discover a new fuel, or a new source of power, which will radically change the whole situation. This is not a fantastic prophecy; it is only necessary to recall the great power we now get from a so-called 7-h.p. motor-car engine compared with a 7-h.p. engine of twenty years ago. Engines are only about half the weight for a given rating, and their power has increased at least 300 per cent. Special fuels, using tetra-ethyl-lead, enable us to get more power from a given weight of fuel. The tendency, you see, is for the *size* of the power unit to get smaller and smaller. It is almost certain that within another quarter of a century a 100-h.p. engine





(Top Left.) A foolproof hover plane helicopter invented by Hafair-Bruno. (Bottom Left.) A new type of aeroplane which can rise vertically, ride forward and backward, and hover in the air. It is propellerless. (Top Right). An aeroplane combining the principles of the gyroscope, the helicopter and the aeroplane. (Bottom, Right.) A remarkable helicopter of unusual construction, having rotating fan at each end of the machine. It lands on the four bumpers.



(Top) A remarkable machine that flies tail first, and is stated to be as safe and as easy to control as a car. (Centre) A rocket plane in flight. (Below) The Westland-Hill "Pteradactyl," which has made a number of successful flights.

will be produced no larger than an attaché case. This means that an aeroplane would be able to carry a correspondingly greater load.

Transmission of Power through the Ether

And then there are experiments with the transmission of power through the ether. Shall we have a gigantic power station transmitting power through the ether in the same manner as we now propagate wireless waves and which the vehicles of the air will pick up by a device as light as a wireless set? It is not outside the bounds of possibility, for experiments over short distances have already shown this to be possible. If such a system were ever brought about it would radically change the whole design and future of aircraft. Will the helicopter be the machine of the future? I am of the opinion that it will, or, alternatively, that a machine capable of both vertical and horizontal flight such as the autogiro will come into more general use. There can be little doubt that flapping wing aircraft will never be successful, so we arrive at the conclusion that aircraft of the future will not resemble present aircraft, that they will be driven by minute yet powerful engines, or, alternatively, that they will draw their power from an external source such as that indicated above.

One point remains to be discussed, and that is the method of propulsion. The airscrew is universally employed at present. Opinion is divided as to whether a propeller is a screw acting in the same way as the screw of a ship or whether its blades are really a pair of aerofoils revolving about a central axis. Opinion, although divided, is almost entirely in favour of the latter theory.

Dr. Noorback has invented an aeroplane with paddle-wheel wings which replace the usual propellers. He claims that it can rise vertically into the air, that it cannot stall, and that it can *reverse*. No results of tests are as yet to hand, but Dr. Noorback is a scientist, not a crank, and one must therefore presume that the machine is based on sound lines. Another aeronautical engineer, Dr. Snyder, has constructed a machine which he calls the "Arup." This consists of an ordinary fuselage and a huge wing of semicircular shape (straight leading edge) extending the full length of the fuselage. The ailerons are situated at the rear, and there are no other surfaces. It is claimed to be extremely safe and automatically stable in all air conditions, and with it tail-spins and flat-spins are impossible. It will land at a speed slower by 5 ft. per second than an ordinary parachute. Under test it reached an altitude of 2,200 ft. Scientists all over the world are experimenting with new types of aircraft which are meeting with the usual derision accorded to apparatus which departs from the orthodox. It must be remembered, however, that this is usually the reward meted out to pioneers. The Wrights, Bleriot, Cody, and the rest of the aeronautical pioneers had to suffer the lampooning of the Press in their early days.

Detail improvements which have come into prominence during the past few years include hydraulic wheel brakes to reduce the run after landing, retractable chassis, which can be drawn into the fuselage and so increase air speed by cutting down head resistance, variable pitch airscrews which have the same effect as a gearbox on a car, and slotted wings which open according to the conditions of flight and so maintain stability.

Aircraft to-day are independent of fog and darkness, for by means of flashing signs and the wireless direction services adopted by most aerodromes, the aviator can keep in touch with land, and ascertain his location, often with greater exactitude than a mariner at sea.

A New Method of Propulsion?

Is there room for some new method of propulsion? Will the turbine principle ever be adopted? Can the paddle-wheel principle be called into service? Will some system of solenoid attraction and repulsion keep our aircraft of the future aloft? Will the airship eventually oust the aeroplane? These are but a few of the questions which come to mind as possibilities not too remote to be practicable; but of one thing there can be no possible doubt, namely, that the aeroplane is here to stay, and that it will more and more become part of civilisation.

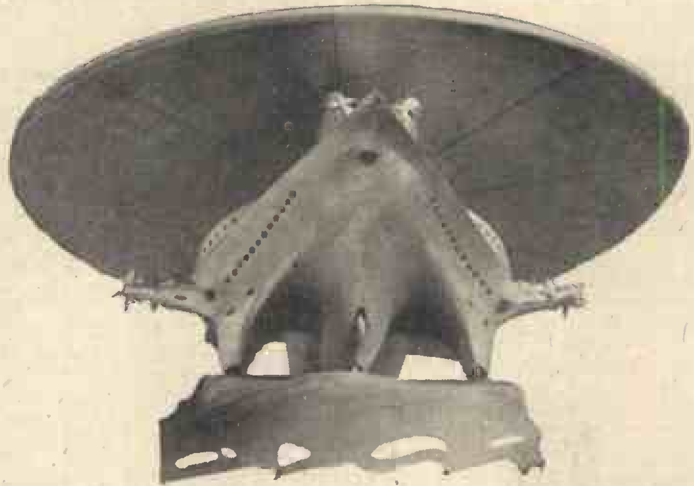
NEXT MONTH

Building a Power-driven Monoplane

Is Television Here?

Electricity in the Home

And many other interesting articles



A new type of aeroplane has been invented by an Italian engineer. His model is completed and has the cabins and engines on the sides. The centre part is left empty and receives the gas produced by the engines. On top of the machine is a revolving disc which is filled with non-inflammable gas, and the model has fourteen aeroplane propellers. The photo shows a front view of the quaint model of the new aeroplane.

STRATOSPHERE EFFECTS

By J. X. STONE

Although it is said that wireless waves travel from transmitter to receiver "through the ether," it is only recently that we have begun to realise how little is known about the path they actually do take.

THIRTY years ago the atmosphere was regarded as a simple ocean of air which gradually petered out to "nothingness" at a height of about ten or twelve

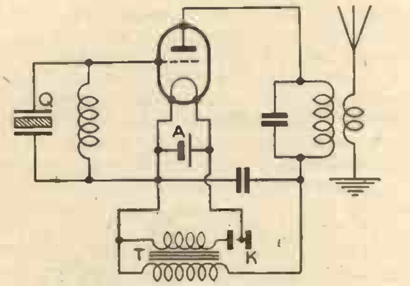


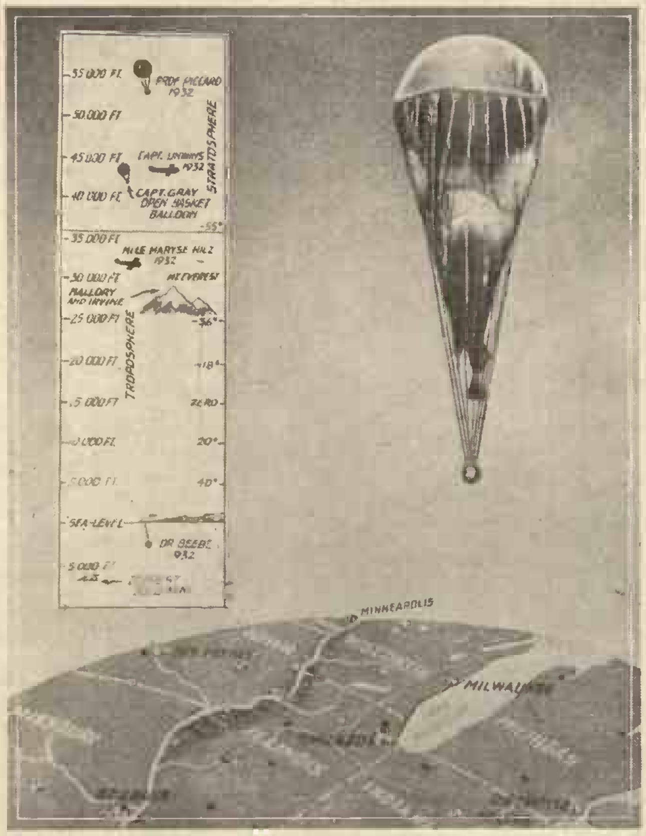
Fig. 1.—The circuit diagram of the "Radio Sonde" miniature transmitter.

miles. It served as a convenient protection at night against the bitter cold of outer space, and as an equally-useful screen in the day against the full fury of the sun. And there our knowledge—and interest—ended.

But when Marconi sent the first wireless signal across the Atlantic, scientists began to realise that the matter could not rest there. If radio waves were the same as light waves—and of this there was no doubt—they certainly could not follow the curved surface of the earth for more than 3,000 miles without some outside help.

And so Heaviside in England, and Kennelly in America, both argued that there must be a conducting layer, well above the accepted limits of the ordinary atmosphere, which blocked the straight-line path of the waves and diverted them back to earth. Before long this ingenious theory was proved to be correct, and the layer was located by actual experiment at a height of some forty miles above the ground.

More recently Professor Appleton has shown that there are at least two other layers, the uppermost being approximately twice as high as the Heaviside layer. Meanwhile other investigators have found that the region between the two layers contains a highly-fascinating collection of molecules of ozone, and other gases, together with wandering masses of free ions and electrons.



A pictorial sketch of Prof. Piccard's balloon ascending into the stratosphere and (inset) a chart showing the highest and lowest points reached by man.

The Lines of Force

From another point of view we also know that the earth is an immense natural magnet with multitudinous lines of force spreading from the North to the South pole. These reach out for hundreds of miles above the ground. At times they interact with moving masses of electrons in the stratosphere and produce some strange results, of which the Aurora Borealis or Northern Lights is a striking example.

Altogether the upper region of the atmosphere has become a happy hunting ground for up-to-date research. The wireless engineer has discovered how to shoot short-wave signals straight "into the blue," and to estimate the heights of the various layers by measuring the time taken for the reflected signal to come back to earth.

And right here they have run into one of the most baffling of all radio mysteries. Some of the "echoes," it is found, take as long as twenty seconds to complete their outward and homeward journey. This means that they must have travelled no less than 4,000,000 miles at 200,000 miles a second. It may be that they make a straight-line journey into outer space until they meet some reflector. There is another theory that in some mysterious fashion the waves get trapped between the upper and lower layers in the stratosphere, and continue to "skip" from one to the other until they have gone many times around the earth. Finally, they manage to break through at some point and get back to earth.

Long Distance "Echoes"

The true explanation of these long-distance "echoes" has not yet been found, but investigations are now afoot which, it is hoped, will provide the missing clue.

Meanwhile, there is much to be done in exploring the so-called lower limits of the atmosphere, particularly the region up to the first or Heaviside layer.

Since wireless gave the first impetus to our curiosity concerning the stratosphere, it is only fitting that it should be largely used in actually carrying out the work of exploration. As already mentioned, most of our precise knowledge of the uppermost regions is based upon the measurement of short-distance wireless "echoes." Recently, an ingenious self-contained radio transmitter has been designed for taking direct observations of the temperature, pressure, and humidity of the regions extending say from six to twelve miles high.

The "Radio Sonde," as it is called, is carried by a small balloon about 6 ft. in diameter, capable of attaining an altitude of over ten miles. The exact height is measured by theodolite observations taken from the ground, whilst a careful record is made of any alteration in the frequency of the radio signals received from it.

The Design of the Transmitter

This is shown in Fig. 1. As it is essential to reduce weight to the lowest possible limits, both the filament current and plate voltage are derived from a single dry-cell battery A, through a vibrating make-and-break contact K, and a step-up transformer T.

It is possible in this way to step-up to the voltage from a 2-volt cell, so as to put 1,000 volts, if necessary, on the plate of the valve. The make-and-break contact, of course, means that the filament is only energised intermittently, as indicated by the curve marked A in Fig. 2. But during each interval a continual series of high-frequency oscillations (marked B) are generated by the back-coupled valve.

These form a practically continuous carrier wave having a frequency which is carefully stabilised by the piezo-electric crystal Q in the tuned grid circuit. The make-and-break contact superposes a note or modulation frequency, which is heard by the operator.

The critical factor is the note frequency due to the make-and-break contact. The rate of vibration of the reed is controlled by a thermometer or barometer.

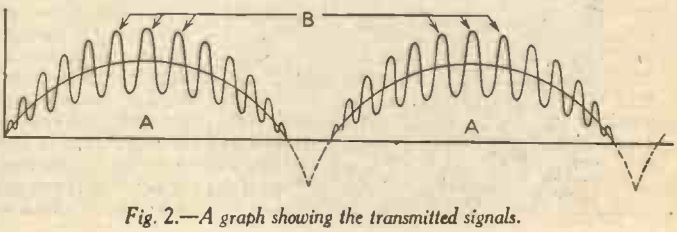
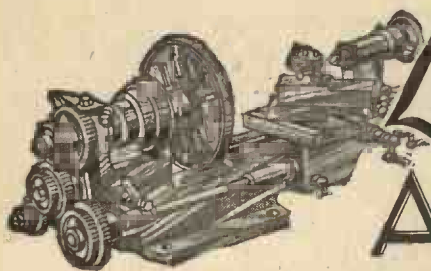


Fig. 2.—A graph showing the transmitted signals.



Lathe Work FOR AMATEURS

USING AND FITTING GEARED SCROLL CHUCKS

By W. H. DELLER

THE handiest and most-used item in the equipment of a centre lathe is definitely a geared scroll chuck. The class of chuck now being referred to is that which is provided with two sets of three jaws. One set is for holding bar work, the jaws being stepped away from the centre also allow them so to be expanded into bored holes when necessary to operate on outside diameters or faces. The second set are stepped away towards the centre and will hold work that is outside the capacity of the other jaws. Without at the moment going into the construction, it is sufficient, to avoid confusion, to state that the bottom or toothed portion of the jaws are square with the gripping faces.

Fitting a Chuck

Chucks are not included as standard equipment with a lathe, so that when a new lathe is purchased the question of a chuck or chucks is one that has to be considered. Where the lathe is a screw-cutter, the most satisfactory procedure is undoubtedly to do the work of adapting the chuck to the spindle on the lathe itself.

Having selected a chuck of dimensions in keeping with the lathe, that is to say, one of a diameter which will swing over the saddle, and ensuring that the weight of it is not too heavy for the spindle, the next consideration is that of fitting an adaptor.

The adaptor or backplate can be made from a standard iron casting. Such castings are supplied in varying sizes suitable for chucks of any diameter.

Before proceeding with the machining,

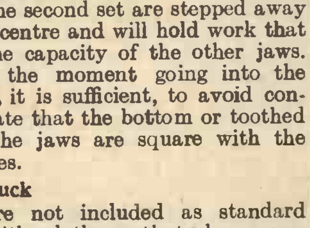


Fig. 2.—Where the jaws are worn so that they grip only at the back, they can be corrected by lapping (see Fig. 3).

reference to Fig. 1 will make several points clear. The first is that the back face, seating on to the shoulder of the lathe nose, must be flat. Secondly, the register bored in the back must be a good fit on the corresponding portion of the lathe nose, and, lastly, the thread must be an easy fit. The true running of the chuck is largely governed by careful attention to these details. It is obvious that a bad-fitting register will allow the backplate after fitting to "pull up" out of truth by an amount equal to the difference in diameters in any direction. A tight- or good-fitting thread is likely to cause trouble should ever it become at all gritty, and may also prevent the back face from seating properly. Where the lathe is a second-hand one and any doubt exists as to the truth of the face of the shoulder, it would be best to correct it by taking a light skimming cut. Where this is done, however, do not forget to see whether it has affected the true running of the face-plate, and reface if necessary.

Machining the Adaptor

To ensure that this register does fit properly it is not a bad plan to turn a short plug on the end of a piece of bar between the centres to exactly the same diameter as the register on the nose of the headstock.

After measuring the total length of the thread and register and finding the

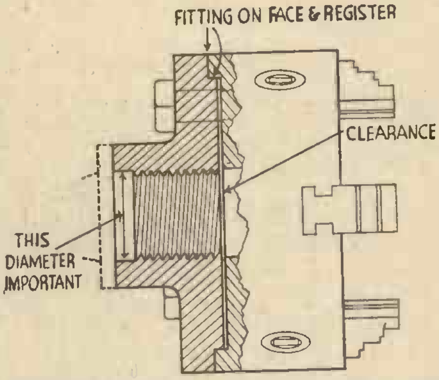


Fig. 1.—The back face, seating on the shoulder of the lathe nose, must be flat, and the register bored in the back must be a good fit.

pitch of the thread, mount the adaptor casting on the face-plate. Turn outside and face sufficient material off the small boss to leave the total length of the casting $\frac{1}{8}$ to $\frac{3}{16}$ in. longer than the length of the nose. This may entail removing a lot of metal, but it should be remembered that by so doing the amount by which the chuck would otherwise overhang is reduced. Bore the hole for the thread slightly larger than is ordinarily necessary to leave a flat on the crest of the threads when cut. After screwing remove the face-plate from the lathe with the casting still upon it, and make sure that the thread fits easily. Being satisfied about this, bore the register about $\frac{1}{16}$ in. deeper than the length of the plain portion so that the plug previously made is a good push fit in the hole. Slightly radius the sharp corner at the front edge of the register and remove the partly machined casting from the plate.

The remainder of the machining is carried out with the part screwed on in position, machining the front so that the face is just proud of the end of the spindle. Measure the depth of the register in the back of the chuck and turn a short spigot on the face of the casting to fit this closely, seeing that it is clear of the bottom by $\frac{1}{32}$ in. Turn the outside diameter of the flange, and if it is necessary to reduce the thickness reverse the adaptor, placing a distance piece on the nose to take up the plain portion. Except for drilling the adaptor is complete. Mark an accurate pitch circle for the bolt holes with the point of a screw-cutting tool. Subdivide the circumference into three equal parts and drill holes to clear the fixing bolts. When the adaptor is placed into position the bolts should enter the threads in the chuck body without any suggestion of binding in the plain holes.

Presuming that a piece of bright bar runs truly when held in the chuck, reasonable care should be taken in order that this condition is maintained for as long a period as possible. Although of robust construction it is possible by careless use to destroy easily the feature that has been established, so perhaps a few of the things not to do may be of service. The commonest trouble is that resulting from constantly using the chuck for holding rough work such as castings, which do not allow the jaws to take an even bearing throughout their entire length. This practice should be avoided, as also that of holding short pieces of bar material near the front ends of the jaws for turning purposes, unless the work is lightly held and supported with the back-centre, otherwise in both cases the tightening of the jaws sufficiently to hold the work securely is bound to impose an undue strain upon the chuck.

Prevent as far as possible the entry of borings into the front of the scroll. A piece of screwed-up paper or rag stuffed into the slot will do much to exclude borings and metal dust.

Another thing to avoid is using undue strain on the key when tightening the chuck. The tommy-bar fitted to the key affords sufficient leverage, and the practice of obtaining extra leverage by supplementing the length of it is one to be condemned. A thorough occasional cleaning will do much to maintain the chuck in good working condition. To do this satisfactorily the chuck is taken to pieces. Remove the jaws and the backplate. The halves of the body casting are held by screws, usually inserted from the back of the chuck. Upon removal of these the scroll and pinions can be taken out for cleaning. However much care has been taken to exclude the entry of dirt a fair amount will have entered; look for it particularly in the bottoms of the bevel gear teeth. While the scroll is out examine the face of it for burr.

Much can be done to restore a chuck that has become out of condition owing to straining or wear of the jaws. Where jaws are worn so that they grip only on the back end as shown in Fig. 2 they can often, provided that they are not too bad, be corrected by lapping. Fix the jaws rigidly by expanding them into a true ring such as a ring from a ball-race. The lapping process is then carried out with an expanding lap rigidly held in the tailstock as in Fig. 3.

In cases where the chuck will not hold bar material so that it runs concentrically more drastic measures have to be adopted. After having noted the direction in which the work must be moved in order to make it run true, remove the jaws and carefully grind a little from the gripping face of the jaw or jaws.

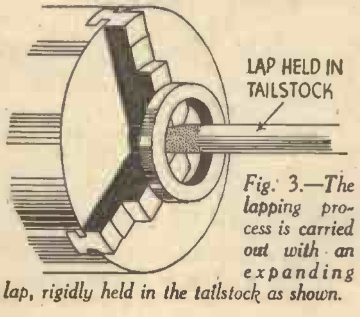
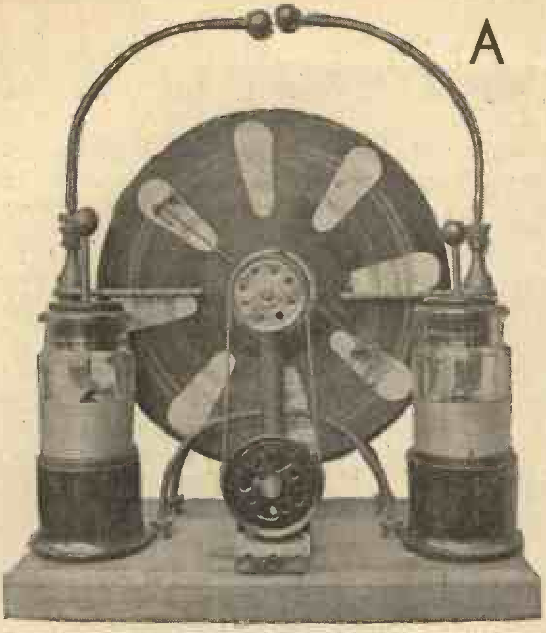


Fig. 3.—The lapping process is carried out with an expanding lap, rigidly held in the tailstock as shown.

A 40,000-VOLT WIMSHURST MACHINE

By W. SHEPHERD, F.G.S. PART TWO

Simple but effective experiments that may be carried out with the aid of a Wimshurst machine, constructional details of which were given last month.



A front view of the Wimshurst machine.

THE Wimshurst machine, as described last month, gives a continuous succession of small thin sparks. An enhanced effect is produced by connecting a couple of condensers to the terminals. These are capable of accumulating the charges of electricity until they are full, and then discharging them suddenly in a violent blue spark. This should on no account be taken through any part of the body, or a severe shock will be felt.

The type of condenser usually employed is the Leyden jar, shown in Fig. 1. It is quite easy to make from a jam-jar as follows. Wash and dry the jar thoroughly, and line it with tin-foil to about three-quarters of the way up inside. The easiest way to do this is to cut up several small strips of "silver paper," and stick them in with seccotine, one at a time, so that they overlap one another. Then the outside of the jar is coated to the same level, in the same way. The cork, or vulcanite stopper, carries a short brass rod with a ball on its upper end. The lower end must make some sort of metallic contact with the inner coat of foil, the simplest way being by means of a short chain.

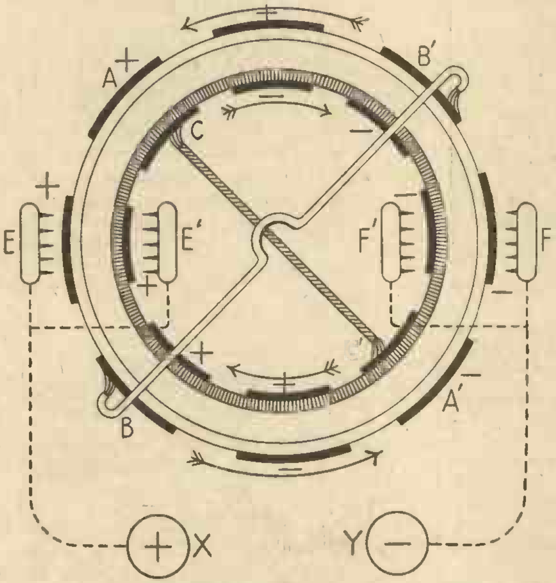


Fig. 3.—The two plates are represented by concentric circles for the sake of simplicity, the back plate with its brushes being shaded.

When two of these jars have been made, connect the brass rods or balls with the two terminals, or the comb-bearers, of the machine, and either earth their outer coats, or connect them together by standing both jars on the same strip of metal. The machine will now produce the large sparks at about one second intervals, the size (but not the length) of the sparks, and the interval, depending on the size of the Leyden jars used.

The Principle of the Wimshurst Machine

In Fig. 2, A is an insulated conductor charged with positive electricity. If an uncharged conductor B is brought near it, a

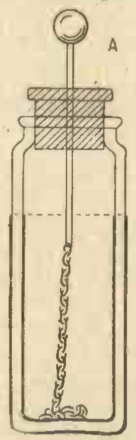


Fig. 1.—Details of a simple Leyden jar.

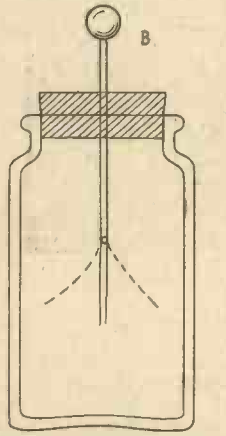


Fig. 4.—The electroscope which is useful for testing charges in the Wimshurst machine.

strange thing happens. Its neutrality is destroyed, and a negative charge is found to be induced on the side nearest A, while its opposite side acquires a positive charge! If it is now moved away again, its two charges "flow together" and neutralise each other, and everything is restored to its original condition. But suppose that while near A, the positive side of B is earthed by touching it with a finger. The positive charge disappears, and when it is removed from the vicinity of A, B is found to be negatively charged. The important thing is that though B has been given an electrical charge, A has not lost any of its original positive charge. It looks like something for nothing, though the new electrical energy has really come from the work done in removing the two balls, which very slightly attracted one another.

It will be noticed in working the Wimshurst machine that it is quite hard to turn the handle when it is functioning well. This is due to the electrical attraction between the various parts of the machine, and the extra energy you have to employ to overcome this is the source of the electricity the machine produces.

In the diagram (Fig. 3) the two plates are represented by concentric circles, for the sake of simplicity, the back plate, with its brushes, being shaded. The black lines are the foils. Imagine the foil A to have a positive charge. Then foil C, being momentarily earthed on the side away from A by the brush, acquires a negative charge, and travels round to comb F′, which collects it up. But before it gets there, it induces a positive charge in foil B′, where that is earthed by a brush, and B′ moves round to give up its charge to comb E. Thus there is a continual multiplication of charges, positive ones always moving towards the combs E, E′, and the negative ones to F, F′.

The Electroscope

A useful little instrument for testing charges is the electroscope shown in Fig. 4. The cork of a clean glass jar carries a brass rod and ball, as in the case of the Leyden jar. But the lower end of the rod supports two strips of metal foil, which hang close together. Gold leaf is the best substance to use, though very thin "silver" or aluminium paper will serve, provided the leaves are long enough to hang down straight by their own weight. If a charged conductor is brought near to B, the leaves repel each other, and fly apart. Charges can easily be carried from one place to another on a metal ball held by an insulating handle, as shown in Fig. 2. The vulcanite handle is taken from a wireless lead-in tube, and the brass rod cemented in with sulphur. A good, round brass door-knob can be mounted in a glass ink-well (the old-fashioned, solid, square type), and used for the same purpose.

An interesting experiment can be performed with the Wimshurst machine, as follows. Disconnect the Leyden jars, and separate the knobs so that no spark will pass. To one of the knobs attach a sharp metal point, such as a gramophone needle, with a small piece of wax, making sure that there is metallic contact. Turn the machine, and a distinct "electrical wind" (consisting of electrically-charged air and dust particles) can be felt blowing off the point of the needle! It will even blow out a candle flame, or turn a small vane.

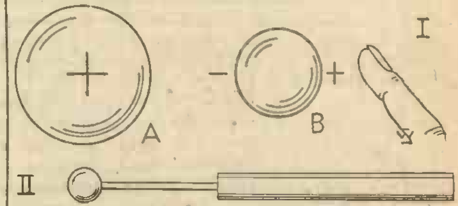


Fig. 2.—Charges can easily be carried from one place to another on a metal ball held by an insulating handle as shown.

MONORAIL

This article deals with the principles of true mono- those in which the car or carriage runs on one vertically above the carriage over

A demonstration railplane, showing the method of erecting over existing railway lines near Glasgow.

THERE are three systems of mono-rails:

(1) The system in which the car is above the rail and is balanced or kept upright by means of gyroscopic control, and known as the Brennan mono-rail.

(2) The system in which the cars run upon and astride a continuous A-shaped trestle, the balancing principle being similar to that shown in the toy acrobat in Fig. 1; A and B representing the cars.

(3) The system in which the car is hung pendulum fashion below an overhead rail, the supporting bracket obviously running down to the car on the outer side of the rail only.

A Question of Speed

Now the reader may say why trouble about mono-rails; isn't the bi-rail good enough? It is very largely a question of speed. It is impossible to attain, with any degree of safety, a very high speed on an ordinary bi-rail unless the cars are given an excessive weight. In 1903 a bi-rail car was run in Germany between Berlin and Zossen, which for a short distance actually attained a speed of 130 m.p.h., but the weight of the car was 94 tons, and the standard gauge was also reinforced with two guide rails, the whole with fixings weighing 460·53 lb. per yard. Now let us consider the three mono-rail systems and see which holds out the best and *safest* prospect of, say, London to Brighton in twenty minutes.

Take No. 2 first. It is a good example of a perfectly workable and safe high speed railway—but it is one presenting considerable difficulties, the chief of which is the impossibility of switching the cars from one line to another except by means of turntables; also such a system would give rise to excessive friction and thus greatly increase the running cost; moreover, although mechanically in most ways sound, it is certainly cumbersome, everything being in duplicate.

Next consider No. 1. The wonder of riding on a single rail, without any other means of support, is one which appeals highly to the imagination. The fact that the Brennan system requires only one rail led many to suppose that the cost would be much less than that of an ordinary railway; but this one rail must obviously be as heavy and strong even if not stronger than the two bi-rails. Again, the

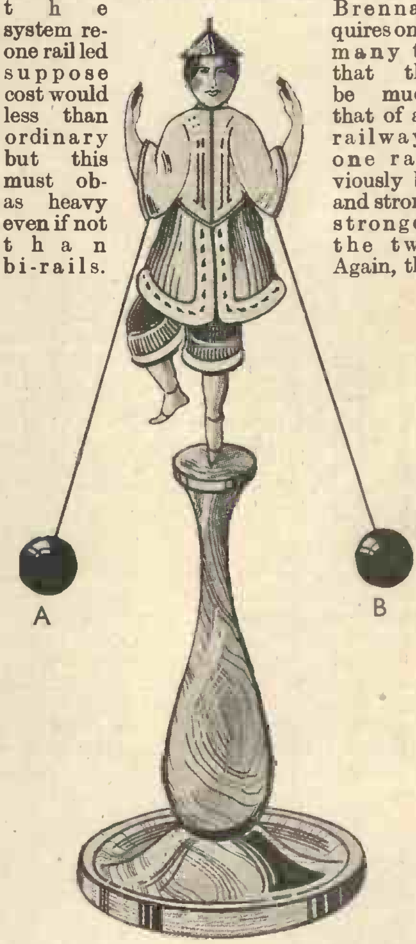


Fig. 1.—A toy acrobat which demonstrates the system in which cars run upon and astride a continuous A-shaped trestle.

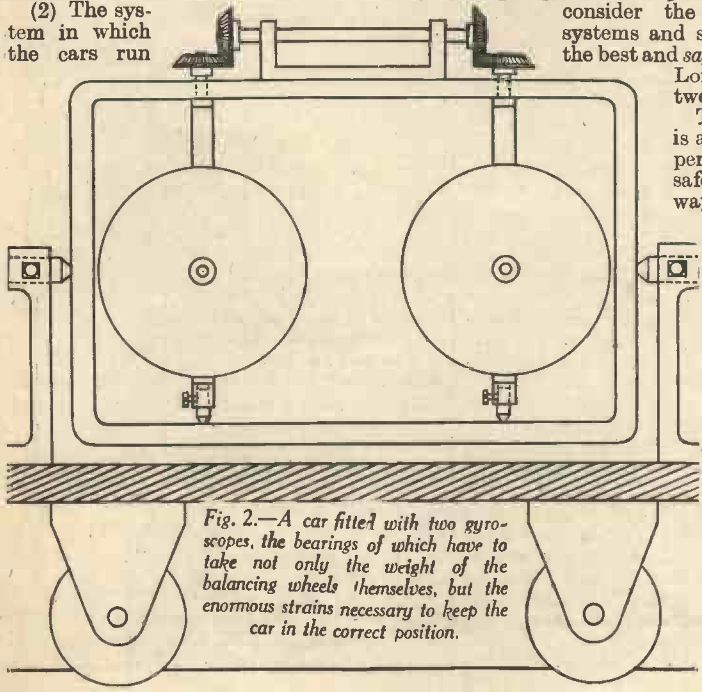


Fig. 2.—A car fitted with two gyroscopes, the bearings of which have to take not only the weight of the balancing wheels themselves, but the enormous strains necessary to keep the car in the correct position.

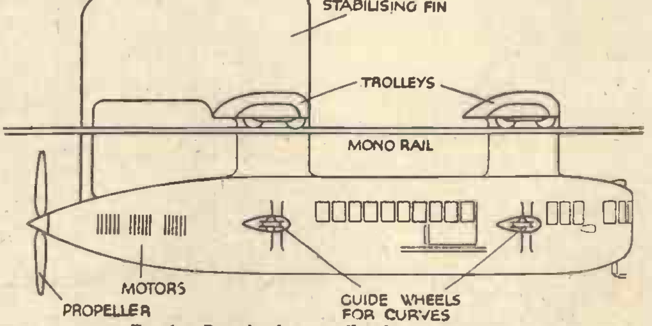


Fig. 6.—Details of a propeller-driven mono-car.

—SYSTEMS

rail systems and excludes any system of bi-rails or rail and is kept from overturning by a rail placed the one on which it runs. By V. E. JOHNSON, M.A.

great expense of having to fit every car on the line with a couple of gyroscopes (see Fig. 2), the bearings of which have to take not only the weight of the balancing wheels themselves, but the *enormous* strains necessary to keep the car in the correct position present insuperable mechanical difficulties. And, lastly, this system, unlike systems 1 and 3, is not mechanically sound, the car is held in its position not by delicate balancing force, but by the brute force of the whirling gyroscopes.

How the Car is balanced

Scientifically the system is fascinating enough, so let us consider very briefly how the car is balanced. Fig. 3 represents a very simple form of gyroscopic mono-rail. As can be seen, the outer ring of the toy gyroscope is itself mounted on another larger ring, thus giving it freedom to "precess," *i.e.*, the axis or axle of the gyroscopic disc is capable of rotating in (when the model is upright) a horizontal plane. This axle, as the illustration shows, runs between two curved metal strips. These metal strips are not the same depth throughout, and are so adjusted that when the rotating axle turns in one direction it touches the upper one and runs along it. When it turns in the other direction it comes into contact with the lower strip and functions in the same way. In either case, when the gyroscope is spinning and the model tilts one way, the gyroscopic axle swings round in one direction and *vice versâ*. The direction of swing depends on which way the gyroscope is rotating. Such a model will take a curve in one direction only, according to which way it is spinning. Louis Brennan overcame this difficulty by gearing two gyroscopes together as shown in Fig. 2.

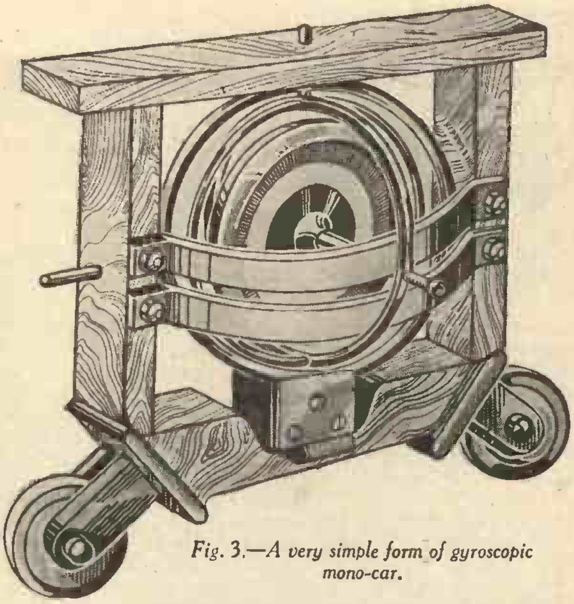


Fig. 3.—A very simple form of gyroscopic mono-car.

System No. 3

Some years ago the writer constructed models on this system which were just rectangular frameworks of wood suspended on easy running pulleys and driven by strands of twisted rubber. He arrived at some very interesting facts, which so far he has never published. In one case the twisted rubber drove a propeller, just like a model aeroplane; in the other by suitably gearing one of the pulley wheels on which the framework ran. Given exactly the same amount and kind of rubber and the same number of turns, the propeller-driven model was just as fast and just as efficient as the other. Electrically-driven models also gave the same result.

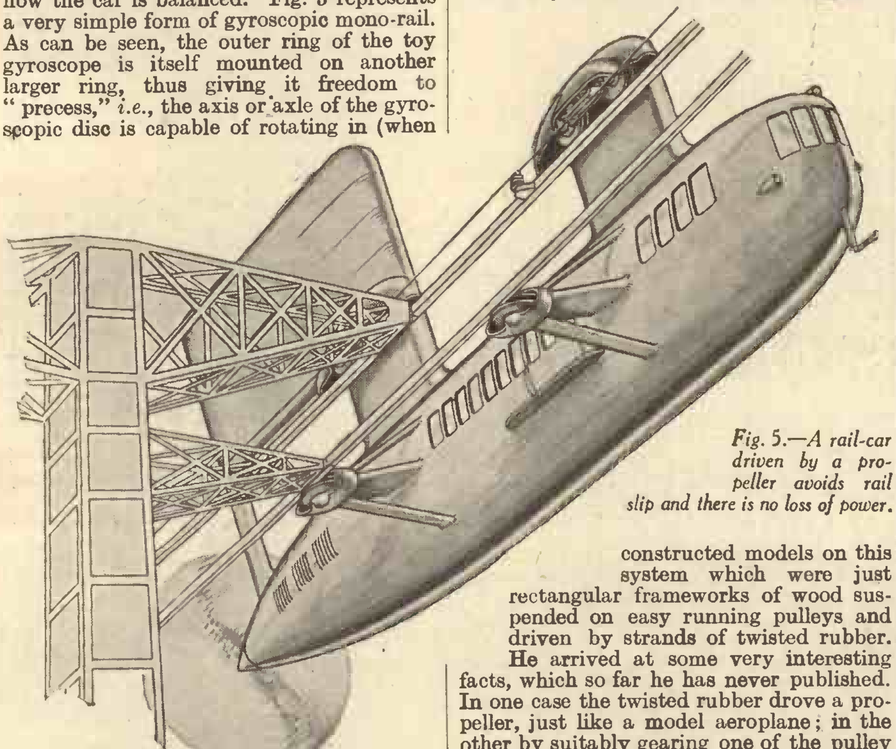


Fig. 5.—A rail-car driven by a propeller avoids rail slip and there is no loss of power.

The track was steel wire on suitable supports some 50 yd. long and curved to the left. In this case a rail was used. In the first experiment the model on taking the curve swung outwards and (naturally being a pendulum) it then swung back and inwards, under gravity. The double flanged wheels then mounted the rail and the model became derailed, resting on the axles of the flanged wheels. It thus became necessary to fix on the skeleton car two double-flanged wheels in a horizontal direction, situated on the horizontal line through the centre of gravity of the car and arrange a suitable horizontal guide rail round the curve for them to run on. These held the model inclined outwards at the proper banking angle, and the curve could then be taken with ease and perfect safety at a speed which would mean in a full-sized car at least 120 m.p.h.

To take a curve in either direction a car must be provided with such guide wheels on both sides, and one guide rail on the appropriate or inner side of the curve.

A Propellor-driven Car

The advantages of driving the car with a propellor or propellers is that no wheel slipping on greasy rails is experienced, and there is no loss of power through gearing and far greater simplicity. Such a system possesses a high state of efficiency because both electric motors and propellers can now be constructed each with an efficiency of over 90 per cent.

Since the car is suspended from above

(*Continued on page 432.*)

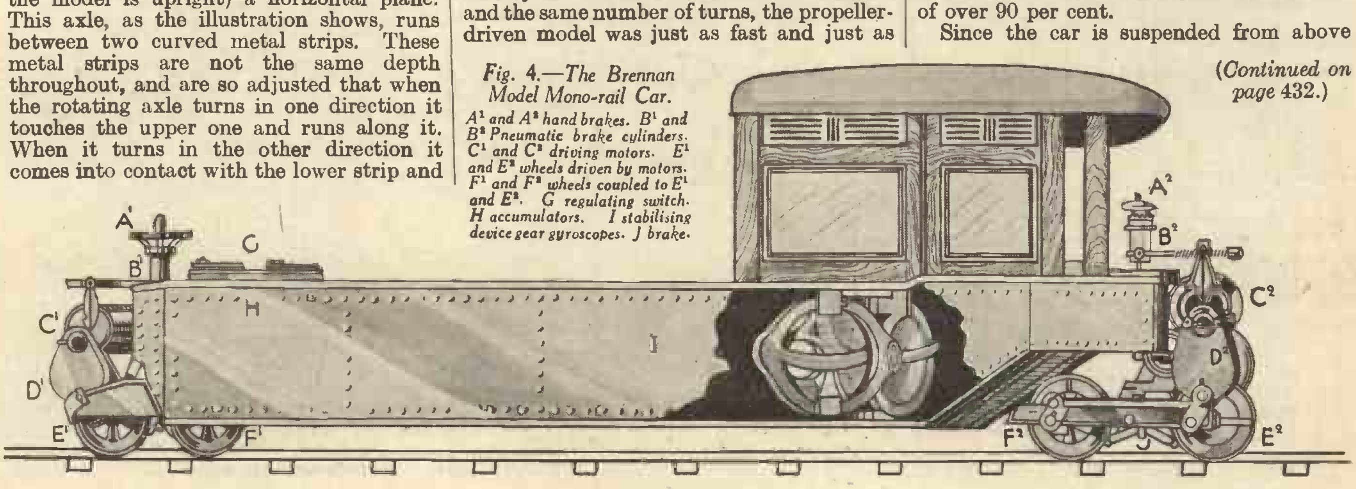


Fig. 4.—The Brennan Model Mono-rail Car. A^1 and A^2 hand brakes. B^1 and B^2 Pneumatic brake cylinders. C^1 and C^2 driving motors. E^1 and E^2 wheels driven by motors. F^1 and F^2 wheels coupled to E^1 and E^2. G regulating switch. H accumulators. I stabilising device gear gyroscopes. J brake.

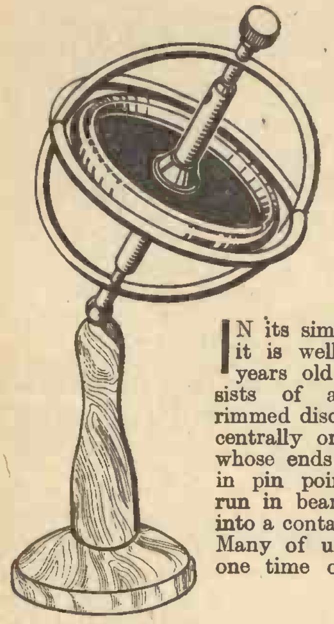


Fig. 2.—*The stand shown here is preferable for experimenting with the top.*

MARVELS OF THE GYROSCOPE

In this article the author deals with the extraordinary powers attributed to this simple little toy.

By V. E. JOHNSON

IN its simplest form it is well over 100 years old and consists of a heavily rimmed disc, mounted centrally on an axle whose ends terminate in pin points, which run in bearings fitted into a containing ring. Many of us have at one time or another possessed one and marvelled at its gravity-defying and balancing properties, but who would have thought that in this toy lay concealed the following secrets: (1) travelling along the top of a single strand of wire, (2) steering a ship with far more accuracy than by means of a mariner's compass, (3) automatically and accurately steering a torpedo, (4) finding the true north, (5) proving the rotation of the earth, (6) steadying either a gun platform on a rolling and pitching vessel or a camera when taking pictures for the "talkies," (7) steadying an entire vessel at sea, automatically controlling an aeroplane in flight, and finally, perhaps, teaching us the true molecular structure of the universe? What conclusions are we to draw from this: that all these marvels are dependent on some wonderful property possessed by the spinning top or gyroscope or that it possesses a number of remarkable properties capable of being differently applied? To a certain extent both principles are true.

Simple Experiments

If it is desired to acquire any real knowledge it is always necessary to experiment. Obtain a toy gyroscope, as shown in Figs. 1 and 2. Hold it with the thumb under one screw-end centre and the first finger over the other, give a good spin to the disc, having previously oiled the bearings, and it will be found that it offers very considerable resistance to any attempts to turn its axle from its original position or from one position to another, the top exerting a peculiar side thrust just as if it were trying to twist itself out of one's hand. In fact, if it is not held tightly, and the spin is a good one, this will probably happen.

A small three-legged wire stand in which either screw end of a gyroscope can rest (see Fig. 1) is generally sold with the top, but the stand shown in Fig. 2 is preferable for experimenting. Spin the disc and place it upright with one screw end in the cup, and it will fall very gradually, circling round and round, faster and faster, as it does so, but not finally falling until its axle is lower than the horizontal.

Its Two Properties

This circling motion is known technically as "precessing." Again spin the top, but in the opposite direction, and notice carefully any difference in its behaviour. Obtain a "set square," again spin the top, the stand having previously been placed on a smooth table. Allow the top to circle or "precess" until it has reached, roughly, the position shown in Fig. 1. Slide the set square along the table so that you give a gentle push to the screw knob, A, in the direction in which it is "precessing," and the top will rise—in opposition to gravity. Now do the opposite—*i.e.*, slightly delay the "precessing" movement, and the top will fall. Note in both cases that the "push" should be perfectly horizontal. In these two simple properties, scientifically applied, lie nearly all the "secrets" of the marvels of the gyroscope.

It is only when the axis *is* allowed to precess that it can exercise any resisting, *i.e.*, stabilising or steadying effect, for if the "precessing" movement is stopped the mechanism at once falls.

Why a Top rises

When an ordinary (not gyroscopic) top is circling round and round, if the spin be fast enough, it rises to a more erect position, not infrequently to a perfectly vertical one. Now, as the top is not touched during the process, the only cause that can produce this effect is the friction between the peg and the floor or whatever it is spinning on. Fig. 3 is a representation on a *very* enlarged scale of the vertical section of the peg of a top. In (*a*) the top is spinning in an upright position and the axis of spin, AB, is vertical. It is spinning on the surface, EF, on its lowest point, A. In (*b*) it is inclined at an angle to the vertical, GL, and spinning about GB′. Now imagine GB′ to be the axle of a wheel, whose diameter and position are denoted by KH, rolling on the table. As this wheel rotates (clockwise as seen from above) the rotation will cause it to roll towards the centre. The circling movement is doing this, for a spinning body sup-

(*Continued on foot of page* 412.)

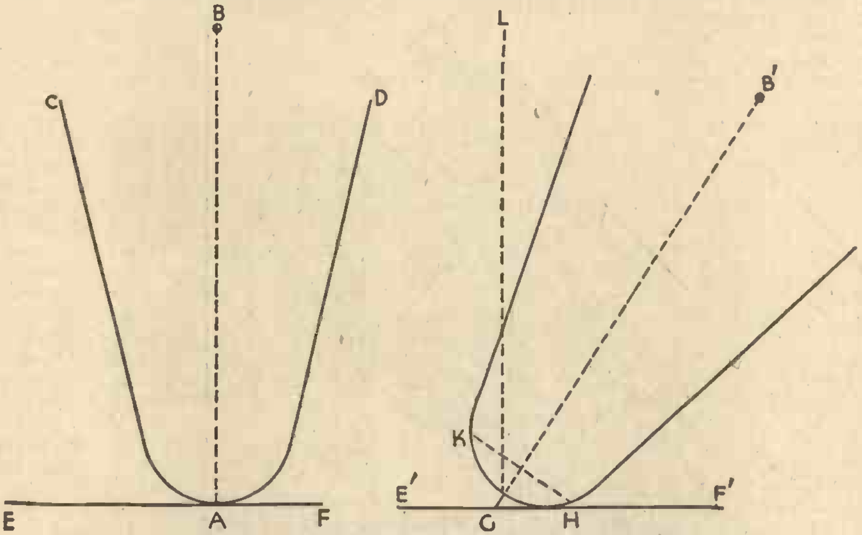


Fig. 3.—A representation, on a very enlarged scale, of the vertical section of the peg of a top.

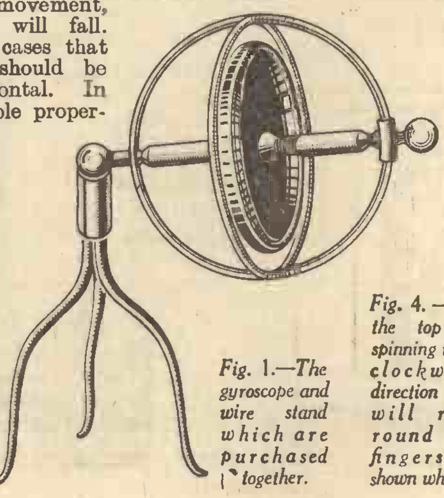


Fig. 1.—The gyroscope and wire stand which are purchased together.

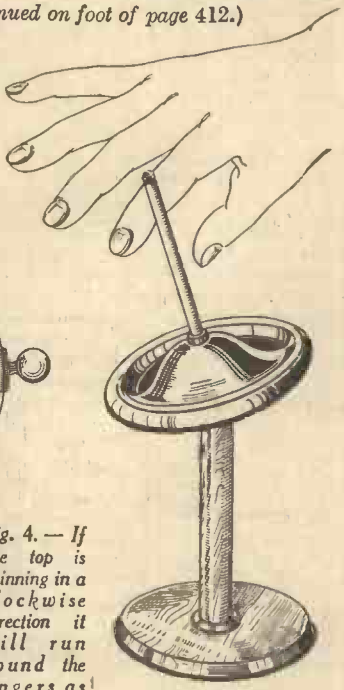


Fig. 4.—If the top is spinning in a clockwise direction it will run round the fingers as shown when they are placed against the axle.

Fig. 3.—The rigid dipole across the structure situated at the top of the South Tower, Crystal Palace.

HIGH DEFINITION TELEVISION

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

The author this month continues his description of the development of high definition television, and deals now with the studio transmitting arrangements and the receiving apparatus.

IN all forms of spot-light television transmissions the principles involved are the same, and the greatly improved results achieved in recent demonstrations may be attributed mainly to entirely new amplifier design, new photo-electric cells of greatly improved sensitivity and light response, the use of cathode ray tubes and the employment of an ultra short wave radio link between the transmitter and the receiver.

Frequency Limitations

Spot-light television in the early days of its development, while extremely interesting, failed lamentably to maintain public enthusiasm once the initial wonder had worn off. Small photo-electric cells of low sensitivity coupled with a relatively weak spot illumination confined artist movement to a very small compass, while the nature of the subject portrayed, owing to the small amount of detail present in the received image, gave very little scope to the ingenuity of the studio producer. With the passage of time considerable improvements were effected, and it is admitted on all sides that the regular television programme now featured by the B.B.C., using the 30-line, 12½ pictures per second apparatus, has reached quite a high degree of quality and entertainment value.

The medium broadcast band of wavelengths, however, definitely limits the sideband spread in the televised image with the result that high definition television has necessitated the development of an entirely new radio technique to serve as a link between the transmitting and receiving ends. This is known as ultra short waves (those wavelengths below 10 metres), and when it is recalled that a difference of only 1 metre—say between 5 and 6 metres—represents a frequency difference of 10,000,000 cycles, (enough for all the broadcasting stations in the world to work with a 10-kilocycle separation), it will be at once apparent that the very high frequencies present in the latest form of television image can very easily be accommodated.

Fig. 1.—Showing the relative position and size of the photo-electric cells.

Spot-light Transmitter Details

In the actual spot-light demonstrations an apertured disc was made to rotate at high speed before an intense arc source of light. The apparatus gave 25 pictures per second, and in consequence, flicker (always apparent with the low definition television transmissions of 12½ pictures per second), was absent. This represents a higher rate of picture portrayed than the modern talkie, where 24 pictures per second is the standard.

The beam of light from the arc lamp is focussed on the top section of the disc, and since this is of large diameter, the pencils of light passing through each minute hole trace out a series of horizontal lines, and in the total field of light scanning the televised subject there are 180 separate lines. Either one of two separate lenses of different focal lengths can be brought into play at will by the engineer in charge of the transmitter, the first giving a close-up field (head and shoulders only) and the second an extended field (head and half the body). A thick wall separates the studio and transmitting room, a rectangular aperture with plate glass let in allowing the focussed light spot to pass into the studio and scan the subject being televised.

During the exploring process different parts of the head and body reflect differing amounts of light, and these are picked up by the three very large photo-electric cells which are positioned just in front of the subject, as indicated very clearly in Fig. 1. The cells have the property of converting these light variations into equivalent voltage variations, and by passing them to the grid of the first valve stage in an "A" amplifier, the resultant signals are amplified and passed to the control room.

At the same time the light spot transmitter generates a synchronising signal which is combined with the picture signal for transmission purposes on the ultra short wave channel. A sensitive micro-

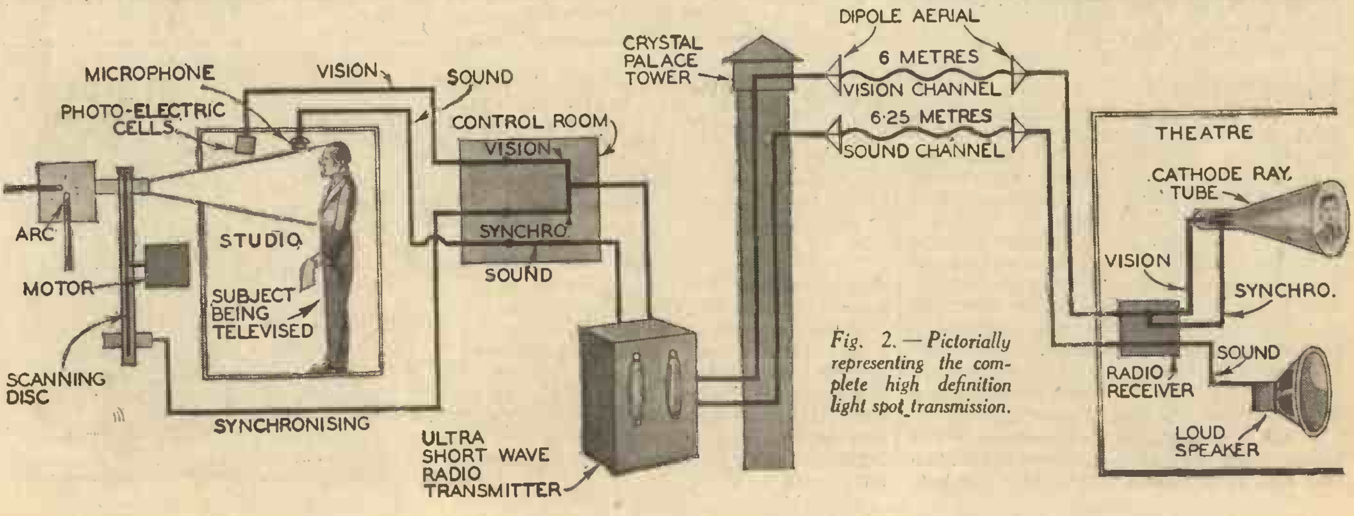


Fig. 2.—Pictorially representing the complete high definition light spot transmission.

Fig. 5.—The effect produced by over-modulating a 120-line cathode ray tube image.

Fig. 6.—" Soft " tubes produce this type of image on the screen.

phone picked up the accompanying sound in the studio, and the resultant signals from this source were also passed to the control room for ultimate transmission on a second ultra short wave channel. Every precaution was taken to make the studio quite sound-proof, while as a guard against high-frequency signals affecting any of the very sensitive apparatus, the studio was also copper-lined, this forming a most effective screen.

The scheme is shown pictorially in Fig. 2, and from this the reader will see that the signals are fed from the control room to the ultra short wave radio transmitter situated at the base of the South Tower at the Crystal Palace. Here they are made to modulate the generated carrier wave, and are then transferred to the special dipole aerial fixed at the top of the tower and indicated in Fig. 3. The rigid structure had to be designed with extreme care in order to withstand the wind pressures encountered at this height, for the tower is actually 282 ft. high. From this aerial the signals are radiated into space, and an elaborate series of tests by the Baird engineers has proved that this ultra short wave radio transmission covers an area embracing the whole of Greater London, and even beyond, for good signal strength.

The Receiving End

The whole of the apparatus shown on last month's cover was accommodated in a small theatre in Film House, Wardour Street. From the point of view of ultra short wave radio reception, this is an extremely bad site for these quasi-optical waves, as they are sometimes called, unfortunately are ready victims to interference from the ignition systems of motor cars, and there are heavy streams of traffic passing along neighbouring thoroughfares. Added to this, additional interference arises from lifts, motors, flashing signs, arcs, and so on, inside the building itself.

Extreme care had therefore to be taken in the design of the ultra short wave radio receiver in order to overcome these difficulties, and although, at the moment, no details have been furnished concerning the type of receiver employed, the clear images shown on the cathode ray tube pay tribute to the fact that the interference difficulties have been successfully overcome. After detection and amplification the signals are passed to the cathode ray tube. This tube is shown in Fig. 4, and is an entirely new Baird development, it being claimed as unsurpassed for size, brilliancy and colour of the received image. The standard cathode ray tube shows a green picture, but this new tube builds up an image on its fluorescent screen which is a pleasing sepia tone.

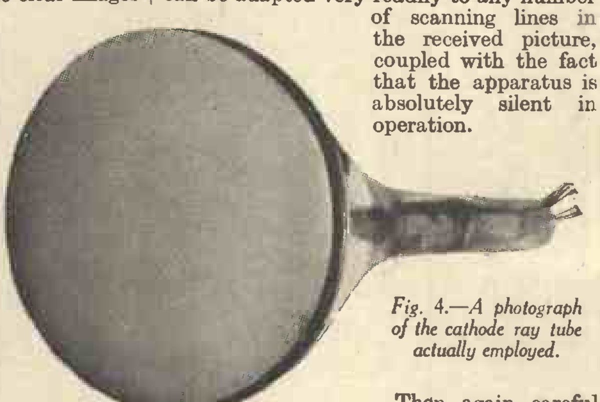


Fig. 4.—A photograph of the cathode ray tube actually employed.

The amplified signals are made to modulate the beam of electrons passing from the cathode and constrained to pass to the front fluorescent screen at enormous speed, owing to the accelerating potential provided by the voltage applied to the orificed anode. The high velocity of the electron impingement on the screen renders them visible and by controlling their movement as a result of the automatic synchronising signals applied to the deflecting plate, and using intensity modulation, an image complete with all the light, shade, detail and half tones of the transmitted subject appears on the screen. This is magnified by a large lens so that it can be seen all over the small theatre, the accompanying sound signals being heard from the large loud speaker situated below the screen.

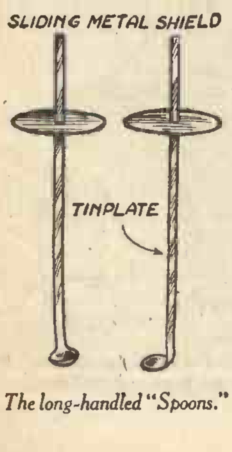
Cathode Ray Tube Technique

The control of the light spot movement, apart from its modulation, is effected by two electrical time bases connected to the two pairs of control plates. The action is called a saw-tooth movement, as the return stroke of each scanning line has to be extremely rapid, whereas the forward movement is quite uniform. The vertical and horizontal traverses of the electron beam can be adjusted entirely independently of each other, but while this is of great advantage in experimental work, it is usually advisable in practice to interlock the vertical and horizontal movements to prevent any " floating " or " hunting " of the image.

Very careful attention has to be paid to the electrical circuits used with the time bases in order to avoid any inductive effects which might give rise to a delay in the " return " stroke of the scan. On the other hand, cathode ray tube working has the big advantage over mechanical methods of reception, in that the time base constants can be adapted very readily to any number of scanning lines in the received picture, coupled with the fact that the apparatus is absolutely silent in operation.

Then, again, careful attention has to be paid to the method of modulating the electron beam to produce the image. If this is not done, the resultant image is quite poor, a fact that will be emphasised by a reference to Fig. 5, which is an early photograph of a 120-line image with the picture over-modulated. The distortion and prominent line effects are very apparent. Then the cathode ray tubes have to be carefully selected, otherwise quite apart from fluffy or misfocussed spots on the screen a " soft " tube will give an image such as that shown in Fig. 6, which is an actual photograph of an early 120-line image taken under those circumstances.

TWO SIMPLE CHEMICAL EXPERIMENTS



The long-handled "Spoons."

By the aid of a long-handled tinplate spoon, the construction of which is shown in the sketch, the home experimenter can perform a multitude of entertaining experiments with his jars of oxygen. A small fragment of lighted candle, for instance, lowered into oxygen burns with a flame of surprising brilliance, as does also a fragment of glowing charcoal. Bright blue flames are given by a pinch of burning flowers of sulphur similarly.

For the second experiment we require a length of florists' iron wire. Hold one end in a flame until red hot, then quickly introduce it into a jar of oxygen (see illustration). The wire takes fire, burning brilliantly and throwing off sparkling globules. As we are apt to regard iron as being of an incombustible nature, the spectacle of iron wire actually burning is most interesting. A darkened room again improves the experiment.

An Experiment with Oxygen.

RUBBER-DRIVEN MODELS

All of these models are simple in construction, and the skilled mechanic or electrical expert may well indulge in a little relaxation by making these toys for amusing his youngsters or those of his relatives and friends.

By "CRAFTSMAN"

SOME little while ago the writer was shown an ingenious toy made by the boys of a certain grammar school. They were called "tanks" by those who produced them, on account of the slow speed at which they travelled. The toy consisted of five parts, the cost of which was practically nil: they were an empty cotton or silk reel, an india-rubber band, one whole wooden match stick and about ½ in. of another, and a short piece cut from the end of a wax candle.

It is illustrated by two views in Fig. 1. From this it will be seen that the rubber band is passed through the hole in the centre of the reel and also through a hole bored in the piece of candle. The short piece of match is passed through the loop in the band at one end, and the whole match is inserted through the other end, next to the candle. To make the toy travel the match is revolved in a clockwise direction with the finger, thus winding up the rubber. When placed upon the floor the match presses downwards and causes the reel to revolve in the direction shown by the arrow in Fig. 1.

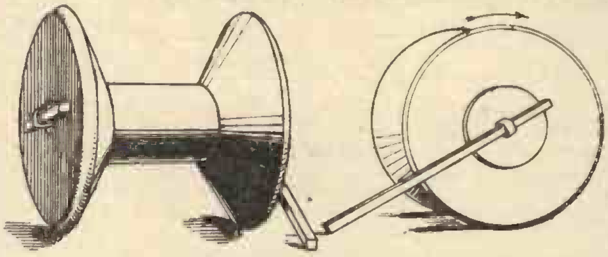


Fig. 1.—Details of the rubber motor used for driving these simple cardboard models.

The ingenious principle involved, namely the friction between the candle and the end of the reel which prevents the rubber from unwinding rapidly, may be utilised to make other such toys which bear a resemblance to some definite travelling object, as will be seen from the accompanying drawings. All of these objects are most simple to make, and the skilled mechanic and electrical expert may very well indulge in a little relaxation by making these toys for amusing his youngsters or those of his relatives and friends.

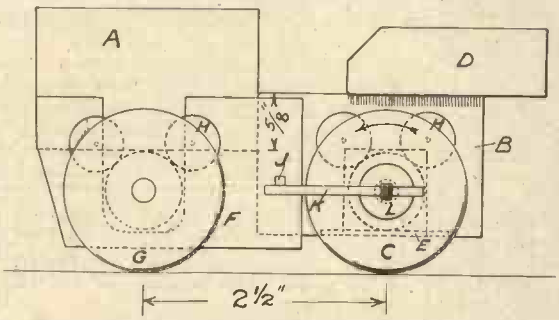
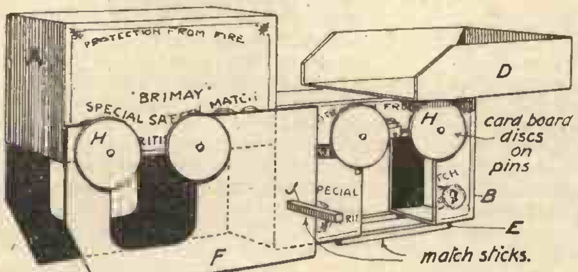


Fig. 2.—A model farm tractor made from two match boxes and pieces of cardboard.



A Farm Tractor

The first travelling object is supposed to represent a farm tractor: this is shown in Fig. 2. It can easily be made in half an hour, or even less. For its construction, besides two of the cotton reels, two empty match boxes are required, with the blue-paper-covered, sliding portion of a third box, four whole matches and a half of another and some bits of cardboard.

Eight little roller discs and the two frames in which the front wheels are carried are cut from the cardboard and the two match boxes are glued together, as shown in the top elevation sketch of Fig. 2, with an overlap of ⅝ in. One of the boxes, A, is not cut in any way, but the other one, B, has a large gap cut out of it in which the driving reel, C, will work. The blue sliding box, D, is glued upon the rear box, B, to represent the driver's seat. Two of the match sticks, E, are glued across the opening in the rear box after the driving reel is in place, and the cardboard frames, F, must be glued on after the front reel, G, is in position. The roller discs, H, are carried upon pins, the object of these being to reduce friction. They should be so placed that the barrels of the reels do not touch any portion of the match boxes. One of the match sticks, J, is passed but not fixed into a hole bored right through the cardboard frames and the rear match box. It must be capable of sliding so as to be clear of the driving match, K, when the rubber is being wound up. After winding, it is slid out to engage with the driving match. This is obviously a better arrangement than letting the driving match press upon the floor.

The mechanism of the driving reel is exactly the same as that shown in Fig. 1; that is to say, a piece of candle, L, is inserted between the driving match and the end face of the reel to make the model travel.

A Motor Lorry

Another adaptation of the candle-cotton reel principle may very well be a motor lorry, the whole of the superstructure of which is also built up from match boxes. In this case also, cardboard discs will need to be cut for reducing friction, and the same kind and size of reel is used for the wheels. Here, however, it will be advisable to drive both of the reels, and so two candle discs will be needed and two rubber bands. The cardboard frames will run from end to end of the vehicle. They can be cut either from one piece of card bent to a U-section, as shown in the end view drawn at the bottom right-hand corner of Fig. 3, or cut as separate frames with distance pieces of card in between. Two of the sliding match sticks will be needed to pass through these frames and four sticks will be glued over the openings in which the reels will revolve. Five complete match boxes are glued above the frames, one on edge in the front to represent the bonnet, and four at the back for the body. The blue slide from a sixth match box is erected behind the bonnet to represent the driver's cab, with a piece of card glued across for a seat.

The rest of the details will be clear from the sketches and, if having built it the reader

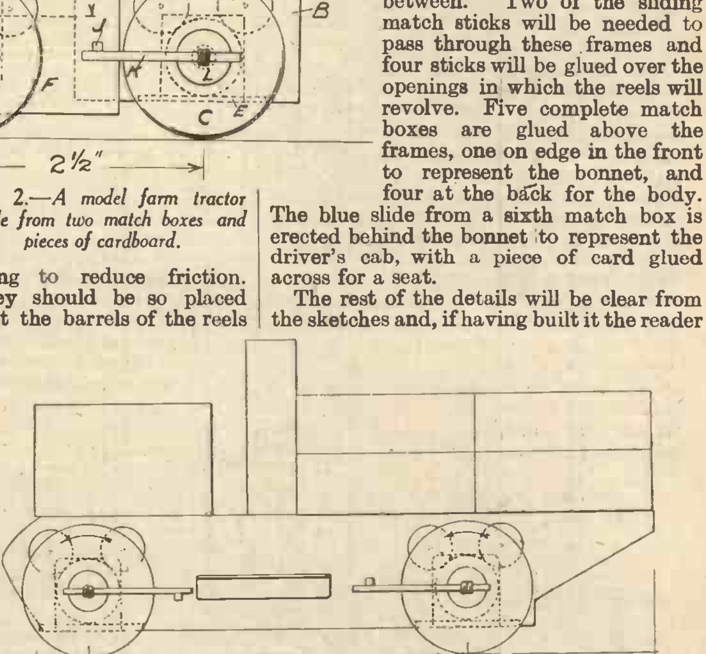


Fig. 3.—A model lorry also built from match boxes and cardboard.

is not satisfied with the speed at which it travels, its rate of travel can be increased by putting a touch of thick engine oil between the candle discs and the ends of the reels.

A Locomotive

Yet another model in which reels and candle discs can be utilised is the railway locomotive. This will involve a little more work in its construction, although it is, of course, an extremely simple job.

Here it will certainly be best to cut two independent frames. As a matter of fact, the easiest way to get them both exactly alike will be to lay two pieces of cardboard together, tacking them lightly with glue one to the other; then cut them out both together with a knife on a piece of board, afterwards separating them. The distance pieces, which are shown in the perspective sketch at the bottom of Fig. 4, should be of such a width that the measurement over the two frames, including the roller discs, is the same as the length of the barrels of the reels.

Two buffer beams cut from cardboard are added at the ends and then a footplate is cut to be glued down on the top of frames, distance pieces and buffer beams. Little gaps are cut out on the edges of this footplate where the reels occur, and over these gaps bits of thin cardboard are bent and glued down to form splashers. The boiler may be made from a piece of brown cardboard tube 1¾ in. in diameter. This is supported on cardboard brackets, two at the front under the chimney and two longer ones at the back to represent the smoke-box and fire-box respectively.

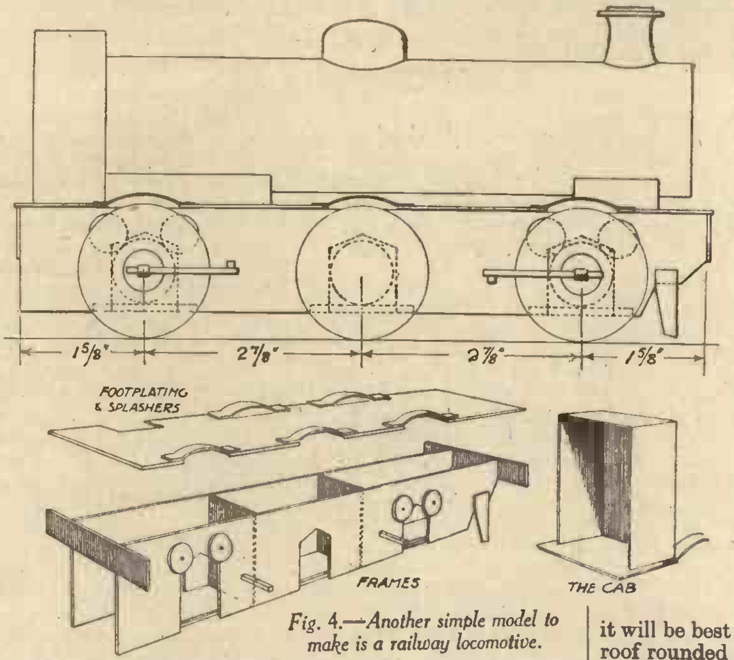


Fig. 4.—Another simple model to make is a railway locomotive.

The chimney is best made from a piece of round dowel wood, or perhaps part of a handle of some kind, such as that of a broom or sweeper. The best way to fix it will be to cut a hole in the top of the boiler tube and let the wood pass into this hole. It should be cut off square at the top and two cardboard discs glued on as shown. Then give the chimney shape and remove its cylindrical form, which may be carved away with a pocket knife to something like the shape shown in the elevation sketch. The dome may also be done in the same way: that is to say, glued in a hole in the boiler and the top shaped and glass papered.

The front end of the boiler tube should be closed with a circular disc of card, which may have another disc of smaller diameter glued on to it for the smoke-box door. The other end is closed by the cab. For this it may be possible by searching around to find a cardboard box of just the right width and depth. Its length will not matter since, if it is too long to form a cab of the right height, one end of it may be cut away. Failing a box, it will be necessary to make a cab by cutting a cardboard front and then bending and gluing another band of card around to form the top and sides. In this case it will be best to make the shape of the cab roof rounded instead of square.

The reader will notice that the centre reel is not driven, so that it must be seen to that no weight of the engine is taken by this: that is to say, make sure that both the end driving wheels carry the locomotive. To make this model travel at a respectable speed the candle discs will certainly need to be oiled.

AUTOMATIC MACHINES AND SPURIOUS COINS

LARGE sums of money are lost every week by the proprietors of automatic coin machines by the practice of submitting counterfeit coins or even metal discs. Providing the blanks conform to the average requirements in weight and physical dimensions, their metallurgical structure is often of little account in withholding the delivery of the goods.

An interesting method of overcoming this difficulty has been devised which uses a very old electrical principle first observed by Seebeck, a German scientist, in the year 1821. His discovery, which has had little practical value until recent times, was that in a closed electrical circuit consisting of two different metals a current will flow when one junction is raised in temperature above the other.

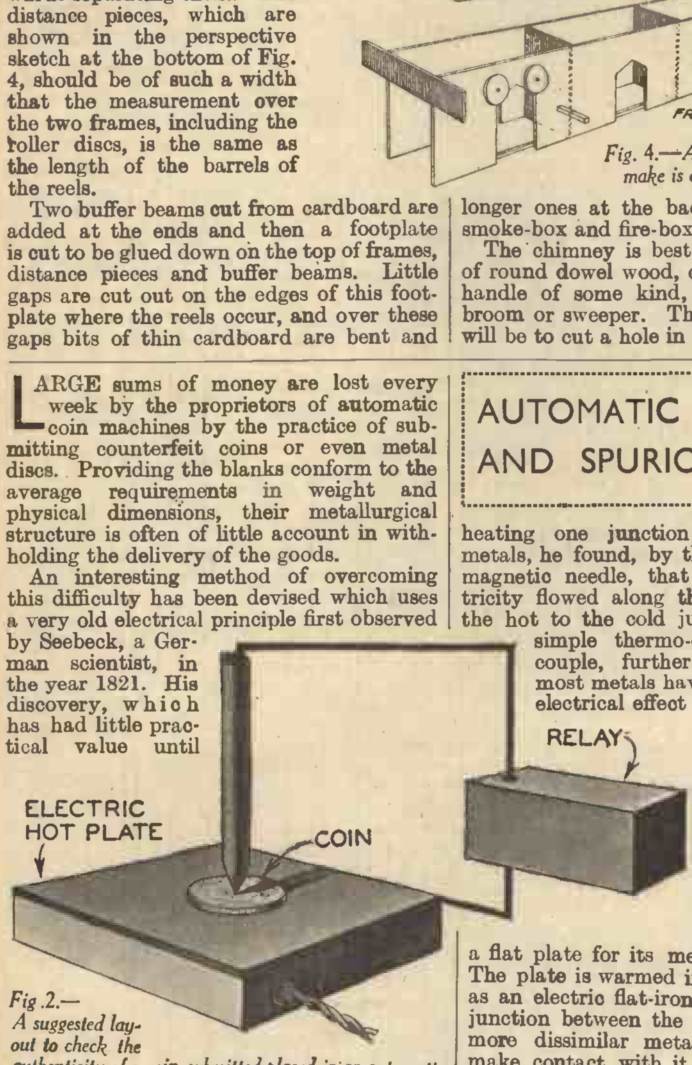


Fig. 2.—A suggested lay-out to check the authenticity of a coin submitted placed in an automatic machine.

A pictorial representation of Seebeck's experiment is shown in Fig. 1, where a bent rod of copper makes electrical contact at each end with a rod of bismuth. Upon heating one junction of the dissimilar metals, he found, by the deflection of the magnetic needle, that a current of electricity flowed along the copper rod from the hot to the cold junction. From this simple thermo-element or thermocouple, further tests showed that most metals have a definite thermo-electrical effect with regard to each other.

How the Principle works

Applying this principle to the spurious coin rejector, if the coin passes its weight and size tests, it finds its way on to a flat plate for its metallurgical test. The plate is warmed in the same way as an electric flat-iron to create a hot junction between the coin and one or more dissimilar metals arranged to make contact with it. At any given temperature a current of definite value will flow, whose strength and direction is governed by the nature of the metal under test. Quite a large number of metals are said to be negative with regard to other metals, because they allow current to flow in the opposite direction.

The thermo-electric currents thus produced pass through electrical relays which are set to operate a mechanism for passing the coin if the values and direction of the currents are correct. Any metal or alloy but the correct one will produce currents of entirely different value, and will lead to their rejection.

An even simpler arrangement is shown in Fig. 2, where a corollary of Seebeck's discovery is employed. If the hot junctions are of the same metals, no thermo-electric current is produced. Thus, in this illustration, the top of the hot plate and the top contact are of the same metal as the coin. If any dissimilar metal is introduced, the relay will operate by the current produced and reject the metal. One advantage of the "Null" method is that the actual temperature of the hot junction is not important, and expensive thermostatic controls to compensate for day and night temperature changes are not required.

In all present-day automatic vending machines provision is made for obstructing the coin slot when the machine is emptied of the articles to be delivered, and many ingenious and varied mechanisms are employed to prevent the machines being operated unless the correct coin is inserted.

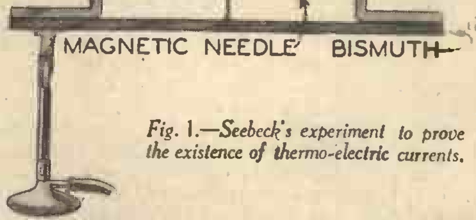
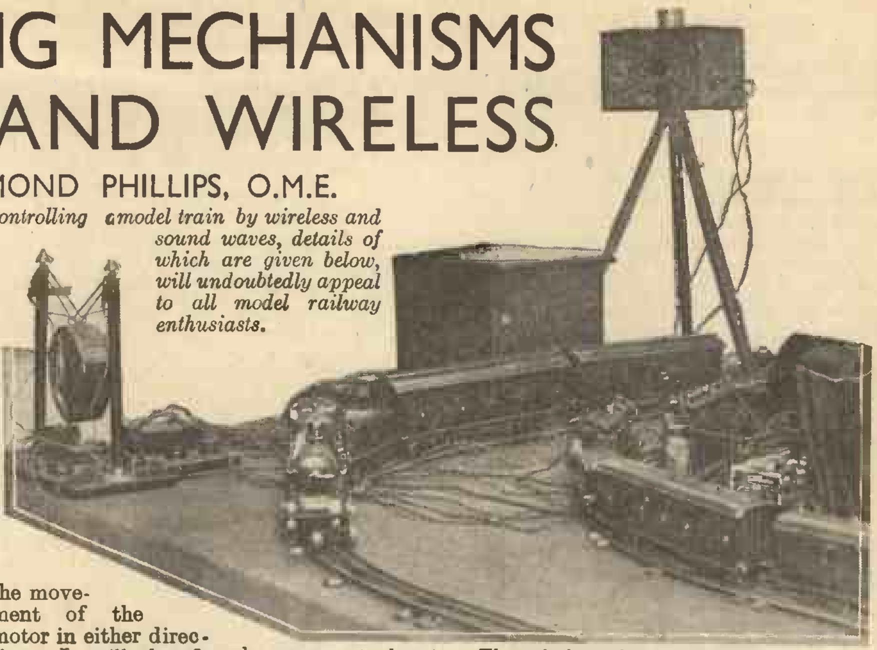


Fig. 1.—Seebeck's experiment to prove the existence of thermo-electric currents.

CONTROLLING MECHANISMS BY SOUND AND WIRELESS

By MAJOR RAYMOND PHILLIPS, O.M.E.

The author's latest method of controlling a model train by wireless and sound waves, details of which are given below, will undoubtedly appeal to all model railway enthusiasts.



A CONSIDERABLE time has elapsed since the author controlled his first model railway by sound waves. This was effected by speaking into a special microphone which was wired up to the train system, and arranged to operate an interlocking relay. The latter controlled the "opening" and "closing" of the main train circuit.

Using the same type of microphone, a combination of sound and wireless control was next devised. The apparatus for this experiment is so arranged that normally a circuit connected with the microphone and a simple pilot relay is "closed." A sudden shout into the microphone momentarily "opens" the circuit, and releases the pilot relay armature. The contacts fitted to the latter then "close" the main circuit of the wireless transmitter. It will be apparent that the effect is to produce intermittent oscillations, so that the contact drum of a selector in the receiving apparatus is rotated step by step with each impulse. This system was satisfactory for private demonstrations, but it was discovered that at public exhibitions spectators sometimes (no doubt out of curiosity) spoke several words into the microphone. This upset the sequence of operations, and it then became necessary to re-set the selector contact drum in the receiving apparatus. To avoid this the wired-up principle was reverted to, until this latest scheme which involves continuous oscillations was devised. With this method it is necessary that the electric motors of model locomotives should be fitted with "sequence" reversing mechanism. A photograph of such a motor is shown in Fig. 1.

The Functioning of the Switch

It will be noted that an electro-magnetically operated switch device is fitted on one side of the motor. The latter is series wound, and its circuits are so arranged that the switch referred to causes a reversal of flow of electric current to the armature windings only each time electric current is switched on and off, thus controlling the movement of the motor in either direction. It will therefore be apparent that with only two movements to control, it greatly simplifies all circuits, as the "sequence" reversing mechanism fitted to the model motor automatically controls its running direction. When model electric motors are made with a permanent field magnet this involves the control of apparatus for reversing the direction of flow of electric current to the track in addition to "opening" or "closing" the circuit.

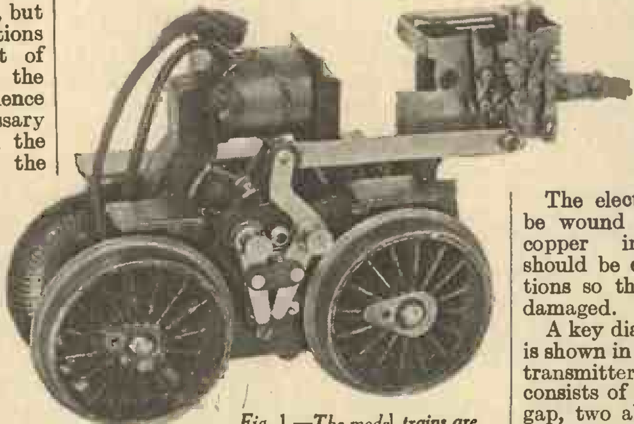


Fig. 1.—The model trains are fitted with "sequence" reversing mechanism as shown.

The special microphone simply consists of a hard brass diaphragm ·005 in. thick and secured between two hard wood rings. The centre of the diaphragm is fitted on both sides with silver contacts upon which lightly press two brass flat springs which at one end are secured to the wood rings, the other ends being tipped with silver contacts. The microphone is, of course, useless for the transmission of speech.

Fig. 2.—Details of the interlocking relay and (above) the microphone.

The author's wireless-controlled model railway fitted up ready for a trial run.

The Interlocking Relay

This consists of an electro-magnet with a movable soft-iron core within another iron core. It is really a form of solenoid. The relay is so arranged that each time the electro-magnet is energised a contact lever is moved in either direction so that a circuit is either "opened" or "closed." Details of the interlocking relay are shown in Fig. 2.

The electro-magnet of the relay should be wound with No. 25 gauge enamelled copper instrument wire, and care should be exercised during winding operations so that the enamel insulation is not damaged.

A key diagram of the transmitter circuits is shown in Fig. 3. It will be noted that the transmitter is very simple and merely consists of a spark coil (½-in. spark), spark gap, two aluminium rods each 48 in. long for an aerial, microphone, and interlocking relay. The transmitter described in the author's handbook can be used for the purpose. All that is necessary is to connect contacts marked 1 and 2 (Fig. 3) to the terminals of the Morse key fitted in the transmitter.

It will be noted on referring to Fig. 3 that two batteries (*i.e.*, 4-volt accumulators) are shown. If desired one battery (if of sufficient capacity) can be used for supplying electric energy to both circuits. In that case it would only be necessary to connect points marked 3 and 4 with points marked 5 and 6 (Fig. 3).

Two batteries are advised, however, in order to avoid any possible chance of a fall in potential. In that event the efficient working

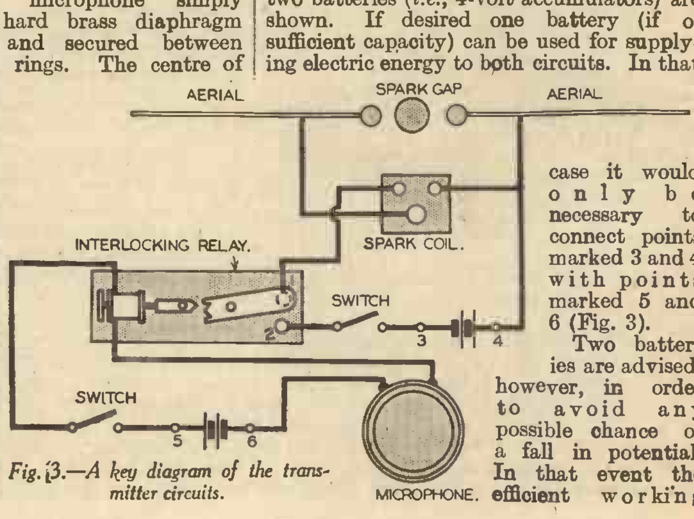


Fig. 3.—A key diagram of the transmitter circuits.

of the interlocking relay would be affected.

A key diagram of circuits for the wireless receiving instrument is shown in Fig. 4. As the apparatus is only required to function at short range in a hall or large room the vertical-type coherer marked A on the diagram is installed for detecting the incoming oscillations set up by the transmitter. This saves any unnecessary expense which would be involved if valves were used

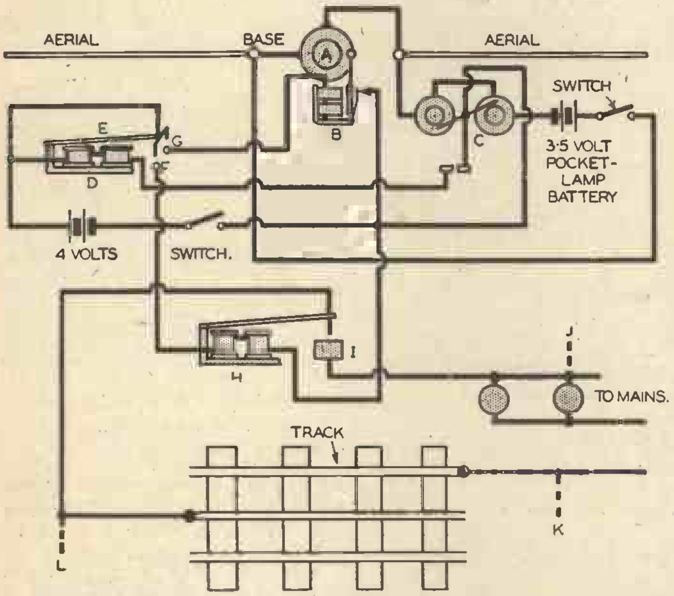


Fig. 4.—The circuit for the wireless receiving instrument.

for the purpose. The usual de-coherer or tapping device marked B is an ordinary electric bell movement. The simple pilot relay marked C is wound to a conductor resistance of 100 ohms.

The Pneumatic Dashpot

The relay marked D is fitted with a pneumatic "dashpot." The latter comprises small bellows similar to those fitted in player pianos, which are attached to the armature marked E so that its upward movement is retarded. This has the effect of keeping the contacts marked F "closed" so long as continuous oscillations are set up by the transmitter, and the contacts marked G intermittently close the circuit connected with the decohering device marked B.

The supplementary relay marked H is fitted with a metallic cup which contains mercury, and is used for "closing" a circuit connected with a lamp resistance and ordinary electric supply mains. This relay is made by mounting a good-quality electric bell movement (three gong) on a suitable baseboard, and after removing the bell hammer, and screwing a short length of No. 14-gauge brass wire into the armature of the electro-magnet the wire is bent to shape so that it "dips" into the metallic cup containing mercury.

The Motor

The model electric motor shown in Fig. 1 is specially made to function with electric current at a high E.M.F. so that a lamp resistance can be used with a main source of electrical energy, but if an ordinary low voltage model motor fitted with "sequence" reversing mechanism is used, a transformer can be connected to A.C. mains. In that event points marked J and K (Fig. 4) would be connected to the low voltage terminals of the transformer. The high voltage terminals would, of course, be connected with the A.C. mains.

Although only one railway track is shown in Fig. 4, others can be controlled from the same circuit by simply connecting the rails to the points marked K and L.

The whole apparatus is so simple that it should not be beyond the capabilities of any skilled amateur to construct most of the components. The latter can be neatly housed in suitable wooden cases, and terminals can be fitted on the top of each instrument for securing the aluminium rods which form an aerial. When all is completed it will be necessary to place the transmitting and receiving instruments in such positions that the aerials are parallel to each other.

The Working of the System

This will be easily understood on referring to the key diagrams of circuits shown in Figs. 3 and 4. Each time a "shock" word is spoken into the microphone the latter will momentarily "open" and "close" the circuit connected with the interlocking relay. This relay will then "close" the circuit connected with the spark coil with the result that a continuous high-tension discharge will flash across the spark gap, and this will set up continuous oscillations from the aerial of the transmitter. The receiving apparatus will then immediately function as the nickel and silver filings in the coherer will be affected and will short circuit the coherer contacts. This will have the effect of "closing" the pilot relay circuit. The relay fitted with pneumatic "dashpot" marked D (Fig. 4) will then function, and contact marked F will "close" the circuit connected with it, and bring the supplementary relay marked H into action so that electric current will be admitted to the model railway, and picked up by the electric motor running on the rails in the usual manner. Contact marked G (Fig. 4) will "intermittently" "open" and "close" the circuit connected with the de-cohering device or "tapper" marked B.

When a "shock" word such as "stop" is spoken into the microphone (Fig. 3) the interlocking relay will "open" the circuit connected with the spark coil. The continuous oscillations set up by the transmitter will then cease, and the receiving apparatus will also cease to function, and all relay armatures will return to their normal positions.

If it is desired to control a model train by speaking three words in sequence, *i.e.*, "Ahead," "Stop," and "Back," it will be necessary before commencing a demonstration to set the reversing switch fitted to the "sequence" reversing mechanism (of the electric motor) in such a position that when electric current is switched on the first movement of the device will ensure that the electric motor runs "ahead." If the sequence of operations is adhered to, it produces a novel spectacular effect.

Fig. 5.—A photograph of the pneumatic "dashpot."

MARVELS OF THE GYROSCOPE
(*Continued from page* 406.)

ported above its centre of gravity always "precesses" in the same direction as its spin. Now if the speed of rotation is sufficiently high, the spin will want to roll the body faster than the "precession" will permit it to roll, in other words the "precessing" movement is being hurried on and the top rises to a more vertical position in consequence. Obviously from the illustration (Fig. 3 (*b*)) the more upright the top becomes the smaller becomes the diameter of the wheel on which it is rolling, or the more rapid can be the rotation for a given distance of circling travel.

A Gyroscope supported above its Centre of Gravity

Fig. 4 shows a simple gyroscopic top whose disc is cone-shaped and whose spinning pin point is above the centre of gravity of its heavily rimmed disc. A rough model can easily be constructed out of a tin or metal basin.

The most interesting property possessed by this type of gyroscope is in the nature of rolling or spinning contact. Give the top, shown in Fig. 4, a sharp spin with the hands; bring one of the fingers, say the left-hand side of the first finger of the right hand, in contact with the axle, the fingers being open. If the top is spinning clockwise, as seen from above, the axle will press against the finger run round the end and down the other side, up the next finger, and so on. It will travel round a ring, in one direction on the outside and in the opposite direction on the inside of the ring. The object must be held firmly and steadily. It will take the sharpest curves you can construct in the most amazing manner. We have then a new gyroscopic principle, all-important in any system of gyroscopic mono-rails.

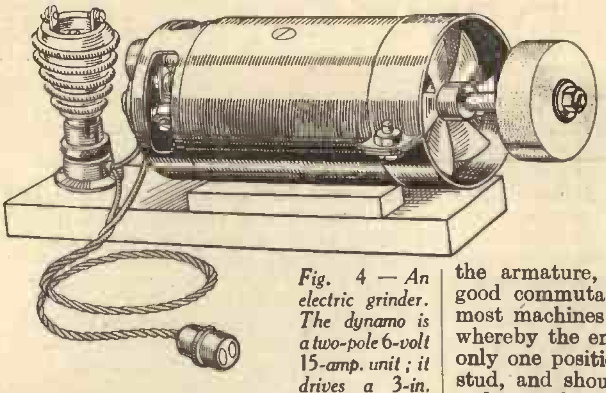


Fig. 4.—An electric grinder. The dynamo is a two-pole 6-volt 15-amp. unit; it drives a 3-in. wheel at 3,000 revs. The cooling fan and guard are clearly shown.

CONVERTING MOTOR-CAR DYNAMOS TO A.C. MOTORS

A query that is very often asked is "How can I convert a motor car dynamo of such and such a make into an A.C. motor?" This is quite simple, provided that the original machine is in good order, as the dynamo armature does not need rewinding.

THE efficiency of these converted machines is not very high, but as they are of small capacities this does not matter. The chief difficulty to be overcome is the heating of the field coils and magnets due to the rapid reversal of the current; with large machines this cannot be overcome, and they must only be used as short-period motors where they are in operation for a few minutes at a time. A test machine taking 4 amperes was run for seven minutes before the field magnets were hot, and then a further ten minutes before it had to be shut down. For the home shop a 1/10th h.p. is quite sufficient for light polishing and grinding, for heavier work then ⅛th h.p. will be required. These machines run at constant speeds, and when suitably wound are ideal for model driving and general experimental work.

A good quality starter motor or dynamo must be obtained; the best place to get one is from a "scrap" yard, and not your local garage. If the machine is only required for model work, then select a small dynamo of the motor-cycle type, for other work get as big a machine as possible, test the bearings by shaking the shaft, and see that the brush gear is in good order. It is essential that these machines be of the two or four-pole type, with the armature at the centre of the housing; an eccentrically mounted armature is not suitable, as complications arise when converting the brush gear; remember that a four-pole machine will run at 1,500 revs., and a two-pole at 3,000. It is advisable to choose a machine with ball bearings rather than brass bushes.

How to Commence

If the machine is working as a dynamo, it will not be necessary to test the armature; if there is any doubt, get another machine, as the armature is not rewound, and is not touched in any way. Dismantle the machine and remove all surplus oil from the case, field magnets and brush gear with clean petrol; wash out the bearings, removing all grease and grit, and put a few drops of light oil in them; it is unnecessary to stuff the bearings with grease, as a little light machine oil frequently applied is more efficient for our purposes. With third brush machines, remove the third brush and connect the two brushes together; similarly, with four-brush machines connect the brushes together, or connect the pigtail of each brush to the frame of the machine; use a stout wire here, as a machine having 1 ampere flowing through the field coils has about 10 amperes circulating through the armature, hence the necessity for a good commutator and brush gear. With most machines there is some arrangement whereby the end plates can be replaced in only one position, this is generally a small stud, and should be filed flat so that the ends may be turned round, the brush gear end should be free, but the driving end may be left in its original position, although, if this is free, it may save drilling extra holes for the fixing bolts (see Fig. 1).

Removing the Pole Pieces

Remove the pole pieces; it may be necessary to use a cold chisel and hammer on the screws, but it can be done. Make a former from suitable wood, using one of the original field coils as a guide. It may be found that these coils can be rewound a little larger than the originals, if so, make use of this, as it is impossible to get too much wire on. One coil is required for each pole, and for the average two-pole machine about 1 lb. of No. 26 D.C.C. should be used, and not less than ¾ lb. For a four-pole heavy-duty machine, use No. 22, and for a light experimental motor, No. 30 or No. 32 will be large enough. Exact quantities of wire cannot be given, but it is not possible to use too much, as a series resistance has to be connected in the circuit, except with the very small motors. Make the former to the pattern of Fig. 2, and wind to the maximum capacity, putting the wire on as evenly and as tightly as possible. When finished, the coils are wrapped with insulating tape, placed on the pole piece, and fixed in position; take care not to trap any material between the pole pieces and the yoke ring. Wind the coils in the same direction, and to ensure the correct polarity connect the beginning of the first coil to the end of the next, and so on; test for consecutive north and south poles with a pocket compass and a two-volt battery in series with the field. With the smaller machines the ends of the field coils are connected to a length of standard flex, the joint is insulated and fixed inside the motor case; a standard plug or adaptor should be fitted. If these small machines heat up too much, then a resistance such as a 100-watt lamp must be connected in series.

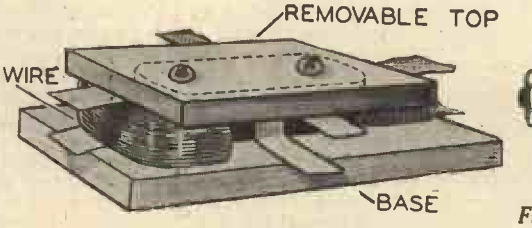


Fig. 2.—Details of the former.

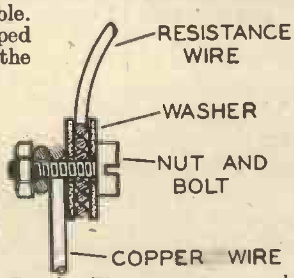


Fig. 3.—The connections on the heater or resistance unit.

The Brush Gear

Reassemble the machine, leaving the brush gear end free to rotate, and connect in series with a small electric fire and the mains. Switch on and turn the brush gear until the armature is rotating at a maximum. Mark this position and drill new holes for the fixing bolts; these should be filed oval so as to give a slight adjustment when the machine is put on load. It will be noticed that if the brush gear is advanced past the maximum speed line, the motor slows down, stops, and finally reverses, until its speed is again at a maximum.

The mounting of the machines depends upon the work that they are designed to perform; one method is shown here. The heating unit is mounted on the same base as the motor, and is connected in series with it; it has been found that with the larger types of motor, when fan-cooled, the maximum permissible current for continuous running is 2 amperes. Wire should be removed from the heater until the motor is operating satisfactorily. Suitable resistance units can easily be made in the following way: take an old bayonet cap lamp and remove all glass and connecting wires, and to the contacts solder stout bare copper wires of about No. 16 gauge. Obtain some plastic fire cement and mould it into a small inverted cone with the cap at the apex; hollow out the base, leaving walls about ¼ in. Cut a wide spiral from the cap down to the base, and then back, starting and finishing at the copper leads; small knobs of cement should be made at the points where the wire turns back, and also at the

(Continued on page 435.)

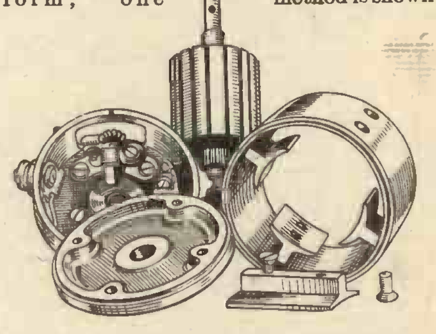


Fig. 5.—Parts of a 6-volt four-pole starter motor ready for re-winding.

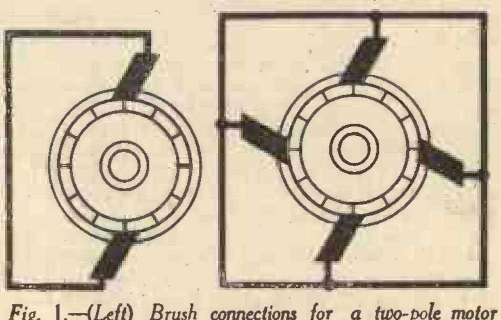


Fig. 1.—(Left) Brush connections for a two-pole motor and (right) connections for a four-pole motor.

HOW TO MAKE A DEMAGNETISER

It very frequently happens that the home experimenter requires a piece of apparatus whereby he can magnetise or demagnetise an object to a known degree. Outlines of other simple experiments are given at the end of the article.

THE apparatus consists essentially of a magnetometer, that is, a sensitive magnetic compass, mounted on one end of a strip of wood on the other end of which the solenoid is fixed. The actual

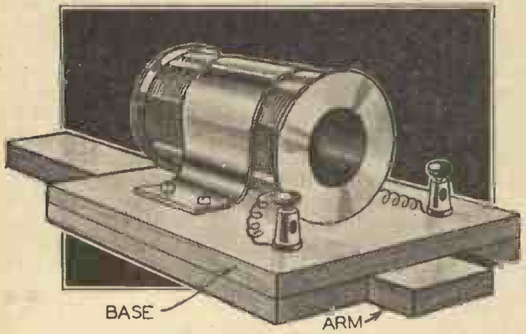


Fig. 4.—The Solenoid.

woodwork will be left to the individual, but the important measurements are indicated here.

Obtain a piece of clock-spring, $\frac{1}{16}$ in. thick, and from it cut the magnet $\frac{3}{4} \times \frac{1}{2}$ in., soften by heating to redness and allowing to cool slowly, drill an $\frac{1}{8}$-in. hole in the exact centre, file off any burrs, and reharden; to do this, heat to redness and *immediately* plunge into cold water. Wrap the steel with several layers of No. 36 insulated wire and connect to a two-volt cell; if the current is too high, put a lamp or other suitable resistance in series; after ten minutes the spring should be a strong magnet capable of lifting several pins.

The bearing for the needle is made from $\frac{1}{4}$-in. inside diameter glass tubing in the following way; take a length of tubing, say 3 or 4 in., and soften the centre in a bunsen flame, draw out to form a slightly constricted portion, and cut at A (see Fig. 1), which gives full details for making the bearing. Seal the constricted end of one tube, and to prevent the glass from becoming too thick and forming unevenly, blow gently down the tube. Cut the sealed end off the tube $\frac{1}{4}$ in. from the tip at B as shown. To cut tubing, mark round the glass with a fine triangular file, and then pull the pieces apart; a better grip may be obtained by holding the tube in a cloth.

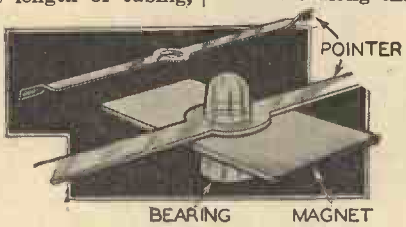


Fig. 2.—The movement. including the pointer.

The Bearing

This must be a push-fit into the spring, and should project about $\frac{1}{8}$ in. on either side. The pointer for the instrument is about 3 in. long, and is cut from sheet aluminium about $\frac{1}{32}$ in. thick, as shown in Fig. 2 and the sketch of the completed instrument. The ends of the aluminium are bent at right angles so as to give a knife-edged pointer. The pointer and magnet are both cemented to the bearing in the same operation, using some commercial glue or sealing wax; allow to set quite hard before balancing. The instrument case is made about 4 in. square and 1 in. deep, inside measurements; the scale is a square of white card fitting tightly inside the box, resting on small blocks, with a centre hole 2 in. in diameter, thus the pointer projects 2 in. at each end over the scale; the circle should be graduated in degrees. The box must be fitted with a glass lid. The magnet is suspended on a fine sewing needle that is stuck into a block of soft wood in the bottom of the box; the needle should be of such a height that it supports the pointer $\frac{1}{8}$ in. above the scale and in the exact centre of the box; balance the movement by grinding the magnet or filing the aluminium; when finished the pointer should lie east and west irrespective of the box position. Before the needle is finally mounted, fix a strip of wood, measuring 1 × $\frac{1}{2}$ in., to the bottom of the box, so that it is at right angles to the magnetic meridian. The strip should be marked off from the centre of the box in inches or centimetres (see Fig. 3), which shows a view of the completed instrument.

The Shape of the Solenoid

This may be varied to suit individual requirements, but the most useful type is shown here. Make a bobbin from thin sheet brass with a centre hole of $\frac{1}{2}$ in., and end flanges 1 in. in diameter and length about $2\frac{1}{2}$ in.

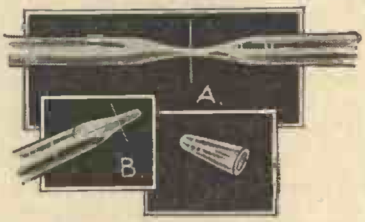


Fig. 1.—Details of the bearings.

Wind it to its maximum capacity with No. 26 D.C.C., observing the usual precautions. The bobbin is mounted on a suitable base that will slide along the wooden arm, and the ends are connected to two brass terminals. Fig. 4 gives a side view of the coil. In this work use only brass nails and screws; *do not* use any iron.

To use the apparatus set it up with the arm lying east and west, and connect the coil in series with a two-volt cell and a variable resistance; a filament resistance will be ideal. Place the coil at the end of the arm and switch on; observe a deflection that increases as the current is increased, or as the coil is moved along the arm; note the increase in deflection when a piece of iron is placed in the coil. A small watch or similar piece of apparatus may be demagnetised by placing at the end of the coil; larger coils will be required for larger instruments; it is not necessary for the instrument to fit inside the solenoid, provided that it is placed as near to it as possible. To demagnetise, say, a piece of steel, place it in the coil and observe the deflection, say, west; connect up the battery with the steel removed so as to make the needle move in the opposite direction, east; replace the steel and adjust the current and position of the solenoid until the needle is at zero. Switch off and, most probably, the pointer will return to a slightly west position, depending on the type of steel; switch on again and adjust until the needle is a few degrees east, repeat until the needle stays at zero when the current is switched off. The lagging effect is known briefly as hysteresis. To compare the strength of two bar magnets, place them at the same distance, measured from the centre of the magnet, along the arm, and observe the deflection; this is proportional to the strength of the magnets; thus, if one magnet gives twice the deflection of another, we may say, roughly, that one is twice as strong as the other, or one will lift twice as much as the other.

For Accurate Work

Experiments on samples of iron and steel may be carried out quite simply, but for accurate work two exactly similar solenoids are required and placed at opposite sides of the magnetometer, so that when the current is switched on, the needle remains stationary. They are connected in series with the same battery and, if necessary, their positions altered, until the needle is at zero; thus, when a piece of iron is placed in one solenoid it is the magnetism passing through the iron that affects the needle and not the coils.

Magnetic Strengths

The strength of an electro-magnet is dependent upon the " ampere-turns " ; that is to say, the product of turns and current flowing, so that this feature may be borne in mind if for any reason it is desired to make a modification of the instrument which is described. If small batteries are to be employed it will obviously be desirable to restrict the current passed by the coil, and to obtain a high degree of magnetism with a small pole it will in that case be necessary to increase the number of turns of wire. This could only be done by using a thinner wire, and, provided that the gauge is chosen with the current-carrying capacity in view, this should not be difficult. When dealing with very small bodies it may be found desirable, in fact preferable, to reduce the current passed by the coil. Whilst a lamp in series will be found quite a simple means of effecting this current reduction, a much better plan for serious work would be to fit a variable resistance in one battery lead. This may then be calibrated (if desired) so that various pre-determined settings may be obtained.

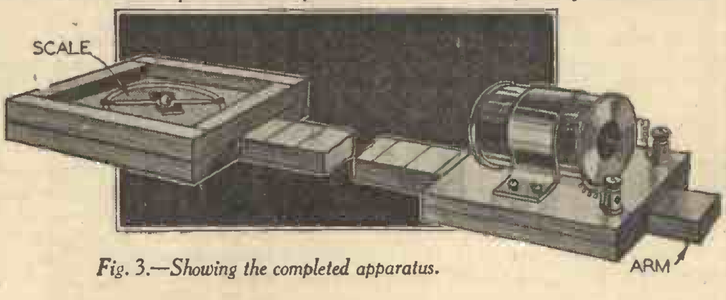


Fig. 3.—Showing the completed apparatus.

SMALL WATER-POWER INSTALLATIONS

By S. J. GARRATT

Judging by the number of queries received from readers who would like to use a water supply for power purposes, there appears to be a considerable amount of interest in the subject. The principles are quite simple to understand and after reading this article the reader should be able to work out the possibilities of this source of supply for himself.

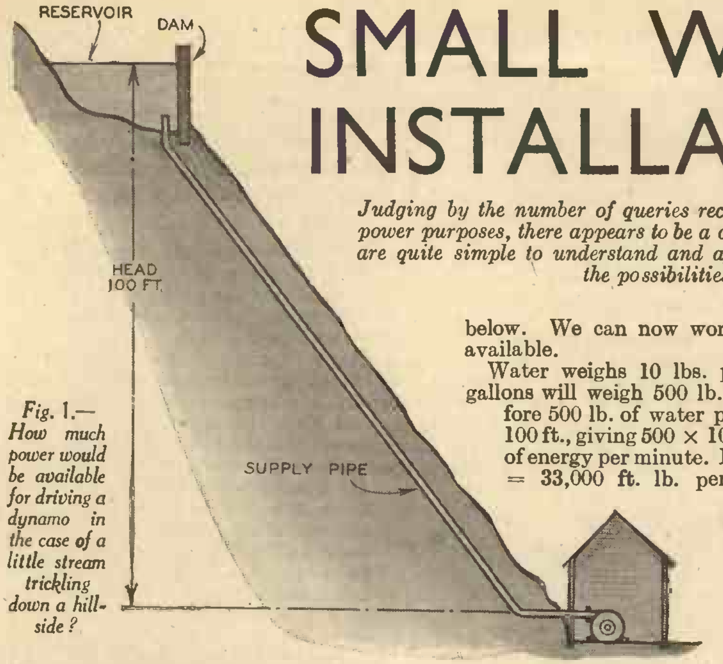


Fig. 1.—How much power would be available for driving a dynamo in the case of a little stream trickling down a hill-side?

THE amount of energy available from any supply of water depends upon two things; firstly, the quantity of water supplied per minute, and secondly, the pressure or "head" on the water. The head is measured by the height of the surface of the water in the reservoir above the point at which it is used; it is usually expressed in feet. The pressure in the case of a household supply from the water mains is not easily ascertained unless a pressure gauge is used, but household water is not supposed to be used as a source of power, so we need not consider such cases.

Let us consider the case of a little stream trickling down a hillside, as shown in Fig. 1, and find out how much power would be available for driving a dynamo, for instance. First of all a reservoir must be provided. We might possibly find a small pool all ready to act as a reservoir, otherwise we must make one by building a dam at a suitable spot. This may be done quite easily by using a few planks of wood.

The Amount of Water flowing

We must next measure the amount of water flowing. The simplest way to do this is to cut a V notch in the top of the dam as shown in Fig. 2. The angle at the bottom should be 90 degrees and the edge of the wood should be chamfered off as shown by the small section, to make a thin edge. The rate of flow can then be ascertained by measuring the depth of water at the bottom of the V and using this dimension in conjunction with the graph shown in Fig. 3. Suppose we find that the depth of water in the notch is $3\frac{3}{8}$ in. By referring to the graph we shall learn that the flow of water is 50 gallons per minute. Now assume that we have a pipe running from the reservoir to a Pelton wheel 100 ft. (vertical distance) below. We can now work out the power available.

Water weighs 10 lbs. per gallon, so 50 gallons will weigh 500 lb. There is therefore 500 lb. of water per minute falling 100 ft., giving 500 × 100 = 50,000 ft. lb. of energy per minute. Now 1 horsepower = 33,000 ft. lb. per minute, so the power available in the present case is

$$\frac{50,000}{33,000} = 1\frac{1}{2} \text{ h.p. (approx.)}$$

We shall not be able to obtain all this amount though, because there will be a certain amount of loss owing to the friction of the water moving through the pipe, and also the fact that the efficiency of the Pelton wheel is considerably less than 100 per cent. Therefore we may reasonably suppose that we may get about one horsepower output for driving a dynamo or other apparatus.

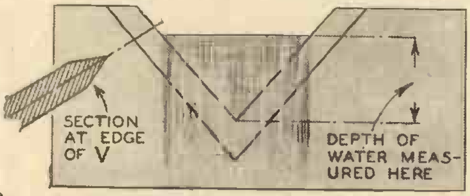


Fig. 2.—By cutting a V-notch in the top of a dam the amount of water flowing may be measured.

The Supply Pipe

The size of the supply pipe is important, and should be 3 in. diameter in the case quoted. The friction in this pipe would then be equivalent to a loss of about 2 ft. of head. If the pipe were only 2 in. diameter the loss of head would be about 12 ft. The graph (Fig. 4) shows the loss of head per 100 ft. of straight pipe for various rates of flow and will be of value in ascertaining the best size for the supply pipe. The term "loss of head" means that if there is, say, 100 ft. head by actual measurement and there is a 12-ft. loss of head, there will be only 88 ft. of head available at the Pelton wheel, the rest being lost in driving the water through the pipe. The power of course falls off in proportion, so the supply pipe should always be kept as large as is reasonably practicable.

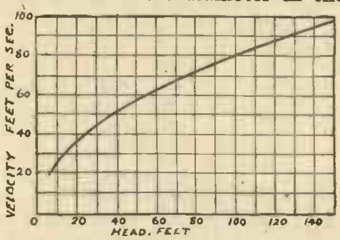


Fig. 5.—Ascertaining the velocity of water from the jet.

A reader once asked the following in a query: "I have a tank of water holding 100 gallons 10 ft. above the floor, and the outlet pipe is 1 in. diameter. What power can I get from this?" Such a question does not give enough information, because the size of the tank means practically nothing, it is the rate at which the water is supplied that is important. Obviously this is true because if water is taken from the tank faster than it flows in, the tank would soon be empty.

Ascertaining the Water flow

The flow in the above case can easily be ascertained by emptying the tank and seeing how long it takes to fill again. Say it takes five minutes, then we can use 20 gallons per minute = 200 lb. per minute, while the head = 10 ft. Using the following formula

$$\text{Horsepower} = \frac{\text{Water supplied (lb. per min.)} \times \text{Head (ft.)}}{33,000}$$

we find the theoretical power is rather less than $\frac{1}{16}$ h.p. In actual practice we should get perhaps about a half of this on such a small installation, or, say, about $\frac{1}{30}$ h.p. At the other end of the scale, a well-supplied lake on a mountain will develop many thousands of horsepower.

If the reader has a suitable supply of water that he can use, he will probably wish to know how to arrive at the size of Pelton wheel suitable for his requirements. Take the case given in the first example above and suppose that a Pelton wheel is required to drive a direct coupled dynamo at 600 r.p.m. Now the velocity of water from the jet will depend upon the head, and can be ascertained from the graph given in Fig. 5. In the present case the head is 100 ft. (disregarding the loss in the pipe), and the corresponding velocity from the jet is found to be 80 ft. per second. To obtain the best power output the peripheral velocity of the buckets on the wheel must be one half of the water

(Continued on page 428.)

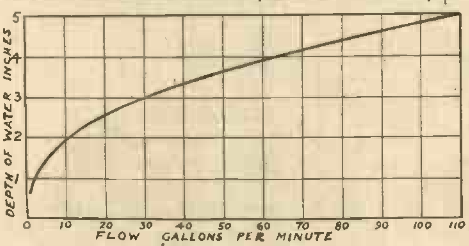


Fig. 3.—The graph to be used in conjunction with Fig. 2.

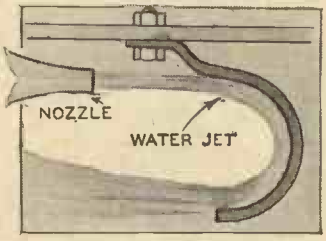


Fig. 6.—The buckets for the wheel may be bent out of flat iron or steel.

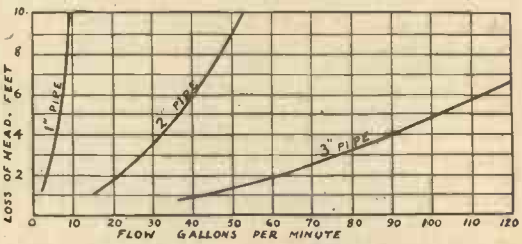


Fig. 4.—Showing the loss of head per 100 ft. of straight pipe for various rates of flow.

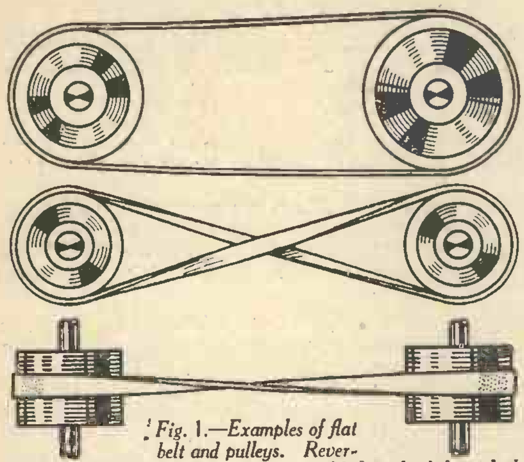


Fig. 1.—Examples of flat belt and pulleys. Reversal of direction of rotation can be obtained by simply shifting the belt.

INGENIOUS METHODS OF

By W. B. RICHARDSON

In a previous article we dealt chiefly with devices for and *vice versâ*. Now rotary motion is by far the most and it is the various mechanisms used for transmitting rotation, varying its speed, with which this article deals.

GEARING may consist of belts and pulleys, shafts, chains, spur wheels, bevel wheels, skew bevels, worms and bevels and universal joints of many different types. There are, besides, countless associated devices such as clutches, ratchets, etc.

Fig. 1 shows an ordinary flat belt drive running over steel pulleys. This system is frequently used to transmit the power from the prime mover (steam engine, gas engine or other type of motor) to the line shaft in factories. Pulleys suitably placed along the line shaft convey the power by means of other belts to small countershafts carrying fast and loose pulleys. By means of a fork-shaped device or "striking gear," the belts can be slid sideways from one pulley to the other. Thus when a belt is passing over a fixed pulley the countershaft revolves and so drives the lathe, or other machine to which the countershaft is coupled. When the belt is slid off the fixed pulley on to the adjacent loose one the counter-shaft naturally stops while the pulley simply revolves round it. In this way a simple means is obtained for stopping and starting the various machines in the shop without stopping the line shaft.

The advantage of flat belts is that they can be used to transmit power when there is a considerable distance between the driving shaft and the driven shaft; no guiding arrangements are required to retain them in position on the pulleys when the shafts are parallel, and if necessary the belts may be crossed to give a reversal of rotation to the driven shaft.

If two shafts are at right angles it is necessary, in order to retain the belt on the pulleys, to arrange the relative positions of the latter as shown in Fig. 2; that is, so that the central line of the belt as it advances towards each pulley is in the diametral plane of the pulley. You will notice the direction of rotation is indicated by the arrows on the belt. If the direction is reversed, however, these conditions no longer hold good and the belt leaves the pulleys.

An Efficient Belt

It is interesting to note that there is a certain velocity of a belt at which it is most efficient. Above this optimum speed its percentage efficiency is less. There are many factors contributing to cause this. One of them is the flexibility of the material of which it is composed. The loss of power due to the stiffness of the belt varies inversely as the radius of the pulley and directly as the speed of the revolution.

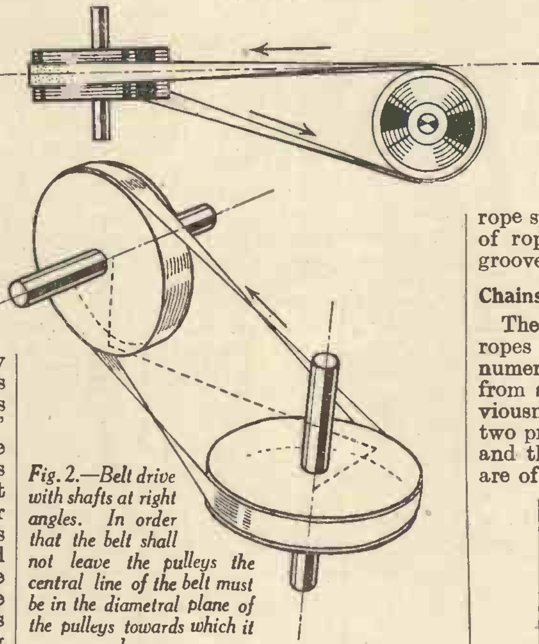


Fig. 2.—Belt drive with shafts at right angles. In order that the belt shall not leave the pulleys the central line of the belt must be in the diametral plane of the pulleys towards which it advances.

Another type of belt drive is that shown in Fig. 3. Here the belt is composed of a centre cord or fabric structure embedded in rubber. The belt is wedge-shaped in section and operates on "V" section pulleys. This is an excellent transmitter of power between fairly close centres. The belt rides between the flanges of the pulley, thus the greater the torque the more securely is it gripped, and consequently there is very little slip. Of course, if the belt gets worn or is too small for the pulleys, it will then "bottom" in the groove and the sloping sides will no longer grip it.

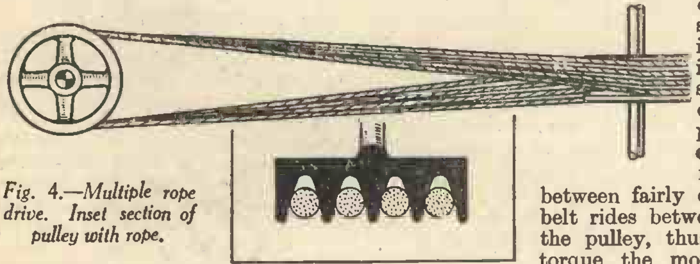


Fig. 4.—Multiple rope drive. Inset section of pulley with rope.

This type of drive was employed to a great extent on early motor cycles. An important advantage which it had over chain and shaft drives was its flexibility, which absorbed a great deal of the "thump" of the engine and made for smooth running. Its discontinuance for this type of work was due to its comparatively short working life, the need for constant adjustment, and its inclination to slip in wet weather—slipping being due to the fact that water acts as a lubricant between the rubber and steel.

Somewhat similar to the "V" belt arrangement is the multiple-fibre rope system, which consists of several turns of rope running over a multiple "V"-grooved pulley, as in Fig. 4.

Chains

The advantages of chains over belts and ropes for the transmission of power are numerous, not the least being freedom from slip, high running speeds and imperviousness to heat, cold and moisture. The two principal types are the *steel roller chain* and the *silent chain*. Both of these types are of hardened steel parts made to within very fine limits of accuracy. They operate on accurately cut sprocket wheels. Fig. 5 is a view of a section of roller chain, while Fig. 6 shows the silent chain. The silent

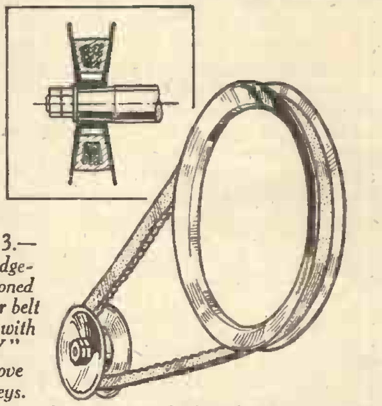


Fig. 3.—Wedge-sectioned rubber belt used with "V" groove pulleys. Inset, section of belt and pulley.

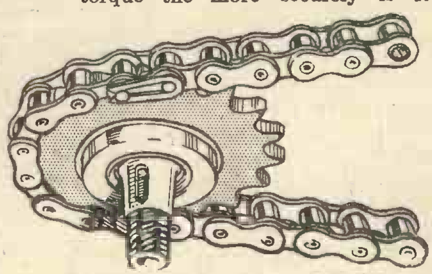


Fig. 5.—Steel roller chain and sprocket.

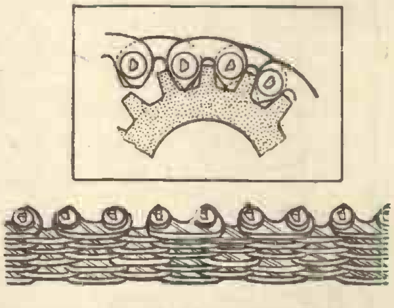


Fig. 6.—Section of "Silent" chain. Inset shows how the chain fits the sprocket.

TRANSMITTING POWER

converting reciprocating motion into rotary motion
common form in which mechanical power is utilised,
the motion from point to point, altering its plane of
This all comes under the general term of gearing.

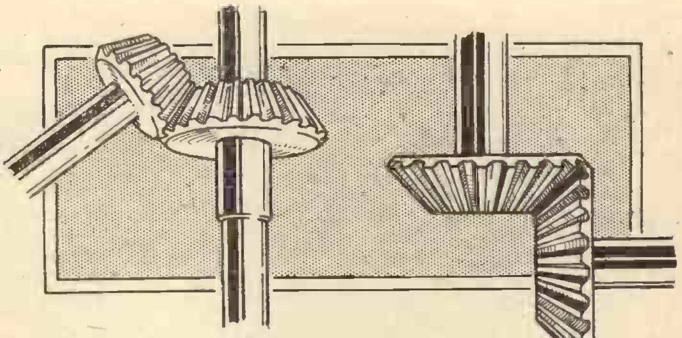


Fig. 12.—Examples of bevel gears.

chain provides a noiseless transmission at high speeds. For this reason it finds one of its chief applications in automobile engines where it is frequently used to transmit the drive from the engine to the camshaft, the magneto and the dynamo used for lighting and starting. The ideal condition under which to run roller and silent chains is in an enclosed oil bath.

Ingenious Belt and Chain Tensioners

For efficient operation of belts and chains it is necessary to run them at a certain tension, especially the former, where the adhesion of the belt to the pulley is largely dependent on the tension. In this connection several devices have been invented for automatically providing the correct working tension. One of the simplest consists of an idler pulley operated by a spring or weight. In Fig. 7 is shown a weight-controlled idler pulley used in conjunction with a flat belt and also a spring-loaded jockey sprocket for tensioning a roller chain.

The mechanism illustrated in Fig. 8 is an ingenious device which combines a compact gear reduction unit and an automatic belt tensioner. The belt from the source of power drives the pulley, which is fixed to a short spindle. This spindle is supported by a fulcrum arm or link, which is able to rotate about the driven shaft S. Fixed to the other end of the spindle on which the pulley is mounted is a pinion which engages with a gear wheel keyed to the driven shaft. Rotation of the spindle by means of the belt drive and pulley causes the pinion to attempt to make an epicyclic movement round the gear wheel, as shown by the dotted arrow.

This is prevented, however, by the tension of the belt, so that instead of the pinion travelling round the gear wheel it remains in the same position and turns the gear wheel instead. Naturally, if the load is heavy so that a large turning force is needed to rotate the gear wheel, then the pinion will exert a greater force in the direction of the dotted arrow and so put a greater tension on the belt. In other words, the greater the load, the greater is the belt tension, which is of course as it should be. In this way absolutely automatic belt tension is obtained because the load controls the tension.

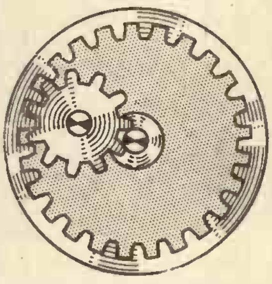


Fig. 10.—Internal toothed gear wheel and pinion which maintains the direction of rotation.

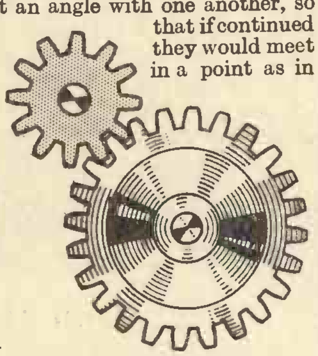


Fig. 9.—Spur gear wheel and pinion giving a ratio of 1 : 2.

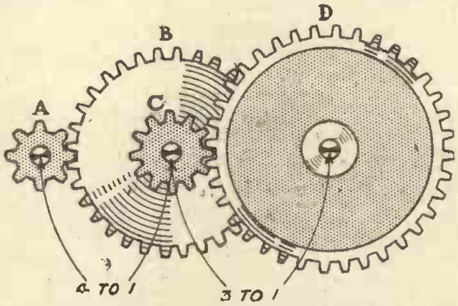


Fig. 11.—A train of spur wheels.

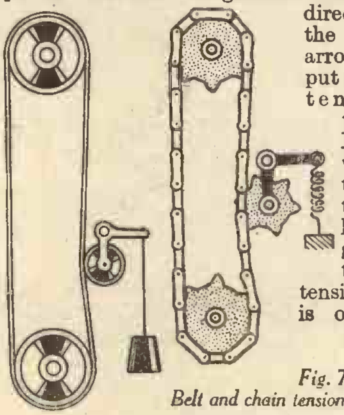


Fig. 7.—Belt and chain tensioning devices.

Spur Gears and Bevels

The transmission of rotary motion from one shaft to another placed close to it is usually effected by means of gear wheels meshing directly with one another. The gears used between parallel shafts, as in Figs. 8 to 11, are called spur wheels. Where there is a difference in the size between two engaging spur wheels the smaller is sometimes designated a *pinion*. When the shafts are at an angle with one another, so that if continued they would meet in a point as in Fig. 12, the gears are called *bevels*, or, if the angle between the shafts is exactly 90 degrees, they are also known as *mitre wheels*. When the shafts are at an angle so that if produced they would *not* meet in a point, then they are called *skew bevels*. The curious looking devices shown in Fig. 13 are not intended to represent an engineer's nightmare, but are actual mechanisms used for converting constant speed rotary motion into variable speed motion. The device shown at D is the familiar Geneva movement used in motion picture apparatus. The right hand wheel is revolved in a series of jerks by the single tooth on the other wheel. Between the jerks each picture is retained in front of the lens for the brief space of time which it takes for the left-hand wheel to make a complete revolution—that is, during the time it takes for the single tooth to come round again.

Gearing and the Law of Work

The power developed by an engine is usually dependent to a large measure on the speed at which it runs. This is particularly so with internal combustion engines and electric motors, where the maximum power is only developed at high revolutions. However, it may not be convenient or possible to use the power in this form, and the final shaft, wheel or other device performing the work may be required to revolve at a much slower speed. On the other hand, the speed of the final shaft may, in certain instances, need to be higher than that of the engine or prime mover. This necessitates the use of some form of gearing to carry out the conversion.

It will be readily appreciated that a difference in the size of a driving and a driven pulley or sprocket, or in the size of two intermeshing spur wheels, will also mean a difference between their relative speeds. For instance, in Fig. 9 the circumference of the small wheel or pinion is only one-half of that of the large gear wheel, so that for one revolution of the large wheel the small one will revolve twice. Obviously, if the pinion were mounted on the shaft of a high-revving engine and the drive to the work taken from the spindle of the gear wheel there would be a step down in speed between the engine and the driven appliance of 2 to 1.

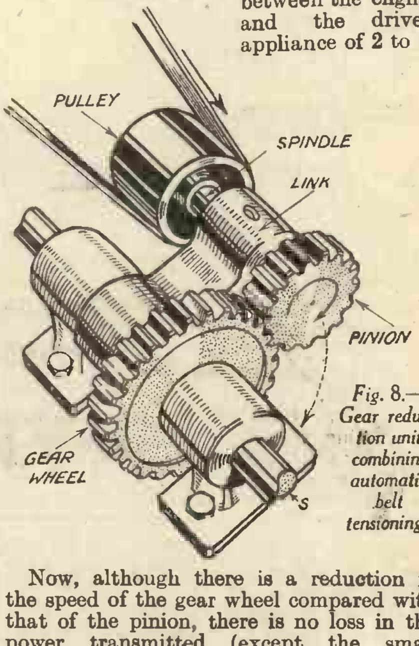


Fig. 8.—Gear reduction unit combining automatic belt tensioning.

Now, although there is a reduction in the speed of the gear wheel compared with that of the pinion, there is no loss in the power transmitted (except the small frictional losses, etc., incidental to any form of transmission), for *what is lost in speed is gained in force*. Thus the turning force of the gear wheel spindle is proportionately greater than that of the engine shaft carrying the pinion. This relationship between the speed and the force is known

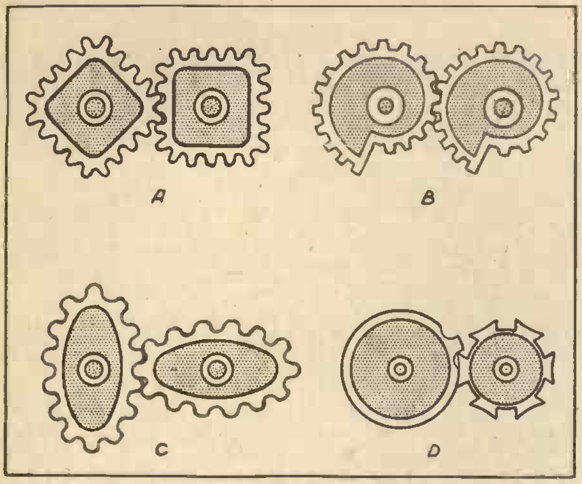


Fig. 13.—Various mechanisms for converting constant speed rotary motion into variable speed motion.

as *the Law of Work*, and is the law under which all forms of gearing operate.

With the simple gear and pinion of Fig. 9, ratios up to about 15 to 1 are usually quite practicable, but for very high ratios it is more usual to employ a train of gears as in Fig. 11. In the example shown it is quite obvious that the ratio between A and D is 12 to 1. There is also the question of the direction of rotation, and sometimes three wheels are used instead of two, merely to retain the same direction of rotation. Alternatively, where the shafts are close together an internal toothed-gear wheel and pinion as in Fig. 10 may be used.

Another type of high-ratio device but with the driven shaft at right angles to the driving shaft is the worm and worm wheel of Fig. 14. When skilfully designed, ratios as high as 70 to 1 can be employed. Above this, however, the efficiency drops off rapidly. Great accuracy in construction and fitting of the worm and wheel are necessary for efficiency and silent running.

Although electric motors, petrol engines, turbines, etc., revolve at very high speeds and usually require gearing down to the work, yet there are other prime movers which have to be geared up to obtain the necessary speed. Many devices operated by human energy, such as treadle lathes, sewing machines, bicycles, etc., are geared up.

It is not always realised that the length of the crank affects the gearing of crank-operated mechanisms. Thus, increasing the length of the cranks of a bicycle has a similar effect to lowering the gear, for owing to the extra leverage obtained, long cranks require less force to push them round than short ones. The reduction in the force is accompanied, however, by an increase in leg speed, since the cyclist's feet sweep out a longer path for each turn of the long cranks than they do with short cranks. The same thing applies to internal combustion engines and other engines using pistons and cranks. For example, a motor car or motor cycle employing a "long-stroke" engine will pull a higher gear than one with a "short-stroke" engine of the same cubic capacity. (The "stroke" is the total movement of the piston from one end of the cylinder to the other, and is, of course, dependent on the throw of the crank).

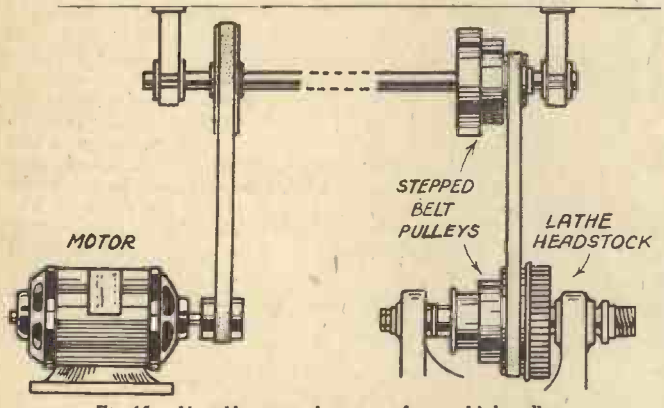


Fig. 15.—Variable gearing by means of stepped belt pulleys.

Variable Gears

An understanding of the Law of Work will make clear the reason for variable gears as applied to motor cars, bicycles and many other mechanisms. As already stated, most prime movers develop their maximum power at high speeds. Now, a car is so geared that when the engine is developing most power it will propel the car at the maximum speed on the level. In climbing a hill, greater force is required to turn the road wheels owing to the effect of gravity. To obtain this extra turning force it is necessary to lower the gear ratio. This will, of course, produce a slower turning of the road wheels, but owing to the Law of Work, a greater turning force will be imparted to them.

Clearly the ideal arrangement would be an infinitely variable gear which would work automatically and so adjust the gear ratio to suit the load under all conditions. Various attempts have been made from time to time to produce such a device, but without much success.

Step-by-Step Gears

The type of variable gear most frequently used, not only in cars and bicycles, but in engineering workshop and factory power transmission, is the step-by-step type. A typical example is shown in Fig. 15. Here three pairs of pulleys, giving three distinct ratios, are mounted on the two shafts. The gear is changed by slipping the belt from one set of pulleys to another, the diameter of the pulleys being such that one belt is suitable for each set of gears.

In the orthodox type of automobile gear box various speed reduction ratios between the engine and the back axle are obtained by sliding into engagement different sets of spur wheels and pinions. A cut-away view of such a gear box is shown in Fig. 16. However, all modern motor cycle gear boxes and many up-to-date car boxes work on what is called the "constant mesh" principle.

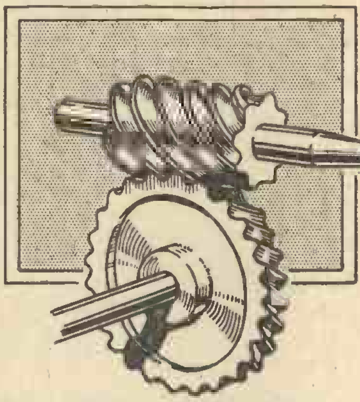


Fig. 14.—Worm and worm wheel for large reduction ratio between shafts at right angles.

Gears in Constant Mesh

The different sets of gear wheels are in constant engagement, but some run free on their shafts. To select a particular gear, dog clutches are slid along the shafts so that they engage with similar dogs attached to the gears required, and thus clamp them to their shafts. In this way the drive is transmitted from one shaft to another. Meanwhile the other sets of wheels which represent the other ratios run idle.

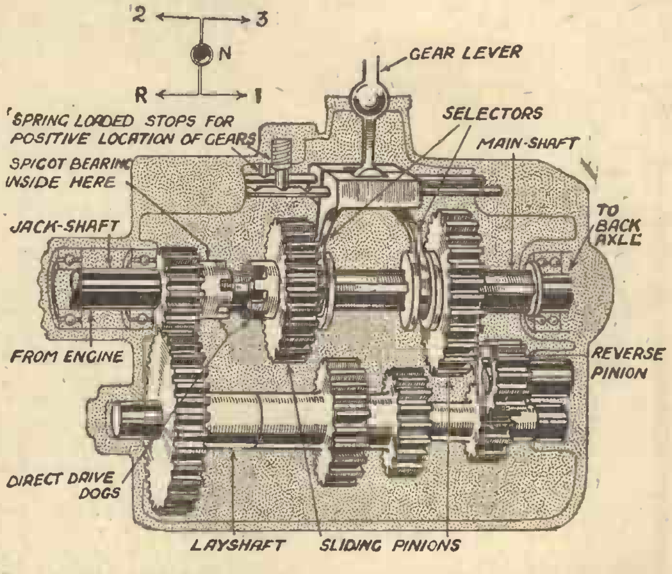
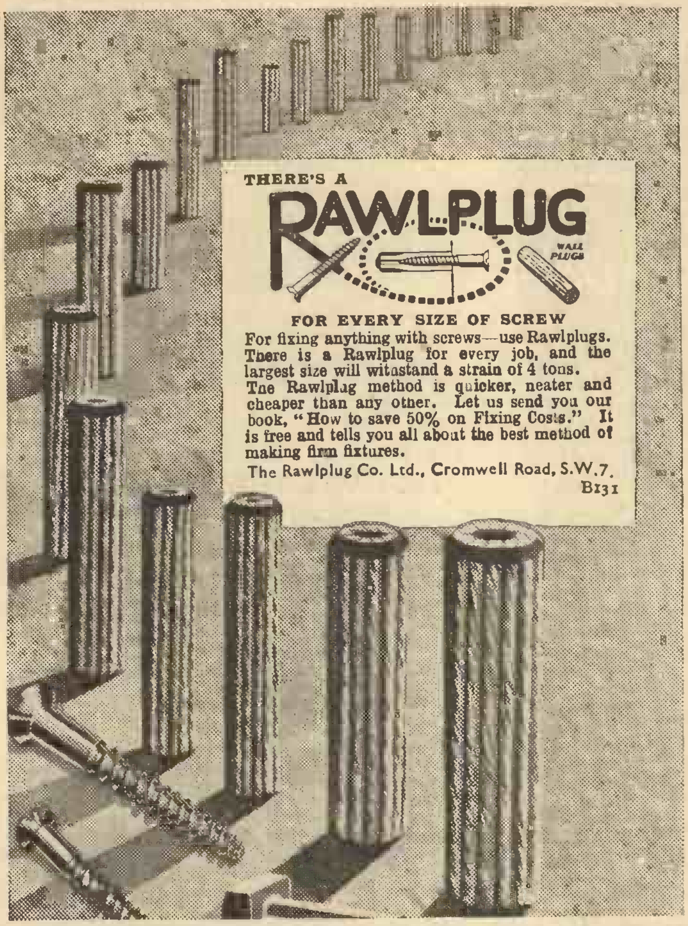


Fig. 16.—The principal parts of a three-speed gear box. The gears are shown in the neutral position. The jack shaft and main shaft are not one continuous shaft, but the end of the main shaft is free to revolve inside the jack shaft.



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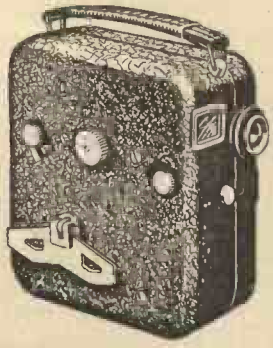

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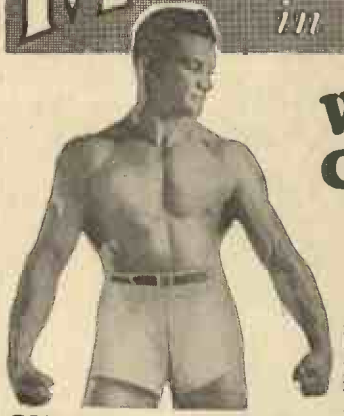

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The PRACTICAL MECHANICS Wireless Experimenter

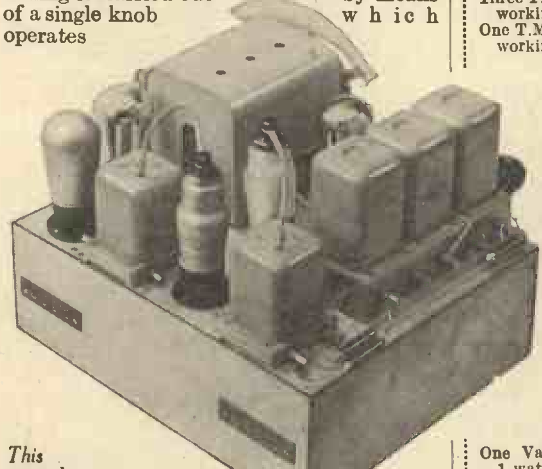
THE P.M. SUPER FIVE

A Five-Valve Superheterodyne Receiver which is Easy to Build and Capable of Exceedingly Good Results.

SINCE the first issue of PRACTICAL MECHANICS we have offered to readers eight different receivers of various types. None of these has employed more than four valves, however, and all have been reasonably cheap to build. This month we present a somewhat more ambitious set which is probably as efficient as any type of battery receiver could be. The "Super Five" is a superlative instrument in every way. It is selective enough to cut out the local station even if that is only a mile away, whilst it has an almost unlimited range. Despite these important advantages, though, it cannot be considered expensive, and it can be constructed just as easily, and with the same confidence, as an ordinary three-valve set. The various photographs and drawings show that compactness is the keynote, whilst they also indicate the extreme simplicity of the wiring.

Attractive Modern Cabinet

As a matter of fact, the chassis (which is metallised) measures only 12 in. by 10 in. and has 3½-in. side runners. The set easily fits into the distinctive Peto-Scott cabinet, which is of the modern horizontal type and accommodates the moving-coil loudspeaker as well as the batteries and accumulator. Controls are few in number, and have been arranged so as to produce a symmetrical arrangement, with the condenser escutcheon balancing up with the speaker fret. Needless to say, tuning is carried out by means of a single knob which operates upon the three-gang superhet condenser. An effective volume control is provided, this acting by varying the grid-bias potential applied to the intermediate-frequency amplifying valve. The only other controls are the three-point on-off switch and the wave-change switch, the latter being an integral part of the coil assembly.



This semi-plan view shows the compactness of the "Super Five."

The circuit calls for very little explanation, since it is of a fairly standard battery superheterodyne type. As mentioned before, there are five valves in all, these being arranged as:—first detector, oscillator, intermediate-frequency amplifier; second detector, and pentode output. Anode-circuit mixing is employed in the case of the first two valves, and the first detector is of the S.G. type and working on the anode-bend principle. One point which calls for some reference is in respect of the 300-ohm fixed resistance wired in parallel with the reaction winding of the oscillator coil; this is to reduce the oscillator output to a suitable figure, and if it is omitted a constant whistle will be heard. A 50,000-ohm potentiometer is used as a volume control, and this varies the bias voltage fed to the grid of the variable-mu I.F. valve. The second detector and output pentode are connected in a perfectly standard and reliable circuit.

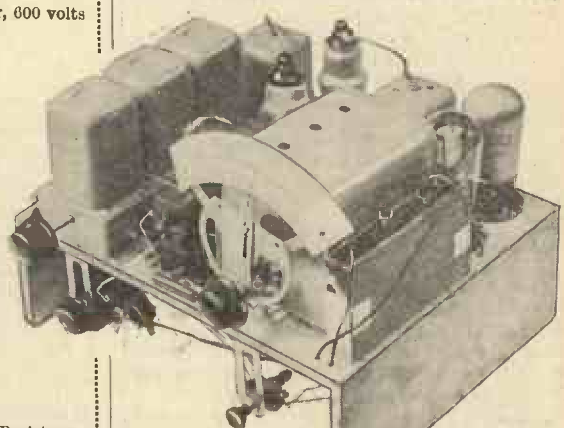
LIST OF COMPONENTS

One Peto-Scott "Metaplex" Chassis 12 in. by 10 in., with 3½ in. runners.
One set Wearite Superhet Coils, type W.S.R.
One Polar Three-gang Superhet Condenser, type "Star Minor" (C.1, C.2, C.3).
One Polar Condenser Drive, type "Arcuate."
Two Wearite 110 k.c. Intermediate-frequency Transformers.
One Ward & Goldstone Screened H.F. Choke.
One Lissen ·0003-mfd. Pre-set Condenser(C. 4).
One Lissen L.F. Transformer, type "Hypernik."
One Lissen 50,000-ohm Volume Control Potentiometer (R.4).
One T.M.C. 1-mfd. Fixed Condenser, type 25 (C.11).
One T.M.C. 2-mfd. Fixed Condenser, type 25 (C.12).
Three T.M.C. ·1-mfd. Tubular Condensers, 600 volts working (C.6, C.7, C.7).
One T.M.C. ·03-mfd. Tubular Condenser, 600 volts working (C.5).
One T.M.C. ·0005-mfd. Tubular Condenser, 600 volts working (C.10).
One T.M.C. ·0003-mfd. Tubular Condenser, 600 volts working (C.13)
One Lissen ·002-mfd. Pre-set Condenser (C.9).
One Varley 2-meg. "Electronic" Grid Leak, 1 watt (R.8).
One Varley ·5-meg. "Electronic" Grid Leak, 1 watt (R.6).
One Varley 20,000-ohm "Electronic" Resistance, 1 watt (R.9).
Three Varley 2,000-ohm "Electronic" Resistances, 1 watt (R.1, R.2, R.7).
One Varley 300-ohm. "Electronic" Resistance, 1 watt (R.3).
One Varley 50,000-ohm "Electronic" Resistance, 1 watt (R.5).
One Lissen 3-point On-Off Switch.
Four Clix 4-pin Chassis Mounting Valve Holders.
One Clix 5-pin Chassis Mounting Valve Holder.
One Bulgin G.B. Battery Clips, type No. 1.
Two Clix Terminal Socket Strips; one for A and E., one for L.S. and P.U.
One Micofu "Microfuse," 100 m.a.
Two British Radiogram Component Brackets.
One Belling Lee 5-way Battery Cord with Terminals marked H.T.+ 1, H.T. + 2, H.T. −, L.T. + and L.T. −.
Four Clix Wander Plugs, marked G.B. − 1, G.B. − 2, G.B. − 3 and G.B. +.
Screws, Connecting wire, etc.
Five Hivac Valves, types S.G.210, L.210, V.S.210, D.210 (metallised) and Y.220.
One Amplion M.C. Loud-speaker Unit, type M.C. 22
One 120-volt H.T., Battery
One 9-volt G.B., Battery
One 2-volt Accumulator.
One Peto-Scott "Super Five" Cabinet.

Special Matched Gang Condenser

A list of the components required is given on this page. It is particularly important that the exact parts should be used, since they have been chosen with rather more than usual care. This was essential because of the fact that the circuit, like all sensitive superhets, is extremely sensitive. On no account should any alternative type of gang condenser be used, because that specified has been designed especially to match the Wearite superhet coils, the vanes of the oscillator section being so shaped that perfect tracking is obtained over the whole of both wavebands.

The drawings and photographs will explain the construction even better than words could do, but a few points which were observed whilst building the original receiver might prove useful. For example, it is best to lay out all the parts on the upper side of the chassis before any of them are screwed down; this is because there is no waste space and the parts must be close together without any of them fouling any others. To ensure this it is well to stand the valves on the chassis before finally fixing the positions of the other parts. Next, draw faint pencil lines round the major components. After that the five 1-in. holes can be bored for the valve-holders and the under-chassis components screwed in the positions indicated. Finally, mount the gang condenser, three-coil assembly, the I.F. transformers, ·002-mfd. pre-set condenser and the G.B. battery clips. It will be noticed that the tubular condensers and fixed resistances are not attached to the chassis, but are supported in the wiring.



A three-quarter view showing the gang condenser and coils.

Wire up with Care

In connecting-up it is not very important that any particular sequence should be followed, although it will be found quickest to start from the left of the chassis and work towards the right, first making as many connections as possible on the underside, and then finishing off on top. A few wires were soldered on the original model, in the interest of neatness, but this is not essential, although it does reduce the lengths of a few rather important wires. In any case, it is desirable that constructors should follow the positions of the various wires shown in the photographs as nearly as possible in order to guard against interaction and unwanted oscillation.

It will be seen that two pick-up sockets are provided on one of the terminal strips and these are connected into the grid circuit of the second detector. Should any reader not wish to use the set in conjunction with a pick-up and gramophone, however, these sockets can simply be left disconnected.

On completion of the wiring the valves should be placed in their respective holders and the various batteries wired up. As the disposition of the valves is rather unusual it might be as well to explain which holder is which. Looking at the set from the front the first valve is the oscillator, for which the type L210 is used; the second is the first detector, type SG210; the third is the I.F., type VS210; of the remaining two, the back one is the second detector, type D210 and the other is the pentode, type Y220.

Battery Voltages

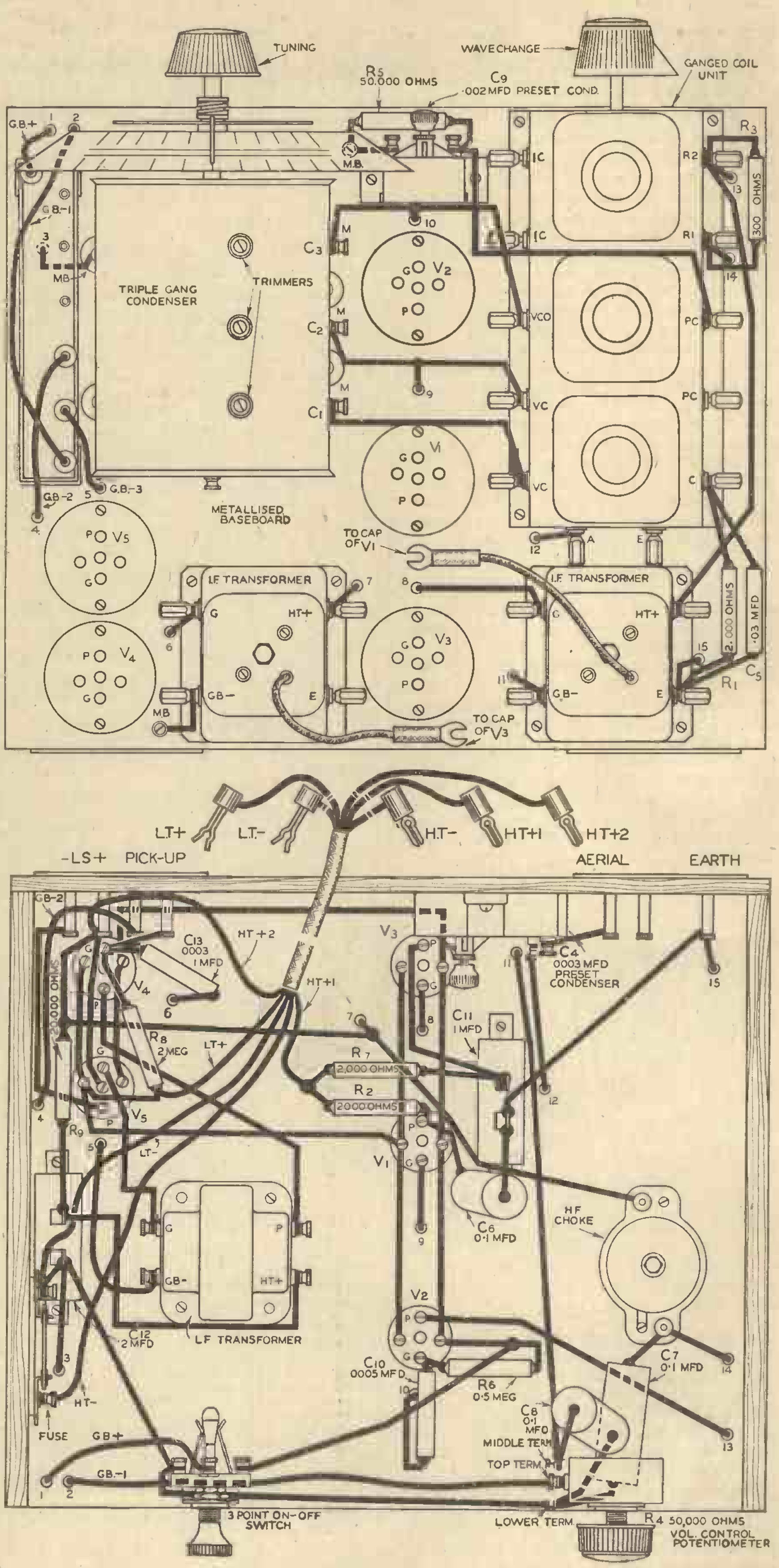
There are three negative grid bias plugs which should be inserted into the 9-volt battery in the following order: G.B. − 1, 9 volts; G.B. − 2, 1½ volts; G.B. − 3, 4½ volts. These figures are given on the assumption that the high-tension battery has a maximum voltage of 120. Of the two positive H.T. plugs, H.T. + 1 should be plugged into a socket giving between 70 and 100 volts, and H.T. + 2 should receive the full voltage of the battery. After first trying out the set it might be worth while to experiment with the best position of wander plug H.T. + 1, but in the case of the original set best reception was secured when this was given 78 volts.

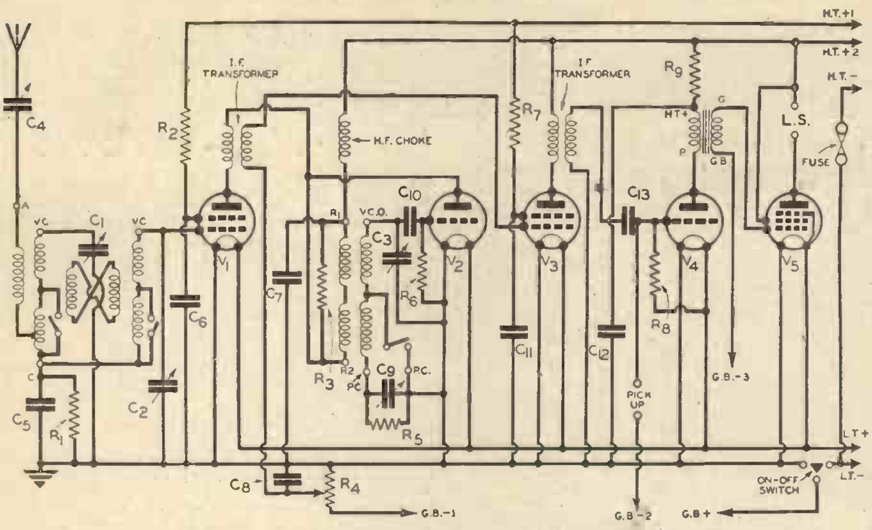
There is a pre-set condenser in series with the aerial lead to the first band-pass coil, and this should be set to its midway position for the preliminary tests, although a different setting can be tried later. Having connected aerial, earth, batteries and speaker, and with the set out of the cabinet, the various trimming adjustments can be made. First of all turn the wave-change switch to the medium-wave position (pointer to the left) and turn the volume control full on (clockwise). By slowly rotating the tuning knob a station will soon be heard—it is essential that the knob should be moved slowly though, because tuning is so sharp that even a powerful station will only occupy about one degree on the condenser scale. When first tuned in the signal will probably be fairly weak, but it can soon be brought up to full strength by setting the trimmers.

Trimming Adjustments

Use a fairly long screwdriver with a wooden handle and start by turning the trimmer screw on the front (oscillator) section of the condenser. It will only need to be moved through a very small arc, so turn it as slowly as possible. After that try altering the other two trimmers, which act upon the band-pass coils, in the same way, slightly modifying the main condenser setting if necessary. The trimmers on the I.F. transformers should then receive attention. Commence by adjusting the left-hand trimmer on the first transformer;

The above- and below-chassis wiring plans for the "Super Five." Note that there is no connection to one terminal marked P.C. on the coil assembly; this terminal is actually connected to the chassis internally.





The circuit shown above will interest more-technical readers.

it will probably be unnecessary to touch the others, but they can be tried, just to make sure.

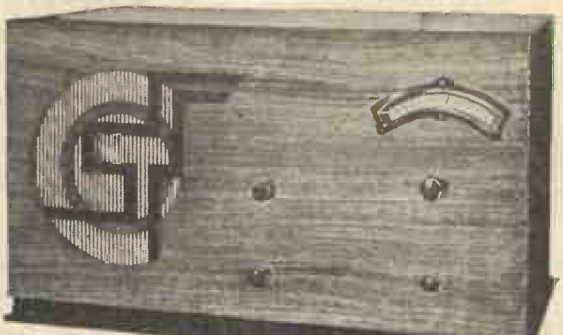
When medium-wave reception is quite satisfactory, turn to the long waves, and tune in the National or other powerful station. To do this it will be necessary to screw the knob of the ·002-mfd. pre-set condenser almost fully "in." Once the station is heard, signals can be increased in strength by careful adjustment of this pre-set, and there will be a definite setting at which signal strength is at its greatest.

The set is now ready for use, and no further adjustment will ever be called for. It can therefore be fitted into its cabinet and used with equal ease by any member of the household.

Fitting the Set into its Cabinet

If desired, the cabinet can be obtained ready drilled to take the various controls, but those who wish to do this part of the work themselves will find no difficulty whatever. The elevation reproduced on this page shows the positions of all the various parts and gives the necessary panel dimensions. It will be found best to mark off the positions on the inside of the cabinet, in order to avoid scratching the highly polished front, and a start should be made by measuring 3½ in. from the left-hand side and squaring a line down the wood. Next measure a further distance of 6⅜ in. along and square a second line. By measuring up the first line distances of 1⅜ in. and 5 3/16 in., the positions of the holes for the on-off switch and tuning knob will be located. The lower hole should be ⅜ in. in diameter and the upper one ⅝ in., and these holes can be made with a centre bit, after making ⅛-in. pilot holes to mark the centres. Up the second line measure distances of 1⅜ in. and 4¾ in. respectively to position the centres of the holes for the volume control potentiometer knob and the wave-change switch spindle. The lower hole should be ⅜ in. and the upper one ¼ in.

A photograph which shows the simplicity of the under-chassis wiring.

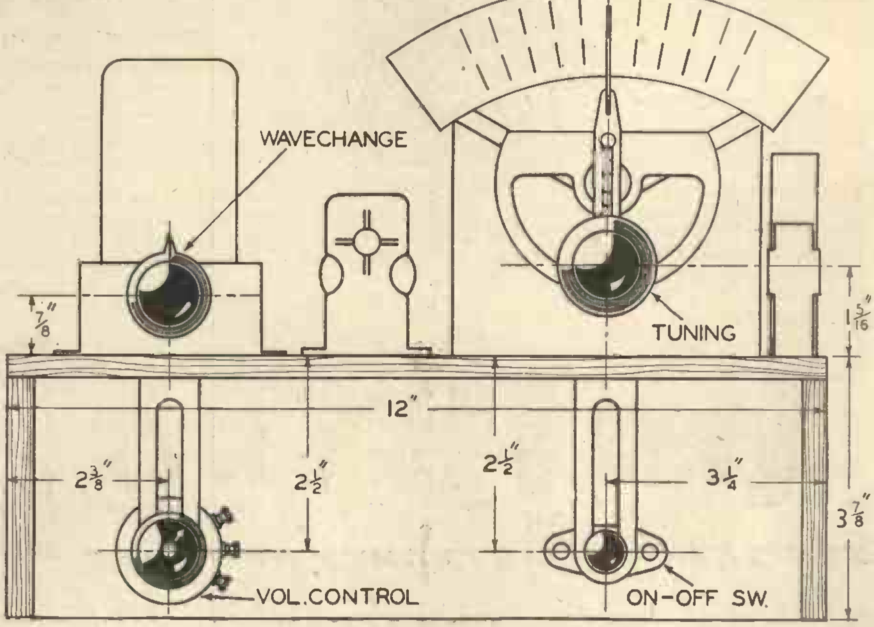


The handsome and "balanced" appearance of the finished set can be judged from this picture.

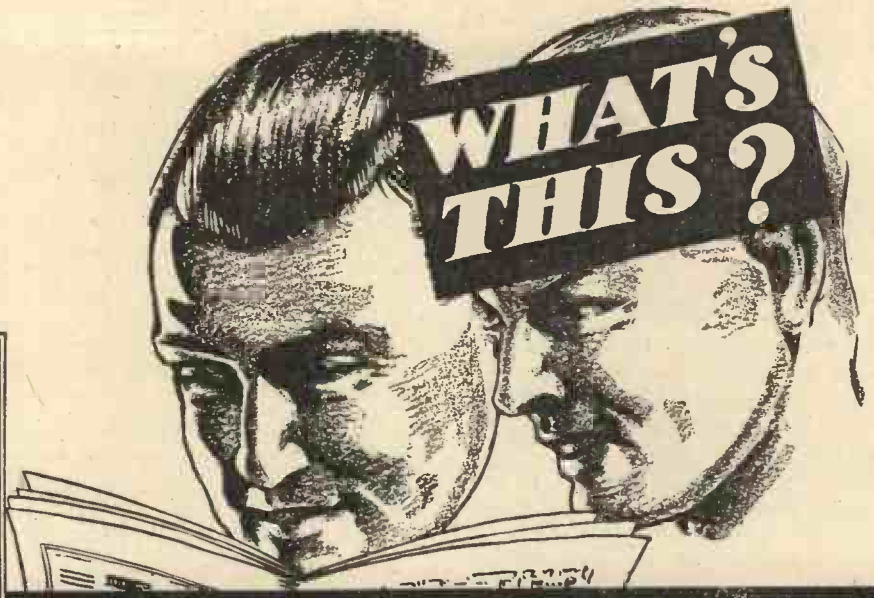
The opening for the condenser escutcheon can be made by drilling a series of ¼-in. holes and then cutting between them with a chisel. Alternatively, it might be made with a fret-saw. The height of the opening can best be obtained by measuring the dial and arranging the escutcheon in such a position that the divisions are clearly seen through it. The shape of the escutcheon hole can best be marked by drawing a line round the plate.

Using a Pick-up

It has been mentioned before that sockets are provided for the connection of a pick-up, but there is no provision for varying the volume lever when gramophone reproduction is being enjoyed. It is therefore desirable that a pick-up should be used which is fitted with an integral control. Otherwise a suitable potentiometer (the best value depends upon the actual unit, and should be chosen according to the makers' instructions) should be inserted between the pick-up leads and the sockets. Simply connect the two "outside" terminals of the potentiometer to the sockets and join the pick-up leads between one "outside" terminal and the centre one.



Use the above front elevation when marking out the front of the cabinet.



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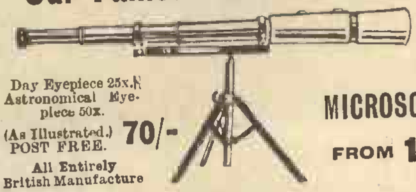

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MODELLING HISTORIC LOCOMOTIVES PART II.

By E. W. TWINING

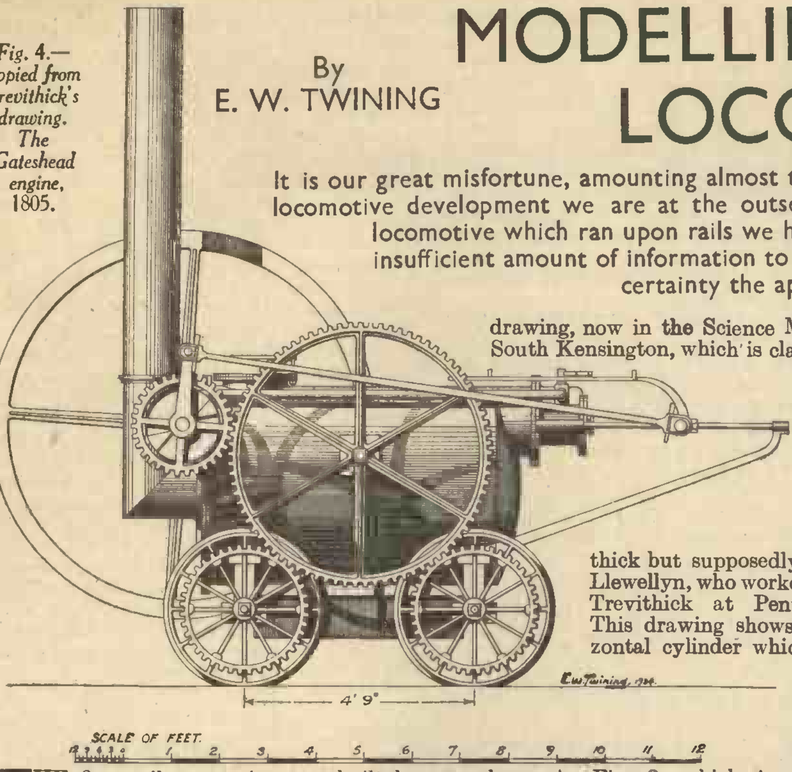

Fig. 4.—Copied from Trevithick's drawing. The Gateshead engine, 1805.

It is our great misfortune, amounting almost to a calamity, that in reviewing the history of locomotive development we are at the outset faced with the fact that of the very first locomotive which ran upon rails we have no reliable drawing or illustration and an insufficient amount of information to enable us even to visualise with any degree of certainty the appearance of the engine.

THE first railway engine was built by Richard Trevithick, a Cornishman, in the year 1803, and tested early in 1804, at a time when he was engaged in setting up a great engine to work the rolling mills of the Penydarran Iron Works, near Merthyr Tydvil, in South Wales. From these works there ran a tram road consisting of cast-iron rails laid upon stone sleepers to a point nearly ten miles away at Abercynon, where the worked iron was shipped into barges upon the Glamorganshire canal. The rails were L-shaped in cross-section, the vertical angles of the two rails of the track being inside, *i.e.*, towards each other. The wheels of the trams or wagons were plain and without flanges, like road vehicle wheels, and were kept upon the track by these angles. Trevithick's engine was built to take the place of horses for transporting iron over this tram road. It had, according to a description by John Farey written in 1815, a boiler of cast iron, 6 ft. long by 4 ft. 3 in. diameter, containing, most probably, Trevithick's usual form of return flue: that is to say, the furnace was inside and to one side of the boiler and the flames passed towards the other end through a U-shaped bend in the flue and returned to the furnace end to enter the chimney, which was erected alongside of the furnace door. There was one cylinder only which was almost totally enclosed within the boiler, but whether it was placed horizontally or vertically is not definitely known. There is a drawing, now in the Science Museum. South Kensington, which is claimed by some to be authentic, though not made by Trevithick but supposedly by one Llewellyn, who worked under Trevithick at Penydarran. This drawing shows a horizontal cylinder which drove the track wheels through gearing as shown in Fig. 3, which is a reproduction of a tracing made from the drawing referred to. The drawing indicates that only the road wheels on the geared side were driven, the other two, and, in fact, all of them, being loose upon fixed axles.

Points of Doubt

Unfortunately, although the drawing appears to be to scale, no scale is shown, but an inscription upon it states that the cylinder had a diameter of 4¾ in. and a stroke of 3 ft. Now Trevithick, in certain letters which still exist, stated that the bore was 8¼ in. and stroke 4 ft. 6 in. There are a number of other figures relating to his Penydarran engine which Trevithick gave in his writings and which throw doubt upon the drawing: points regarding the distance the engine travelled for each stroke of the piston, by inference the gauge of the wheels and particulars of the blast pipe and chimney measurements, all of which are at variance with Llewellyn's drawing and from which, unless Trevithick himself was in error, we must conclude that the drawing is either not to scale or represents some other engine, or an engine which was designed but not built.

An account of the Penydarran engine's momentous run, at which an important bet of 500 guineas a side was decided, published in an encyclopædia fifteen years after the event, states that the cylinder of the engine was vertical. Now we know that most of Trevithick's stationary engines had vertical cylinders enclosed in the boiler and that the locomotive which ran on a circular railway near Gower Street, London, in 1808, had a cylinder similarly disposed, but in the same year, 1804, in which the Penydarran engine was built Trevithick made drawings for an engine with a 9 in. horizontal cylinder of 3 ft. stroke driving flanged wheels through gearing, and these drawings are still in existence; in fact they also are in the South Kensington Science Museum. These drawings found their way to Gateshead-on-Tyne, apparently shortly after they were made, and from them an engine was built in the year 1805 for Mr. Blackett, to run upon the Wylam Colliery railways. From this it would seem probable that for his locomotives Trevithick had adopted the horizontal position for his cylinder and that probably not until some four years had elapsed did he put it upright.

For Interested Readers

Nearly all the contentions, both for and against the Llewellyn drawing, were ably put forward by Mr. W. W. Mason in a paper read before the members of the Newcomen Society last year, and interested readers are strongly recommended to peruse this, and particularly the discussion which followed it, published in the Transactions of the Society, Vol. XII. A copy of the volume will probably

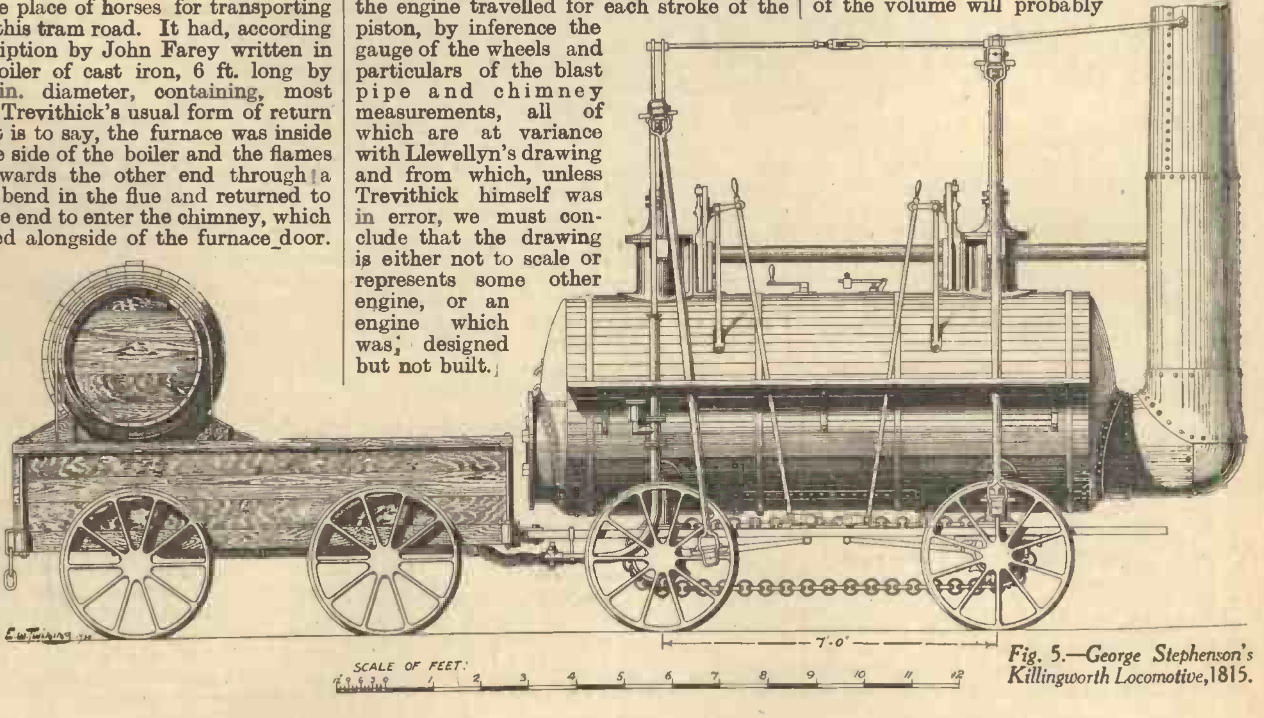

Fig. 5.—George Stephenson's Killingworth Locomotive, 1815.

be found in most large libraries, or may be purchased from the Society's Treasurer by application to the Science Museum, South Kensington, London, S.W. 7, price 20*s*.

Trevithick's Gateshead drawings have a scale appended and therefore the whole of the measurements of the engine can be taken off. The differences between the Penydarran and the Gateshead engines were possibly the sizes of the cylinders and the rims of the wheels; the latter being flanged and the other not. A very important point about the design of engine shown in the Llewellyn drawing is that it is absolutely impracticable in one respect: the piston rod and great crosshead, the latter extending the full width of the engine, would be reciprocating immediately over the furnace opening which, even were the engine used for stationary work, would be a source of danger to the engineman in stoking, whilst, when travelling, it would be impossible for him to get near enough to use a shovel. Mr. E. A. Forward, of the Science Museum, called attention to this point at a meeting of the Newcomen Society in 1921. See Vol. I. of N.S. Transactions. Trevithick fitted a damper and water pump and applied the blast in the chimney, yet the Llewellyn drawing shows neither damper, pump, nor exhaust pipe.

The Gateshead Engine

In the Gateshead engine, a side elevation of which, to scale, is given in Fig. 4, the cylinder, piston rod and crosshead are at the opposite end of the boiler to the furnace, but the same arrangement of return flue is retained. If in the Llewellyn drawing we turn the chimney and fire around to the other end the two engines are almost alike and we get a practicable machine. It therefore seems likely that the drawing which purports to represent merely a "Tram Engine" (to quote from the inscription referred to) was merely an attempt at a design, perhaps a preliminary design, which was seen to be impracticable. I believe it to be probable that the cylinder of the Penydarran engine *was* horizontal, but I think it likely that the general arrangement was the same as or similar to that of the Gateshead locomotive. I cannot believe that Trevithick would build an engine with a furnace which was inaccessible. I said a while back that the Llewellyn drawing was either not to scale or represents some other engine, possibly not built. I maintain that the drawing, though crudely done, *is* to scale, and that the scale is 1 in. to the foot. Based on this the stroke is 3 ft., in accordance with the inscription, and the gauge of the track also 3 ft. or thereabouts. Now Mr. Mason has demonstrated that the gauge of the Penydarran rails varied between 4 ft. 7 in. and 4 ft. 8½ in., so, if the drawing represents some other engine, whether constructed or not, it was one designed for the narrower gauge of 3 ft., some of which existed, and, as I understand, still exists in South Wales for the lines about works and yards.

Before I leave Trevithick's work I strongly recommend that the Gateshead engine be modelled; for that was undoubtedly the source from which Blackett & Hedley drew their inspiration which led to the building of their famous "Puffing Billy" for the Wylam Colliery lines. This in the year 1813. "Puffing Billy" is preserved in the Science Museum, South Kensington, and is the oldest locomotive in the world.

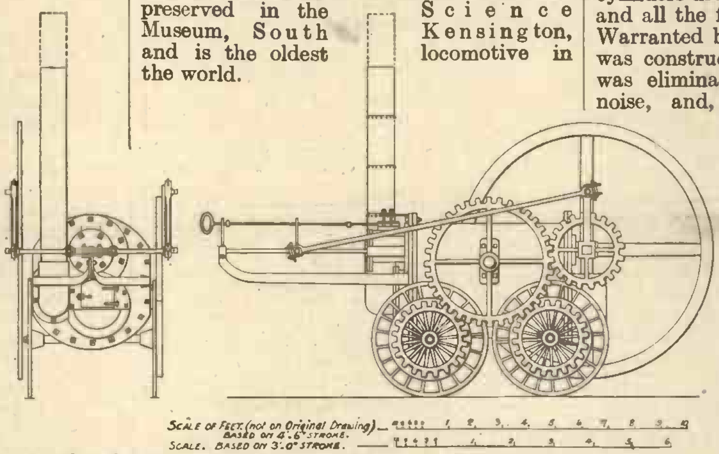

Fig. 3.—Copy of the Llewellyn drawing of "A Tram Engine," dated 1803.

Blenkinsop and Murray

In dealing with the subject chronologically, mention must be made of the work of Blenkinsop and Murray, who, two years before Blackett and Hedley, built an engine for the Middleton Colliery near Leeds in 1811. This machine, and others which followed it, were successful. The special feature of a cogged wheel engaging with a toothed rack extending the whole length of the line was introduced, the reason for which has frequently been mis-stated. It has been said that the builders, ignoring Trevithick's achievement, believed that insufficient adhesion for traction could not otherwise be obtained, but there are really no grounds for this assumption. The real reason probably was that the engines were too light for the loads they had to pull and could not be built heavier owing to weakness in the road. It was considered to be less costly to build light engines and add the rack than to relay the track with heavier rails.

The Genius of Stephenson

Immediately after Blackett and Hedley, there entered the lists one who, with, later, his son, soared to greater heights—and to whom the world owes more—than any other man, either before or since, in developing the locomotive. I refer, of course, to George Stephenson. Inspired doubtless by the work of Trevithick and the experiments upon the railways of the Wylam and the Middleton Collieries, Stephenson, who was mechanic and enginewright of the Killingworth Colliery, near Newcastle, took up the question of using locomotive power and was entrusted with money by the owners of the colliery to build an engine. This was tried on the rails in July of 1814, and performed with a fair and encouraging amount of satisfaction. The cylinders drove the wheels through gearing, and all the four wheels were thus coupled. Warranted by this success a second engine was constructed in 1815 in which gearing was eliminated on account of wear and noise, and, as in Trevithick's London engine of 1808, the connecting rods worked directly on to crank pins in the driving wheels. The two axles were coupled by sprocket wheels and endless chain. The two cylinders were each of 9-in. bore by 2-ft. stroke, and the diameter of the driving wheels was 3 ft. The chimney appears to have been of extraordinary height and terminated in an open-topped cowl, which it would seem could be turned according to the direction of travel, or, when the engine was stationary, in the direction of the wind. The shape of this cowl is clearly shown in the model which was illustrated on p. 379, Fig. 1, in last month's issue. Its object was obviously to induce an increase of velocity of the gases up the chimney. Just how it was moved by the engineman is not quite clear, as it was out of his reach except by the use of a rod or pole.

An elevation drawing of the engine and tender is given in Fig. 5. From this it will be seen that the furnace and flue are of the straight-through type, the boiler being fired from the opposite end to the chimney. Stephenson, like Blenkinsop, evidently considered that when weighed against the difficulties of constructing return flues the straight furnace yielded a sufficient amount of heating surface, though Hedley had adopted the return flue originated and used by Trevithick for both stationary boilers and locomotives.

SMALL WATER-POWER INSTALLATIONS

(*Continued from page* 415.)

velocity. Therefore the diameter of the wheel must be such that when it rotates at 600 r.p.m. its peripheral velocity must be 40 ft. per second. This is very simply worked out thus :—

Circumference (in feet)

$$= \frac{\text{Peripheral Velocity (ft. per sec.)}}{\text{Revs. per sec.}}$$

$= \frac{40}{10} = 4$ ft. The diameter of the wheel will therefore be $\frac{4}{\pi} = \frac{4}{3{\cdot}14} = 1{\cdot}27$ ft. or, say, 15 in.

The other important dimension is the size of the jet. This can be found from the following formula, which has been simplified as far as possible :—

Jet diameter (inches)

$$= {\cdot}7 \sqrt{\frac{\text{Flow (gallons per min.)}}{\text{Water Velocity (ft. per sec.)}}}.$$

The Buckets for the Wheel

In the present case the flow is 50 gallons per minute and the water velocity at the jet was found to be 80 ft. per second, so our calculation becomes ${\cdot}7\sqrt{\frac{50}{80}} = {\cdot}7\sqrt{{\cdot}625} = {\cdot}7 \times {\cdot}81 = {\cdot}567$ in., or, say, $\frac{9}{16}$ in. diameter for a single jet. If two jets are used the *area* of the jet orifice should be halved, not the diameter. The nozzle should be reduced gradually in diameter from the supply pipe to the jet outlet, the last part being parallel for a length equal to the diameter of the jet.

If a home-made wheel is used the buckets may be bent out of flat iron or steel to a semicircular shape and the jet must be arranged so that the water strikes the side of the bucket tangentially as shown in Fig. 6. There must be no projections such as screwheads, etc., to disturb the smooth flow of the water. Hemispherical buckets, either single or double, are generally used on bought Pelton wheels, which would be expected to give somewhat higher efficiency than home-made ones.

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By OUR AIR EXPERT

A New Type of Model Fuel-driven Engine

A MINIATURE aircraft engine that uses a patented fuel in stick form and drives a radial engine and propeller at 2,500 r.p.m. has been perfected by a Los Angeles inventor who is marketing first a true scale reproduction of a Lockheed Vega, having 24-in. span.

A model Lockheed Vega fitted with the new type of model fuel-driven engine.

Doing away entirely with rubber band and clockwork motors the new model plane takes off and flies away within two seconds after an ignited stick of the fuel is placed in a sealed chamber in the fuselage. A quarter-turn valve under the tail surfaces gives access to the fuel chamber which automatically feeds its power to the five-cylinder radial engine.

The engine and fuel chamber and propeller complete weigh only 8 oz. The engine is $2\frac{1}{2}$ in. in diameter, has a $\frac{3}{8}$-in. bore, $\frac{1}{4}$-in. stroke, and develops approximately 1/25 h.p at 2,500 r.p.m.

There is no carburettor nor ignition; the wingspan is 24 in. Other models of Army, Navy and racing planes will soon be ready. The inventor is Fred S. McFarland and his ships are being made by the Mototoy Mfg. Co., whose address readers may have upon application.

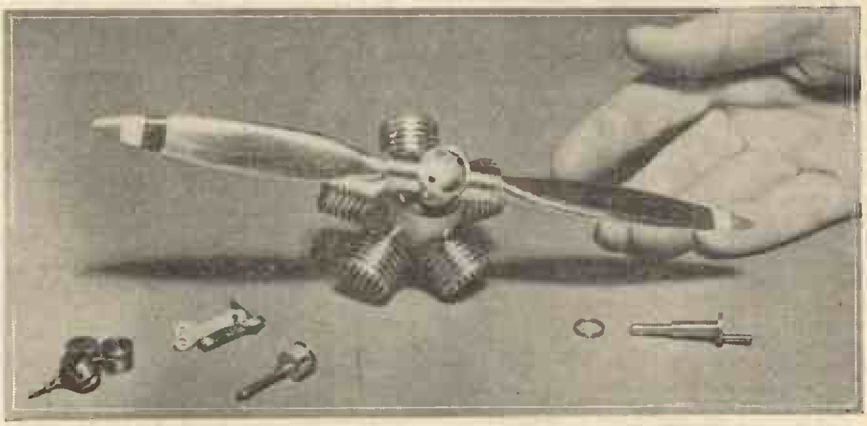
The Hallam Miniature Petrol Engine

I have recently completed one of the Hallam 13·5 c.c. two-stroke petrol engines from a set of castings supplied by J. Hallam & Sons, Poole, Dorset. This engine is very ingeniously designed, so that anyone who possesses a small lathe can make it. The liner (of steel) is supplied bored and ready for lapping. The cooling fins are separate pressings which are pushed over the liner and thus eliminate machining. The only parts which require turning are the cylinder head, the two halves of the crankcase, the piston, and the casting which surrounds the ported portion of the liner. The engine is of the usual two-stroke, three-port type, the ports being drilled and filed in the liner. Bosses are cast on the body casting for the mixing chamber stub, the transfer passages and the exhaust port. The contact breaker is of the exposed type, having an advance and retard arm. It fits over the front crankcase casting and carries lugs for the contacts and contact-maker blade. The crankshaft is taper-ended and machined from the solid, the crank-pin being tubular and silver-soldered into position. The mixing-chamber must be used in conjunction with a petrol tank having a cut-off needle valve, and the mixture is controlled by means of a taper needle in the top of the mixing-chamber casting. I have not yet had an opportunity of testing this little unit, which is the lightest on the market. I have, however, tested one made by Mr. Hallam and find it quite efficient.

Power-driven Model Aircraft

Lively interest is now being shown in small power-driven aircraft of all types; miniature petrol engines are gaining in popularity, compressed air engines are greatly in evidence, and one or two readers are building model steam engines of the flash boiler type. Superheated steam engines, whilst sometimes troublesome, when properly tuned up, provide an ideal source of power. I should be glad to publish details of such a design if sufficient interest is shown.

Model petrol engines, on the other hand, require a considerable amount of skill to make and to operate. I have tried most of the model petrol engines on the market, and I should like to dispel an impression that you merely have to swing the propeller and off they go. Far from that! A very delicate adjustment of the mixture is necessary. The ignition timing must be just right and the engine must be free and have good compression. If the engine fails to start after a few swings, the engine becomes charged inside with neat petrol. No engine of small capacity will run under these conditions and it becomes necessary to "dry" them out. Once the correct mixture strength has been found, the jet should be locked, and most engines will then start even from cold after two or three swings.


The model engine complete with adjustable-pitch propeller. Some of the engine parts are also shown.

The tail unit of the model Lockheed Vega shown above. Note the power plug, which fits into the tail.

American Models

I have received from the Cleveland Model & Supply Co. (Inc.), 1866–0 West 57th Street, Cleveland, Ohio, U.S.A., a number of interesting photographs of flying scale models, two of which I reproduce on the next page. The construction is largely of balsa wood, the wings being covered with jap tissue paper. Complete outfits for building a wide variety of models are available from the company named. These models are not, of course, intended for distance or duration flying, but they certainly look most realistic in the air.

This Year's Competitions

I notice that this year's competitions are following more or less orthodox lines. I still do not like that ridiculous fuselage formula which is responsible for the stereotyped fuselage model one sees in evidence

SF38. Buhl Bull Pup. A well-known American commercial light plane. This is a model of a production machine very popular in America. The model flies very gracefully.

The Fokker D-7. This famous aeroplane is well known for its splendid war work, and is considered to be one of the most efficient "old timers" ever designed. The model flies very steadily for a distance of approximately 500 feet or more.

on Wimbledon Common and other London flying centres. The amusing part about this formula is that it was designed to improve the appearance of model aeroplanes, to bring them more in line with model engineering practice, and to kill the so-called freak spar machine. Now the most important thing about a fuselage is that it should be covered, and yet the competition rules framed by the S.M.A.E. do not make it compulsory for fuselages to be covered. I admit that one would be foolish not to cover it, but I can see several possibilities of model builders obtaining advantages over their competitors by omitting to do so. I suggest to the Competition Secretary of the S.M.A.E. that if it is necessary to have a fuselage formula (I am quite certain that it is not) he should include a clause to the effect that such fuselages must be covered. I am of the opinion that a rule merely stipulating that a model must have a fuselage of reasonable proportions would be more satisfactory. The formula referred to is: Minimum value of maximum cross-sectional area

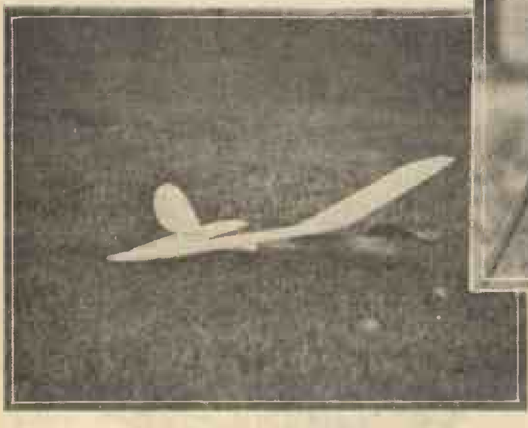
$$= \frac{(\text{overall length of model})^2}{100}$$

It would be interesting to know who was responsible for deciding these particular proportions and what was the basis upon which it was made. I think every intending competitor has a right to know this. Let us assume that such a formula results in an inefficient fuselage (I am quite sure that it does), then every aero-modellist is compelled to make a machine which is inefficient. It would be far better to allow sufficient latitude for originality in design. The position now is that the S.M.A.E. is deciding for all time what is efficient and what is not. In other sports, no similar ruling exists. In motor racing, for example, it is merely the power which is limited for a certain class. In others, the style of bodywork. I am sorry to have to labour this point, which I have referred to many times before, but I feel that the time has now arrived when the S.M.A.E. should correct this fallacy.

A complete set of machined parts for the Hallam 13·5 c.c. two-stroke petrol engine.

MODEL AEROPLANES AND AIRSHIPS

I OFTEN receive queries regarding model aeroplane construction which could be more adequately answered by consulting my 1*s.* handbook "Model Aeroplanes and Airships," obtainable for 1*s.* 2*d.* by post from "Practical Mechanics," Geo. Newnes Ltd., 8/11 Southampton Street, Strand, W.C.2. This little book of 96 pages deals with materials for model aeroplanes, types of model aeroplanes, technical terms, how an aeroplane flies, methods of construction and design, covering and proofing, making dope, making wheels, lubricant, gears, floats, model airscrews, tables of pitches of model airscrews, loading and speeds, making a simple tractor monoplane, a long-distance tractor biplane, a fuselage monoplane, a tail-less monoplane, model helicopters, a flapping-wing model, winders, spar machines model gliders, how to fly model aeroplanes, building model airships, making a box kite, anf full-size gliding. The contents are indexed.—F. J. C.

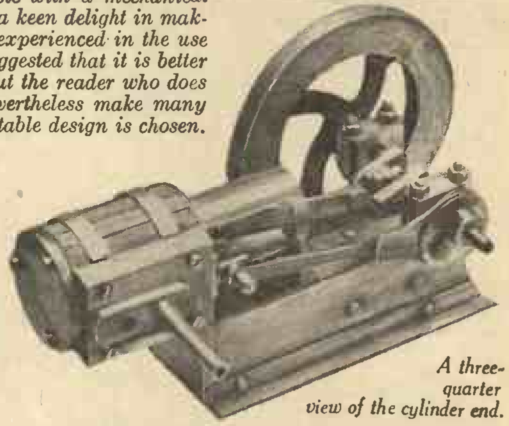


The top photograph shows a fine horizontally-opposed overhead valve petrol engine mounted in the fuselage of a model monoplane. The photograph on the left shows Mr. Trevithick's small compressed-air monoplane, a most consistent flier. The model on the right is of an enormous rubber-driven monoplane, having a wing span of 12 feet, which consistently flies for nearly two minutes.

BUILDING A SLIDE VALVE STEAM ENGINE WITHOUT A LATHE

A three-quarter view of the flywheel end.

There are many people with a mechanical turn of mind who take a keen delight in making models but are not experienced in the use of a lathe. It is not suggested that it is better to do without a lathe, but the reader who does not possess one can nevertheless make many working models if a suitable design is chosen.



A three-quarter view of the cylinder end.

THIS engine is a single-acting one, as this avoids the greatest difficulty of making a stuffing box that will not bind on the piston rod. The photographs give a good idea of the neat and workmanlike appearance of the model, which by a modification to the bedplate could be made as a vertical engine suitable for driving a model boat.

All the parts except the crankshaft are made of brass soldered or bolted together. The cylinder is a selected piece of brass tube ¾ in. bore by about $\frac{1}{32}$ in. thick, which is to be finished to the shape and dimensions shown in Fig. 1. The notch $\frac{3}{16}$ in. wide × ⅛ in. deep at the back end is the port by which steam enters and leaves the cylinder. The flange at the back end is also notched to coincide with this port. The other flange is provided with a downward extension which is attached to the bedplate.

The Valve Chest

The pieces forming the valve chest are shown all separated in Fig. 1. The body is soldered on to the cylinder, and the valve face soldered over the body, the whole lot forming one piece. All parts coming into contact should be "tinned" with solder and the surplus wiped off, then sweat the parts together. Extra solder may afterwards be run in with a soldering iron where required.

The surfaces of the valve pieces should be smoothed off quite flat with a fine file, emery cloth being liable to round off the corners. All dimensions should be carefully followed, particularly the $\frac{3}{32}$-in. width of the port in the valve face and the $\frac{3}{16}$-in. width of metal at the back end of the hole in the slide valve itself. These dimensions are of the greatest importance as the valve setting depends upon them.

Mark out the $\frac{3}{32}$-in. boltholes in the cover and drill these through all four pieces at once. The bolts are 8 BA with cheese heads; they are put in from the cover with the nuts behind the valve chest. Be careful not to leave the bolts too long or they may press into the cylinder and make a dent when screwed up tight.

The valve must be an accurate fit in its slide but should show no tendency to bind.

The bedplate should be built up from $\frac{1}{16}$-in. sheet brass to the dimensions in Fig. 2. The two side pieces are quite flat but the centre portion is bent in two places. These three pieces are held together by means of small pieces of ¼-in. angle brass, sweated and riveted with $\frac{3}{32}$-in. copper rivets. The object of the rivets is to avoid risk of melting the pieces apart when fixing the cylinder and bearings. The angle pieces at the foot form a flange for holding down bolts.

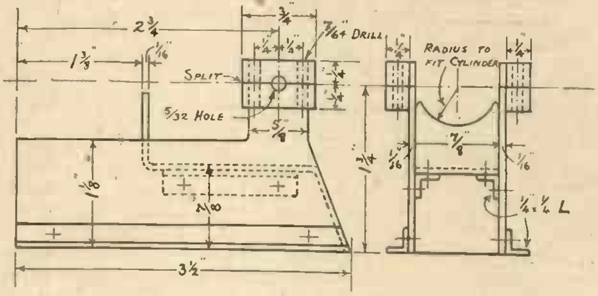


Fig. 2.—Dimensions for making the bedplate.

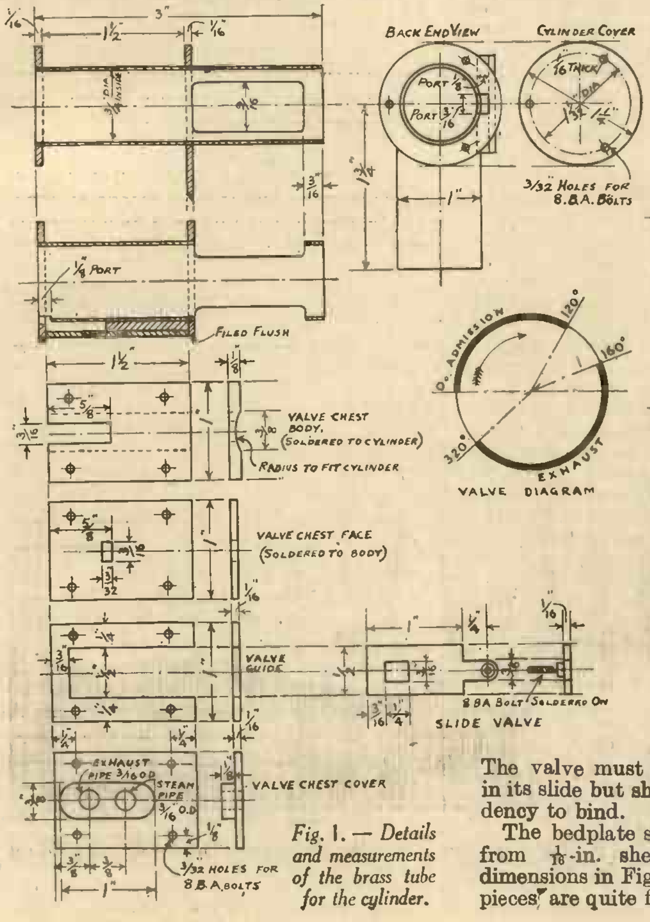
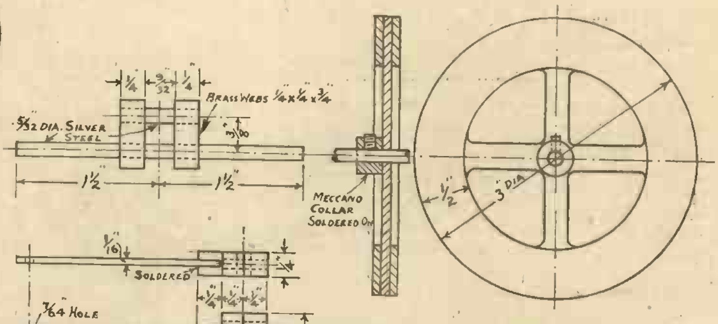
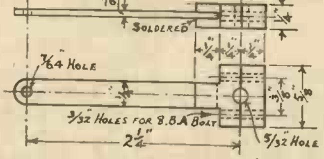


Fig. 1. — Details and measurements of the brass tube for the cylinder.





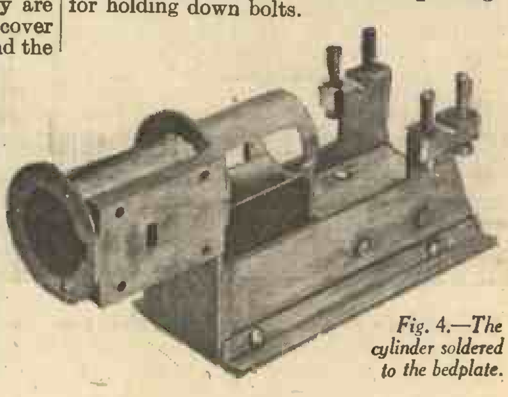
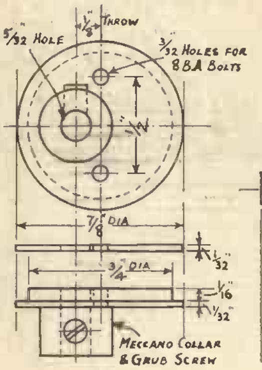
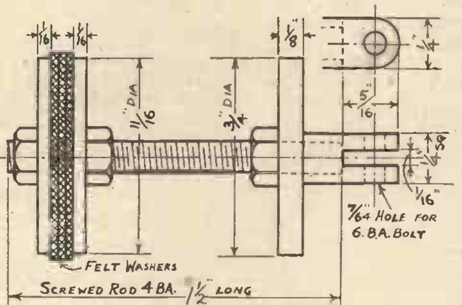


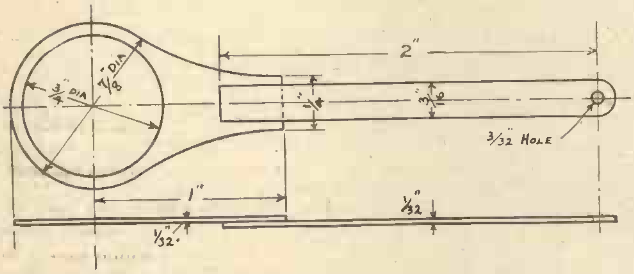
Fig. 4.—The cylinder soldered to the bedplate.

The Bearings

These are solid blocks of brass soldered on, and should be greater in depth than shown by the dimensions in the first place, to allow for the thickness of the sawcut when splitting the bearing. First drill the two $\frac{7}{64}$-in. boltholes in each, then split the halves with a fine saw. Smooth off the two adjoining faces and bolt the halves together with 6 BA bolts. Next mark each bearing with centre punch marks, so that they can always be fitted back in the same place and then drill the $\frac{5}{32}$-in. hole through both bearings at one operation so as to keep them in line. This requires care, and it is helpful to get somebody to watch the drill to see that it is held straight if a hand brace is used. The bearings should then present a very neat and pleasing appearance.







The cylinder may now be soldered to the bedplate. A soldering iron should be used for this operation, which should be done quickly to avoid melting off the parts already soldered. The photo (Fig. 4) shows the appearance of the engine at this stage. The front end of the tube where it forms the crosshead guide is soldered to the upward projection of the bedplate and the extension of the front cylinder flange to the side plates.

The crankshaft and crankpin are pieces of $\frac{5}{32}$-in. diameter silver steel, the webs being of brass. Solder the two webs together while drilling them, then melt them apart and solder the whole lot as shown in Fig. 2. The piece of shaft between the webs is, of course, cut away, but don't do this until last.

The connecting rod does not need much description; it consists of a block of brass soldered to a length of $\frac{1}{4} \times \frac{1}{16}$-in. brass, the split bearing being made in the same manner and in the same order of operations as the main bearings.

The flywheel will doubtless look neater if bought ready-made from a model supply stores, but as some readers may prefer to make everything themselves, a method of doing so is shown in Fig. 2. It consists of a kind of sandwich of three pieces of brass, the centre piece having spokes, while the side pieces are plain rings soldered to the centre. The brass should be cut with a fret saw. The collar and grub screw can be obtained from most of the better toy-shops; it is soldered on to the side of the central plate and care must be taken to get it central, or the wheel will not run true.

The Piston

The piston with its rod and crosshead is shown in Fig. 3. The arrangement of felt washers is better than winding string in a grooved piston. The fit of the piston can be adjusted by tightening up the nuts and squeezing the washers out a little. The crosshead consists of a plain disc $\frac{1}{8}$ in. thick. The fork end may be screwed to the rod if a 4 BA tap is available, but it may be soldered on otherwise. The 4 BA rod is kept in stock ready screwed by most model stores and by wireless accessory dealers.

The eccentric is very simple and consists of two brass discs soldered to the side of a brass collar. A third disc is also required as a side plate, but this is bolted on instead of being soldered. A new farthing will do quite well for the central disc if a suitable brass washer is not forthcoming. A hand-filed disc should not be used for this central disc.

The eccentric strap and rod is in two pieces, as shown clearly in Fig. 3. The overall length is not given in this drawing, as it should be adjusted to the required length when fitting up by altering the overlap as required. If the coin is used for the eccentric, the hole in the strap must, of course, be made to fit that.

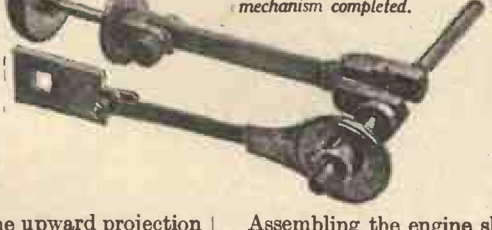


Fig. 3.—The eccentric strap and rod is in two pieces as shown. The photograph below shows this piece of mechanism completed.

Assembling the engine should present no difficulty. The crankshaft should first be fitted in its bearings, then the connecting rod, crosshead, piston, etc. Adjust the piston on its rod by means of the two nuts so that it comes as far back as possible. Then fit the cylinder cover making the joint with a thin paper washer coated with gold size. The eccentric should next be fitted on to the shaft so that the crank throw is 60 degrees ahead of the eccentric in the direction of rotation.

The Valve Guide

Now fix the valve guide temporarily in position on the valve chest, but leave the cover off so that the valve and ports can be seen. Set the slide valve so that the back end of its $\frac{1}{4} \times \frac{1}{16}$-in. hole is just uncovering the port in the valve face at its front edge and turn the shaft until the crank throw is at its inner dead centre. The eccentric rod should then be fitted to the valve and its front end soldered to the eccentric strap in this position. If everything is correct the valve timing should then be as shown by the diagram Fig. 1. When making the joints in the valve-chest cover, etc., use a trace of red lead.

The wood lagging adds a great deal to the appearance if carefully done. It consists of strips of mahogany $\frac{3}{16}$ in. wide, very neatly fitted and held in place by means of two clips of springy brass $\frac{3}{16}$ in. wide. The wood should be grooved to let the brass strip into the wood for about half the thickness of the brass. The clips are merely sprung into place, no other fixing being required.

A suitable boiler for this engine should have about 30 sq. in. of heating surface and should work at about 30 lb. per square inch pressure. Don't superheat the steam, for this would introduce some risk of melting the soldered joints if overdone.

MONORAIL SYSTEMS

(*Continued from page* 405.)

and not held up from below, and can be far lighter in construction.

Now with regard to the question of "points" and of passing from one set of rails to another. I found no difficulty in constructing such, but since the wheels are double-flanged the points must move in a vertical plane, *i.e.*, they must come down on to the rails and not up to their side.

The propeller should be placed at the rear of the "streamlined" car, so as to avoid the extra air friction on the surface of the car if it were in front.

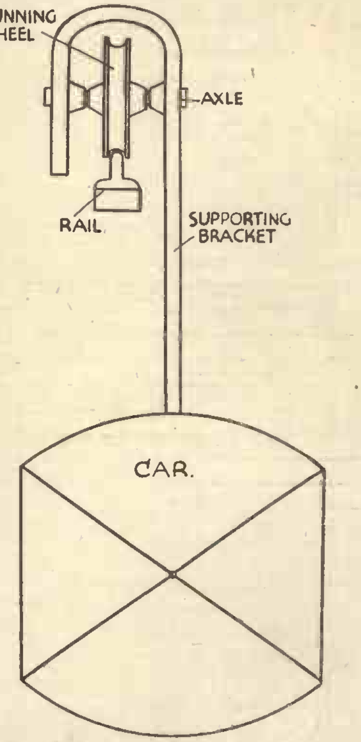


Fig. 7.—A pendulum type of rail car.

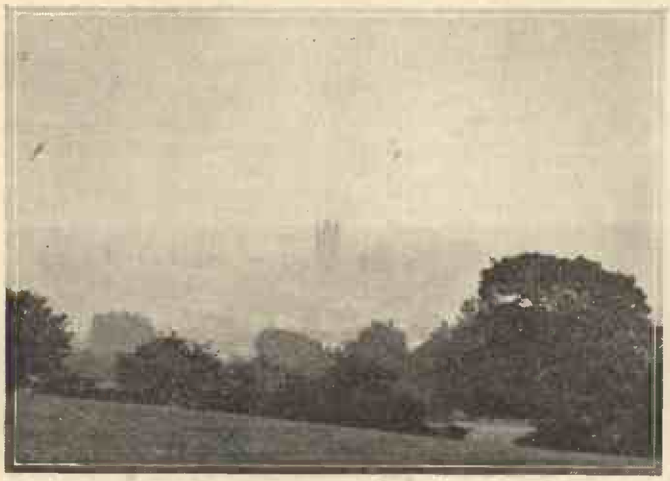
Since the car hangs like a pendulum it would in a strong broadside gusty wind tend to "swing" possibly quite disagreeably, and to obviate this a vertical wind vane could be suitably fixed to the car. This wind vane could be in a vertical plane above the rail and of such a size that its lateral "leverage" or "turning moment" about the rail should be the same as the streamline car.

Objections will, of course, be raised to the elevated "track" and the pylons supporting it, but this system (not propeller-driven) is already being tried successively in more than one part of the world.

THE NEW INFRA-RED PHOTOGRAPHY

By PERCY W. HARRIS, F.A.C.I.

Editor of *The Home Photographer and Snapshots*



A view of Canterbury Cathedral. The photograph on the left was taken on an ordinary plate, and the one on the right by infra-red process.

IT is not many years since photographic plates and films were sensitive only to blue light, and as a consequence the pictures taken with them were scarcely true to Nature (assuming a black-and-white picture as true to Nature). Red came out jet black, yellows about the same, greens much too dark and blues much too light. A Union Jack, for example, photographed, on the old plates and films came out as two black crosses (the red part of the picture) on a practically white background, for the blue of the background, instead of showing up darker than the white part, reproduced at about the same density.

It was not long before progress made plates and films obtainable everywhere of a sensitivity such that every visible colour can now be correctly reproduced in monochrome. Reds are not too dark, nor blues too light, and greens are very naturally reproduced. These plates and films are called "panchromatic," which means sensitive to all colours.

With this state of affairs reached, there did not seem to be much more that could be done, but scientists had much curiosity regarding the rays we cannot see with the eye, so experiments were carried on to see whether it was possible to take photographs with what may be termed "invisible light."

There are two ranges of such light rays, one at the blue end of the spectrum—beyond the blue and violet, called "ultra-violet"—and the other at the opposite end, called "infra-red." It is now possible to take photographs in the dark with either kind of rays, and some very remarkable photographs have been produced for the purpose of detecting forgeries in a way which is described later. Ultra-violet photography has been known for some years, but infra-red has only come into prominence recently, due to the development of special plates which are particularly sensitive to these rays.

A photograph by reflected light of the head of a whirligig beetle taken with panchromatic plate and tricolour red filter.

Infra-red Rays

The infra-red rays being those of the "heat" range, they can be understood better if the kind of light obtainable from a piece of iron heated in a furnace is considered. If the heat is raised high enough the iron will melt, but just below melting point the iron can be seen to be what is called "white hot," meaning of course that it gives off almost white light. Taking this piece of iron out of the furnace and watching it as it cools down, it will be seen that brilliance of its whiteness will diminish gradually to orange, into a red, a dull red and, finally, while it is still tremendously hot, it will cease to be hot enough to give out any rays visible to the eye. Scientists know, however—and measurements are easily made, too—that after it has ceased to give out visible red rays it goes on giving out infra-red or invisible red rays for a good time. These rays have been given out all the time since removing it from the furnace, but before this point is reached they have been mixed with visible rays.

A family group taken in complete darkness on an infra-red plate.

It was mentioned at the beginning of this article that not long ago photographic plates were only sensitive to blue light and, of course, for this reason we were able to develop them in orange and red light without fogging, for the plate would not be acted upon in this light. It was discovered that by mixing certain chemicals, and particularly certain dyes, with the emulsions with which the plates and films are coated, the range of sensitivity to colour could be extended. Thus it can be said that the modern photographic plate and film is virtually the original kind of emulsion treated with certain chemicals to extend its sensitivity from the blue end over the whole visible spectrum. In recent years, dyes have been discovered which make the emulsion sensitive to these infra-red rays without, however, reducing the sensitivity to the visible light.

Arranging a Filter

Now the sensitivity to the infra-red rays is very much less than to the visible rays, so that if any really interesting work with infra-red photography is to be done, arrange a filter in front of the lens so as to cut off all the visible rays which would so powerfully affect the emulsion otherwise. Special infra-red filters are easily obtainable, and look to the eye like pieces of black glass, for naturally you cannot see through them. To take an infra-red photograph, use a camera exactly the same as an ordinary instrument and insert the plate or film in

This photograph shows the head of the beetle taken with infra-red plate and infra-red filter.

the dark slide or holder just as for an ordinary photograph. The lens has to be different—more accurately expressed, it *may* have to be different, for all lenses are not suitable for infra-red work.

The Problem of Focussing

Obviously, rays cannot be focussed on the screen which are invisible to the eye! Fortunately, however, the visible red rays and the invisible infra-red rays can, with a suitable lens, be made to come to the same focus point, and therefore a focus which is right for invisible red is in such circumstances right for the infra-red. Sometimes the difference in focus point is known (in the case of lenses which do not focus equally to both kinds of ray) and therefore after a visible focus has been obtained the plate or film can be moved slightly backwards or forwards into the correct plane.

One of the first interesting things found about infra-red photography was that infra-red rays were not absorbed and dispersed by atmospheric haze to anything like the extent that the visible rays are. This meant that if two cameras are set up side by side before a landscape, one with ordinary panchromatic film taking a picture in visible light and the other with the infra-red film or plate taking pictures in infra-red light only, and if the morning were a misty one, then the ordinary picture would show the scene as it appears to the eye (even worse in some cases) while the infra-red picture would show everything as sharp and clear as if there were no mist whatever. This immediately suggested that infra-red photography would be particularly suitable for telescopic or telephoto work, for lenses of the telescope variety are obtainable which will give a picture on a film or plate just as seen through a powerful telescope. The trouble has always been that the mist in the air has limited our range of vision to such an extent that only in very rare cases are such photographs of practical use. Why not try infra-red plates for such occasions and see what happens with the photograph? This was done, using lenses of tremendous focal length or, put in simpler words, of very great magnifying power, and the result immediately astonished the world. Photographs taken from the shores of Dover and the hills behind the town showed details of the houses and trees on the French coast, pictures taken from Wales showed Ireland, photographs taken in America, from an aeroplane, of mountains hundreds of miles away actually proved the curvature of the earth visually—all of these came crowding one after the other to show that a new art had been made possible. Indeed, the emphasis on long-distance photographic work created the impression that infra-red photography means long-distance photography through a telescope lens, which of course is not necessarily the case.

An infra-red photograph of the nebula in Orion.

Medical Work

Other lesser known, but really just as interesting, applications of infra-red photography have been made in medical work. Subjects illuminated by infra-red light photograph quite differently from the way in which they come out with ordinary light, and it can be shown that the infra-red rays penetrate more deeply into the skin before they are reflected back. For example, I have seen two photographs of a woman's leg, one by ordinary light and one by infra-red light, the former scarcely showing the varicose vein trouble from which the subject was suffering, and the latter clearly revealing the intricacies of the veins and the clots which were quite invisible to the naked eye. This penetrative power of the rays has also been found to reveal symptoms, particularly in the early stages of some diseases, which could not be determined otherwise.

A forger working on a document such as a will or a cheque can sometimes do his work so skilfully that even the most careful examination with a magnifying glass will not reveal the forgery. Paper, chemicals, inks and the like, however, may photograph very differently under infra-red light, or for that matter under ultra-violet. Thus infra-red photographs of suspected documents have on a number of occasions clearly revealed forgeries and alterations (residues of old ink which were thought to be removed and so forth) which were quite undetectable otherwise. In all of these photographs, of course, it is essential to screen the lens and plate from any rays other than the infra-red, for the sensitivity to infra-red is much below that of ordinary light.

An ordinary photograph of the nebula in Orion.

Landscape photographs taken with infra-red light have a very peculiar "snowy" appearance, for green vegetation seems to reflect the infra-red rays very powerfully; therefore most green stuff photographs as if it were brilliantly white. Some other substances which reflect ordinary light powerfully do not do so with infra-red rays and the whole effect of a picture is therefore changed.

Photographs of human beings may or may not appear different from ordinary photographs, according to the circumstances. Members of the darker-skin-races usually photograph quite differently. For example, a negro may come out with a Mongolian appearance due to the fact that his black skin will reflect the infra-red rays quite well and certain characteristics beneath the skin normally invisible will come out in the finished picture. This is well shown in one of the illustrations accompanying this article. Group photographs taken in the dark have often been published, and here you will see a peculiar look about the eyes. This is due to the fact that the pupils are dilated as far as possible in the dark room in an endeavour to see, and, of course, as the human eye is not sensitive to the infra-red rays the dilatation shows up very clearly. Fabrics used for dresses, too, are liable to give peculiar effects.

AN EFFICIENT LIQUID SPRAYER

The advantages of the spray gun are becoming more widely recognised, and its use is extending from the commercial to domestic applications. It is quicker than the brush, gives a better coating, is more economical and involves less labour. Furthermore, its applications are more extensive, for, in addition to painting and distempering, it can be used for creosoting fences, spraying trees with insecticide and other purposes of atomisation.

THE principle of operation is quite simple. A powerful jet of air, issuing from a fine nozzle, blows across a similar nozzle connected to the paint supply. The jet of air rushing across creates a small vacuum in the paint supply pipe. The ordinary atmospheric pressure is sufficient to force paint up the pipe to destroy the vacuum until the paint itself is torn off the top of the nozzle and finely atomised. The process is continuous until either the air or the paint supply fails.

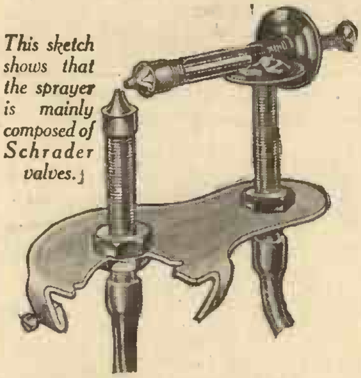
The essential parts of the spray gun are shown in the part-sectional sketch. Three valve stems taken from discarded motor-cycle tubes of the Schrader type are required. One is chosen for air delivery, and this is drilled right through with a $\frac{3}{32}$-in. twist drill. This size is correct for tapping a No. 2 B.A. thread from the flange end of the valve stem. The interior part of the valves is not required. When the thread is made, a long No. 2 B.A. screw is filed carefully to a point as shown in the illustration, to form the needle of a regulating valve. Now sweat or solder this valve stem across the centre of the flange of a second valve stem, so that both flanges are touching. Leave plenty of solder round the joint. If, now, a small drill is put through the second valve stem, its point should come through the tunnel of the other stem. Do not drill through the top side. Clear the threaded portion, damaged in drilling, with the tap previously used.

The Schrader valve caps form the spray nozzles, the first operation being to file away the slotted portions. The centre holes in these caps are not standard in size; if they are larger than $\frac{1}{16}$ in. diameter they should be filled up with solder and then re-drilled to this size. Remove the brass cone with rubber surround, which will be found inside the cap. A lock-nut is screwed against the back end of the air nozzle so that the latter may be adjusted backwards or forwards and then locked. The needle regulator screw is tightened up until its pointed end meets the nozzle hole. File away the threads at the front end, so that air has free egress. If there is any leakage of air from the head end of the regulating screw, its threads should be treated with vaseline.

The only operation to the third valve stem, used as the paint nozzle, is to saw off the flange so that a short rubber pipe can be fitted as a connection to a longer tube reaching nearly to the bottom of the container. The paint nozzle is adapted in the manner described, except that, in this case, the hole should be slightly smaller than $\frac{1}{16}$ in. The paint feed pipe should not exceed $\frac{1}{16}$ in. in diameter, because the pressure created by the vacuum will not lift a large quantity of liquid. For this reason the feed pipe for heavy liquids should not be too long. The paint and air supply valve stems are bolted to a piece of flat aluminium forming a lid to the container. The supply stem is fitted outside the container by the extension piece shown in the illustration. The hole for the paint stem is drilled so that the nozzles are almost touching with the bottom of the air nozzle hole level with the top of the paint nozzle. The best conditions for working can be found later by adjusting the air nozzle. Three projecting flaps are arranged equidistantly round the cover plate, and are bent round the neck of the container. One is drilled and tapped so that a screw may make a rigid method of fixing. A glass milk bottle of the half-pint size will make an excellent receptacle. Different paints or liquids can thus be stored in their own bottles, and the spray gun fitted to the top of the one required.

Sufficient pressure to operate the gun can be obtained by pumping up a 5-gallon oil drum by means of a motor-car pump. The

This sketch shows that the sprayer is mainly composed of Schrader valves.



method recommended, however, is to use an efficient vacuum cleaner, many of which provide a pumping action by reversing the connecting pipe. Another plan is to hire a cylinder of compressed air for the purpose. These are obtainable quite cheaply from the British Oxygen Company, Limited, of Greenwich, London.

It is very important to see that the spray gun does not become clogged up with dried paint after use. A simple way is to transfer the gun to another bottle containing a solvent for the paint which has been in use. Spray the solvent for a minute or two until the paint has been washed away from the inside of the tube and nozzle.

CONVERTING MOTOR DYNAMOS TO A.C. MOTORS

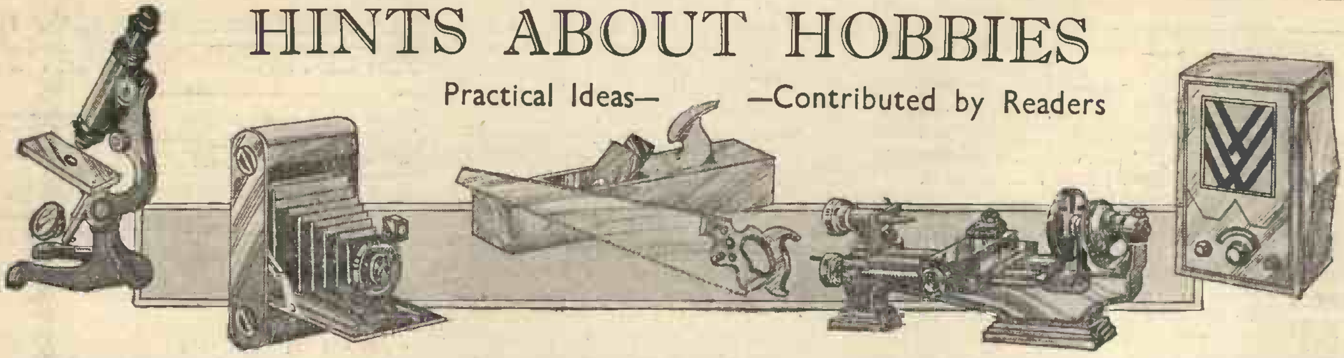
(*Continued from page* 413.)

leads. When dry, a heating spiral should be wound on the former and the length adjusted as before; the wire should just glow in the dark; the connections should be made to small nuts and bolts passed through eyes in the copper wire (see Fig. 3).

Nothing has been said about cooling arrangements, and with all these machines a fan is necessary; it may be dispensed with in the very small machines, but in the large ones it is essential. Cut a disc from stout sheet iron, and make six radial cuts to form the blades of a fan, and drill to fit the armature shaft. The end plate, which does not contain the brush gear, is drilled with several large holes for ventilation purposes; these should be filed into slots and be as big as possible without materially weakening the structure. It should project beyond the fan for a distance of $\frac{1}{2}$ in., besides being a precautionary measure it increases the cooling of the fan. The cover for the brush gear may be used as a fan guard, since on some machines this is just a simple strip of metal. Figs. 4 and 5 show a completed machine adapted for grinding, and one ready for rewinding.

HINTS ABOUT HOBBIES

Practical Ideas— —Contributed by Readers

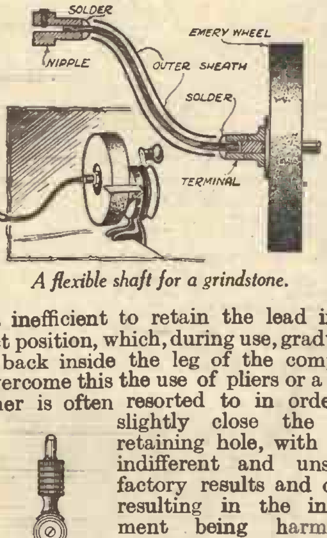


An Efficient Flexible Shaft

THIS simple device can be made by means of an ordinary grindstone as shown in the sketch. Screw a terminal on the grinder shaft locking the stone, and attach a short length of Bowden cable. When the handle is turned the grindstone acts as a flywheel and drives the flexible shaft which will drill holes up to $\frac{5}{32}$ in. or more, if the nipple is enlarged.

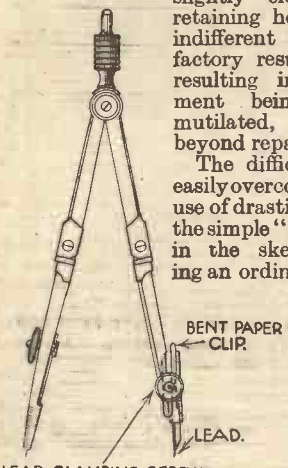
When the Compasses Wear

THE sketch on this page shows a "hint" which will be of interest to draughtsmen particularly. It relates to a defect in compasses which often develops and becomes annoying as they show signs of wear. The clamping screw generally becomes inefficient to retain the lead in its correct position, which, during use, gradually slips back inside the leg of the compass. To overcome this the use of pliers or a light hammer is often resorted to in order to slightly close the lead retaining hole, with very indifferent and unsatisfactory results and often resulting in the instrument being harmfully mutilated, sometimes beyond repair.



A flexible shaft for a grindstone.

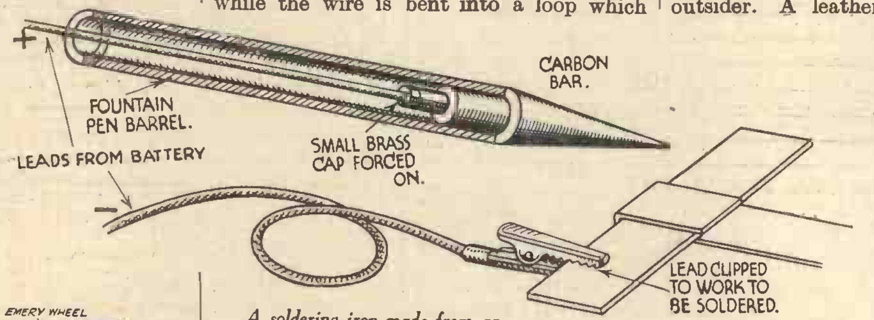
The difficulty may be easily overcome without the use of drastic measures by the simple "dodge" shown in the sketch of bending an ordinary paper clip to the shape indicated. It will be seen that one end of the wire is made to project downwards inside the top end of the hole containing the lead and its end made to bear against the end of the lead inside the leg, while the wire is bent into a loop which extends down outside the leg and underneath the clamping screw and so forms a washer for same. On screw being tightened it grips the wire in any desired place according to the position of the lead, so preventing its movement backwards inside the leg of the compass during use. The lead may be adjusted outwards by slacking screw and sliding the wire clip further down and retightening. This "tip" is applicable to any compass of this type and will be found to be quite effective.—J. M. (Somerset).



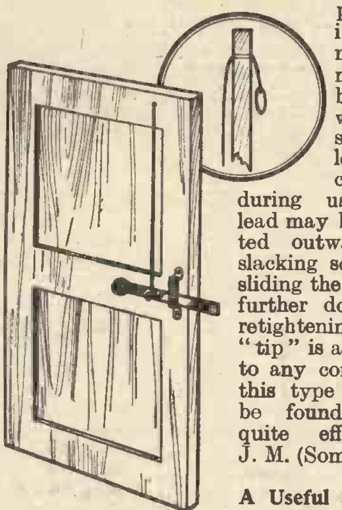
When the lead fitted in a compass becomes loose by the continuous wear it can be made a tight fit by means of a paper clip, as shown.

THAT HINT OF YOURS

Every reader of PRACTICAL MECHANICS must have originated some little dodge which would be of interest to other readers. Why not pass it on to us? For every item published on this page we will pay 5s. Address your envelope to "Hint," PRACTICAL MECHANICS, George Newnes Ltd., 8-11 Southampton Street, W.C. Put your name and address on every item. Please note that every hint sent in must be original.



A soldering iron made from an old fountain pen and a stick of carbon.



A hidden door latch which is useful for an outhouse, etc.

A Useful Soldering Iron

THIS handy little soldering iron has a carbon bit instead of a copper one and can be worked off a 12- or 6-volt accumulator.

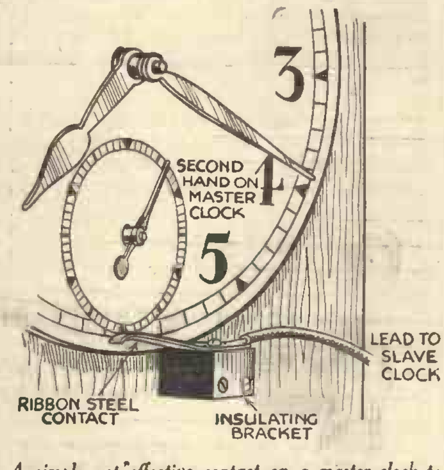
It is simple to work and can be made in less than half an hour. First get an old fountain pen and remove the nib-holder, ink-sack and filler spring, and then drill a small hole in the end, the size of the hole depending on the wire used. The carbon bit is ground from a carbon rod from an 8*d.* dry battery, the other end being fitted with a brass cap. The wires are connected up as shown, and when the bit is brought near the work a small arc is formed.—G. A. (Lancashire).

A Hidden Door Latch

THIS latch is useful for an outhouse which is in constant use, and while being easy to operate, it is not obvious to an outsider. A leather thong is tied in a knot round the knob on the latch, passed through a hole near the top of the door, and again tied in a knot or fastened to a small brass ring, which is painted the same colour as the door. If the door opens outwards the latch is not fastened to the door but to the side of the hut. The latch may be used to keep children out of the workroom, where they may hurt themselves.

Constructing an Electric Clock

A READER writes thanking us for the article under the above heading, which appeared in our March issue. He states that he has made the clock and it is working perfectly, and also suggests the following hint regarding the slave clock which was described in our April issue. The idea is a simple yet effective contact on the master clock to operate the slave clock. He used the seconds hand, working on its own spindle and making a contact by means of a short strip of ribbon steel fixed on an insulated bracket on the outside frame. This makes a perfect contact once every revolution of the seconds wheel. A glance at the sketch should make this quite clear.—J. M. (Glasgow).

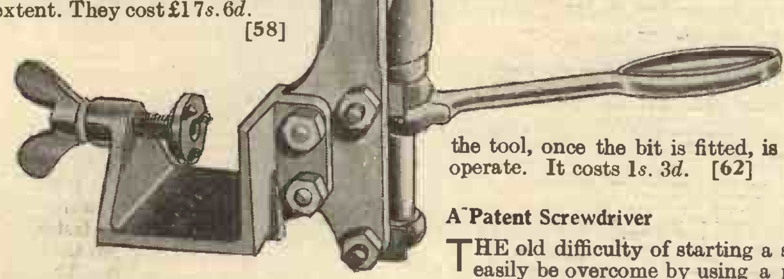


A simple yet effective contact on a master clock to operate a slave clock.

A Review of the Latest Devices for the 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.*

The "Clico" Bench Shears

MOST handymen know how tedious a job it is, when using the ordinary type of tinman's snips, to cut thin sheet metal. The illustration below shows the latest form of cutting shears which is now on the market. They are fitted with a bench clamp at the back for fixing to the bench and are operated by working the lever (shown on the right of the sketch) up and down. They are easy to operate and will speed up the cutting operation to a considerable extent. They cost £1 7*s.* 6*d.* [58]



A novel form of bench shears for clamping to the bench. so making them easy to operate.

A Die-holder for the Lathe

A LATHE die-holder is now obtainable for producing true threads in a lathe and for making studs, bolts and set screws. The body is knurled, thus making an efficient hand grip which travels along a spindle as the thread is being cut. It avoids releasing the tail-stock spindle and is obtainable in two sizes, costing respectively 5*s.* 6*d.* and 7*s.* 6*d.*, postage being 6*d.* extra. [59]

An Ingenious Gimlet.

THERE is no novelty in a combination tool, as there is quite a number on the market at the present time, but the gimlet shown in the sketch will undoubtedly prove a boon to the handyman. As will be seen, it incorporates a ratchet handle and the tools (six of which are supplied in varying sizes) fit into the handle and are locked by means of a small knurled screw. It costs 4*s.* 6*d.* [60]

A Two-speed Bench Vice

THE average vice fitted in a workshop has a comparatively slow opening and closing movement and considerable time is wasted in adjusting the jaws from the wide-open to the almost-closed position. The advantage of the vice illustrated is that it has a two-speed gear. A quick-pitch thread opens or closes the jaws rapidly, but through the centre of this thread runs a bar with a fine thread upon it. When the work is gripped in the vice, the quick-pitch thread is out of action and the fine pitch operates, making it a simple task to obtain a really powerful pressure upon whatever happens to be between the jaws. Little pressure is required to release the vice, and the quick-pitched thread comes into operation again almost instantaneously. The jaws are 2¾ in. and this tool is undoubtedly a very useful accessory for the workshop. It costs 55*s.* 6*d.* [61]

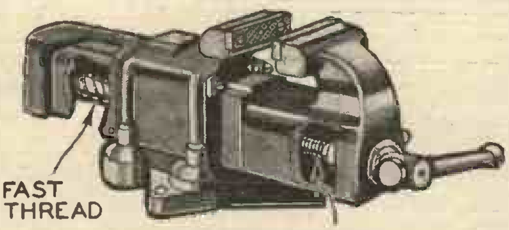
The latest type of gimlet comprises a ratchet handle and a set of six bits, each of which fits into the handle as shown.

A Useful Bit-holder

WHEN using the ordinary brace and bit, the handyman often has to drill a hole in an awkward corner where it is impossible to turn the brace. The bit-holder shown in the sketch will enable the workman to overcome this difficulty by simply removing the bit from the brace and fitting it into the holder. The bit is held in place by a small knurled screw and the tool, once the bit is fitted, is simple to operate. It costs 1*s.* 3*d.* [62]

A Patent Screwdriver

THE old difficulty of starting a screw can easily be overcome by using a new type of screwdriver which is now on the market. This tool will firmly hold screws ranging from four-gauge to twelve-gauge so that in ordinary woods a gimlet or bradawl is not necessary. The screw itself forms a gimlet and the prongs of the "docto" (as it is called) are so shaped that the holes are countersunk in the process of turning the screw into the material. It has a 4-in. blade and a fine polished handle fitted with a heavy ferrule. It costs 2*s.* 3*d.* [63]



A two-speed bench vice.

A Complete Outfit of Tools

IF you are in need of a set of tools, you can now buy a complete set at a very reasonable cost. All the tools are guaranteed full size and of good quality. The set contains one hand-saw, one brass-back saw (8 in.), a hammer, pair of pincers, one smoothing plane, two screwdrivers (one large and one small), two chisels, two files (handled), one oil stone, one spoke shave, one mallet, a rule, spirit level, cork sand-

(*Continued overleaf.*)

NEW TOOLS, GADGETS & ACCESSORIES

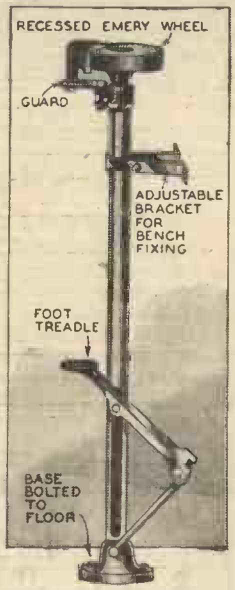
(Continued from previous page.)

paper rubber, two sheets of sand-paper, marking gauge, two capenters' pencils, firmer gouge, two gimlets, a steel axe, one set of six bits, a brace, two bradawls, nail punch, one square, one countersink, a grip and cutter, and one adjustable wrench. The complete set is obtainable at the very low price of 35*s.* carriage paid, and the set can also be obtained in a strong hinged box for 8*s.* 6*d.* extra. [64]

A bit holder that takes ordinary bits, so enabling them to be used in awkward corners where the brace cannot be turned.

An Efficient Treadle Grinder

THE sketch on this page shows an efficient type of grinder which speeds up the job of grinding. The mechanism is enclosed in a steel tube which is screwed into the base and cross-riveted to prevent the possibility of rotation. Both ball cones are screwed into the standard, the top one being locked by a split cap, which may be swivelled to any degree for convenience of hand-rest position. The rests provide a comfortable steady for the left hand, and have a close-fitting support extending radially over the top surface and vertically over the periphery of wheels. The bracket carrying the main rest has two long perforations at 90 degrees, allowing full universal adjustment. The bench-fixing clip may be locked to the standard at any height or angle as may be required for securing the machine to any wall, bench or rail. The crank is a one-piece mild steel unit having two long pins; one pivots in two substantial bearings in the base, and the other forms a twin-bearing knuckle joint with the treadle. The return-stroke spring is neatly mounted on the latter. All parts are interchangeable and one stroke of the treadle gives over 1,000 revs. It is ideal for harvesting knives, joiners' garage and all mechanics' tools. The horizontal recessed wheel gives maximum convenience and wear, and takes work of any size across the flat top. It is obtainable in two sizes, No. 1 costing 50*s.* and No. 2 58*s.* 6*d.* [65]



A dustproof, frictionless and practically waterproof treadle grinder.

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.

A Lightning Arrester for your Wireless Set

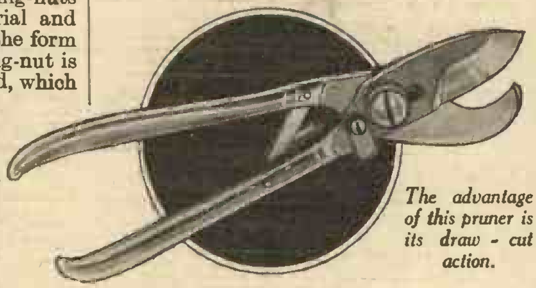
IT is always advisable to protect an exposed aerial by fitting some form of static discharger or lightning arrester, and the device illustrated is extremely easy to fit. As may be seen from the complete and the dismantled apparatus, a small galvanised iron bracket is supplied, together with the bakelite enclosed spark-gap, and the latter is provided with large wing-nuts to facilitate the connection of aerial and lead. The bakelite moulding is in the form of a hollow cowl, and the lower wing-nut is attached to a heavy gauge brass rod, which is screwed into the upper portion of the cowl. The upper wing-nut is similarly attached to a piece of rod, and this is embedded in the bakelite and is non-rotatable. The ends of both of these rods are finished dead flat, and before the lower rod is screwed into position mica discs with a small central hole are dropped into the bakelite moulding, so that when the lower rod is screwed tightly home it is insulated from the upper rod and so to earth through a suitable earth lead attached to the lower wing-nut. With the advent of the summer months and consequent static discharges such a device is a useful accessory to the aerial system, and it costs only 2*s*. 6*d*. complete. [59]

An Ingenious Projector

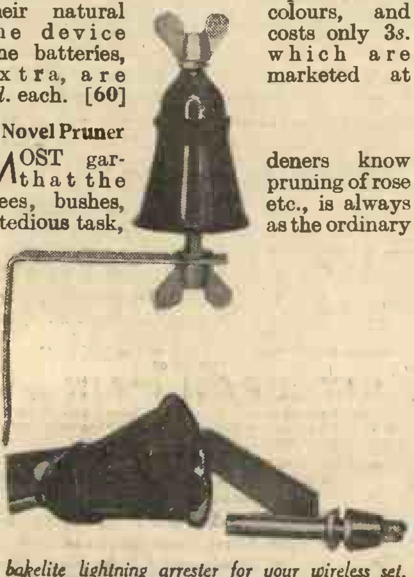
A PROJECTOR known as the "Magius" projector has recently been introduced to the market and works from two ordinary torch batteries. It will project pictures from illustrated books, photos, postage stamps, or plastic objects such as flowers, etc. The objects are reproduced in their natural colours, and the device costs only 3*s*. The batteries, which are extra, are marketed at 6*d*. each. [60]

A Novel Pruner

MOST gardeners know that the pruning of rose trees, bushes, etc., is always a tedious task, as the ordinary type of pruner invariably jambs when cutting through a thick stem. The pruners shown in the sketch will be found to overcome this difficulty, as they work with a draw-cut action. As will be seen, when the cutters are in use, the top blade is drawn along the stem of the bush, thus cutting through it quite easily. The Kelson pruner, as it is called, costs 10*s*. 6*d*. [61]



The advantage of this pruner is its draw-cut action.



A bakelite lightning arrester for your wireless set, which is sold complete with a galvanised iron bracket, massive metal parts, and a strong bakelite cowl.

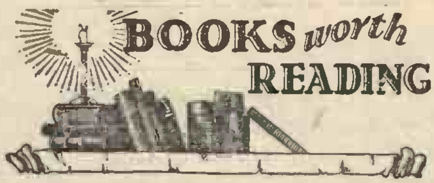
A Vest Pocket Microscope

THE simple little microscope shown on this page satisfies the demand for an instrument giving a greater magnification than any pocket lens can give without the disadvantage of bulk and expense inseparable from the simplest of standard microscopes. The slide focussing device has been retained in preference to a rotating collar, as it enables the instrument to be held in focus with one hand, leaving the other hand free to hold the object under examination. The instrument can be adjusted for three different magnifications: 40, 50 and 60, a range which makes it suitable for a great variety of purposes. It sells for 17*s*. 6*d*., and can also be obtained in a soft leather case for 1*s*. 6*d*. extra. [62]

The latest type of pocket microscope.

Develop your own Films

IF you desire to develop your own films at home you should certainly use a "Correx" tank. This tank makes the development of roll films a simple task. The film is wound on a spool together with a separating apron placed in the tank and the developer is poured through a lid funnel. Development can be timed, and the developer is poured off through a spout at the side. Washing and fixing follow in a similar manner. It costs 25*s*. [63]



British Aviation Illustrated

By C. A. SIMS. 96 pages with 70 Illustrations in Photogravure. Price 3s. 6d. net. Messrs. A. & C. Black, Ltd., 4, 5, and 6 Soho Square, London, W. 1.

THE rapid strides made in flying is rather marvellous when one considers that at the beginning of the nineteenth century there was no such thing as a flying machine. This book, attractively illustrated in photogravure, shows the birth of the heavier-than-air flying machine, follows through its various phases, until it arrives at the present-day machine capable of a speed of nearly 400 miles per hour. By means of words and pictures the reader is given an insight into all the many branches of aviation, in as simple and straightforward a manner as possible. No claim is made that the book is of a technical nature or that its contents require a deep study. It is just the story of aeroplanes—how they fly, how they are built, and what they do.

British Ships Illustrated

By A. C. HARDY, B.Sc., 95 pages with 47 Illustrations in Photogravure, Price 3s. 6d. net. Messrs. A. & C. Black, Ltd., 4, 5 and 6 Soho Square, London, W.1.

THIS book seeks to show, by means of representative photographs, the types of vessels which compose our all-important mercantile marine. The photographs have been carefully chosen in order to show the vessels in their natural surroundings, if the term may be used, so that they can be directly connected with the work which they are intended to perform. An acknowledged authority on ships, the author gives a clear summation of the present position of British shipping with regard to the types employed and the machinery by which these types are propelled.

British Locomotives Illustrated

By W. J. BELL, M.I.Loco.E. 95 pages with 44 Illustrations in Photogravure. Price 3s. 6d. net. Messrs. A. & C. Black, Ltd., 4, 5 and 6 Soho Square, London, W.1.

THIS book gives examples of the latest types of engine on each of the great lines, L.M.S., L.N.E.R., Great Western and Southern Railways, and also of the lesser known locomotives, such as the three-cylinder Pacific type locomotive, "Hurricane," on the 15-in. gauge Romney, Hythe and Dymchurch Railway. There are also several photographs of early engines to indicate the evolution of the locomotive, and illustrations of one or two famous trains. A brief introduction outlines railway development from "The Rocket's" first trial to the present day, and each illustration is faced with an informing descriptive note.

British Aeroplanes Illustrated

By C. A. SIMS. 95 pages with 44 Illustrations in Photogravure. 3s. 6d. net. Messrs. A. & C. Black, Ltd., 4, 5 and 6 Soho Square, London, W.1.

THIS book consists of photographs and descriptions of British aeroplanes that are at present in every-day service. Its range covers the principal type used by the Royal Air Force, Imperial Airways and other air transport firms, flying schools and the many private owners. The descriptions enable the reader to obtain a good knowledge of the uses and performances of the various types without going very deeply into the technical side. The photographs have been chosen to show the most important features. They have been taken from various angles, including close-up views on the ground, whilst flying past the cameras, and from other aeroplanes in the air. It is an ideal book for the air-minded.

What the Clubs are Doing

Club Reports for inclusion in this feature should not exceed 250 words in length, and should be received not later than the 10th of each month for inclusion in the subsequent month's issue.

STREATHAM COMMON MODEL RAILWAY CLUB

MEETINGS are held every weekday at 201 Glen-eldon Mews, High Road, Streatham, from 6.30 p.m. to 10.30 p.m.

The Club held a very interesting Exhibition late in April, at which a large number of visitors were present.

The main attraction of June is the Social, which we are holding (D.V.) on the 23rd. Invitations will be sent to any reader if he will write to the Secretary requesting one.

"The Rocket" (June issue) is now ready, and contains a full report of the Model Railway Exhibition and a report of our own Exhibition, besides the usual features. It can be obtained for 5d., post free, from the Secretary.

Secretary: L. J. Ling, Brooke House, Rotherhill Avenue, Streatham, who will, on receipt of a post card, forward a copy of "Concerning Ourselves" free to anyone interested in the Club.

INSTITUTE OF SCIENTIFIC RESEARCH

ON April 7th a meeting was held at which the Secretary gave a lecture, illustrated by experiments entitled "The Manufacture of Fertilisers." After mentioning why fertilisers were necessary, he told how fertilisers were obtained before they were synthesised commercially. Next he gave details of the process by which ammonia and nitrates can be synthesised from common substances, and concluded by describing the various processes at a large fertiliser factory.

On April 9th a visit was paid by the entire Club to the printing works of the *Yorkshire Evening Post*. After seeing the news room, where news comes in on teleprinters, Creed tape machines, and telephones, we visited the type-setting department, where we saw "Linotype" machines in operation, and also saw moulds of type being made for the printing machines. We concluded this visit by seeing the massive printing machines, which print 40,000 copies per hour.

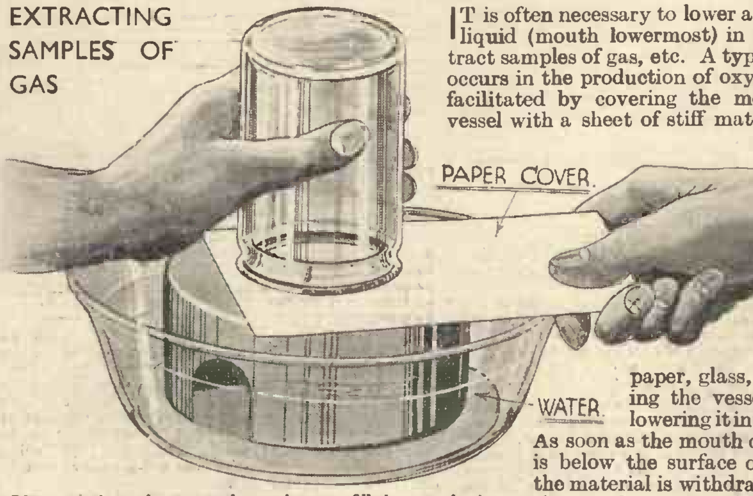
On May 5th a meeting of the Physics and Chemical Section was held, at which F. Underwood, Esq., gave a lecture entitled "Egyptology." He first talked about Hieroglyphics, then spoke about Papyri, and the "Book of the Dead." Finally, after discussing the Pyramids, the Sphinx, and Cleopatra's Needle, he gave a few interesting facts about life in Ancient Egypt.

The next meeting of this section will be on June 2nd, at which P. Berry, Esq., will give a lecture, illustrated by experiments, entitled "Microscopes."

For further details please inquire of Mr. D. W. F. Mayer, 20 Hollin Park Road, Roundhay, Leeds 8.

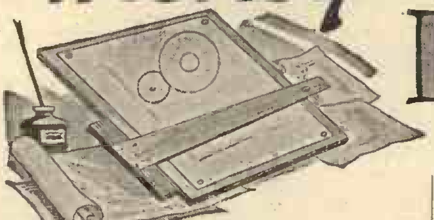
EXTRACTING SAMPLES OF GAS

IT is often necessary to lower a vessel into a liquid (mouth lowermost) in order to extract samples of gas, etc. A typical example occurs in the production of oxygen. This is facilitated by covering the mouth of the vessel with a sheet of stiff material such as paper, glass, etc., inverting the vessel and then lowering it into the liquid. As soon as the mouth of the vessel is below the surface of the liquid the material is withdrawn, keeping the vessel upright and the necessary oxygen, etc., can then be collected.



Placing a sheet of paper underneath a gas-filled jar to facilitate its removal without the gas escaping.

Money Making IDEAS



SUGGESTED BY OUR READERS

Leaving on the Electric Light

"AS a householder and family man, I have been annoyed sometimes on coming downstairs in the morning to find that the electric light has been left on all night in some room. This may be the experience of others.

"Would it be possible to put some cheap current detector, such as a galvanometer, over the electric mains before the fuse box? If the current was on, the galvanometer needle would move, and, say, make contact with a stud, which would complete a circuit worked from a pocket battery. On this circuit would be a small red light, fixed in the bedroom of the head of the house—or other convenient place. This circuit might be switched off on rising and set when going to bed.

"The idea is, when you switch off your bedroom light and all is supposed to be dark—if there is another light burning, the red light would light and show it at once.

"If the above is practicable do you think it is marketable?" (J. M., Ayrshire.)

The annoyance experienced by the inventor has been probably shared by all householders using electric light at some time or the other, and the suggested arrangement could probably be developed into a commercial proposition, but whether it could be so inexpensively constructed and installed as to prove commercially successful is a moot point. It is thought that the average householder, for the sake of saving a few pence occasionally, due to a lamp being inadvertently left burning, would not trouble to instal an apparatus which required attention on his part, *e.g.*, operating a switch night and morning and renewing batteries. For these reasons it is not thought that such an apparatus would command a ready sale.

Improving a Patented Article

"I understand from reading your replies to letters under Patent Advice that anyone can Patent an improvement on a patented article. My article is one-tenth the price of the patented article and differs in every way with exception of one small part; the action is the same, will serve the same purpose, but can be used for small work whilst the patented article can only be used for large work; in fact my article will do the work that the patented one will not do. If I patent my article (provided it is allowed), would I have to get a licence to manufacture and sell my article from the patentees of the larger article?

"How could I tell whether I am infringing the other Patent?" (H. T., Bristol.)

The inventor is correct in assuming that it is open to anyone to obtain a Patent for an improvement on a patented article provided it is really an improvement, *e.g.*, more useful or less expensive to produce. As the inventor has not given any particulars either of the patented article or his improvement, it is not possible to give him any useful advice. For an opinion as to whether his invention would be considered an infringement of the patented article it would be necessary to consult a reputable Patent agent. If the invention is in fact an infringement of the prior Patent, it would not be possible to manufacture, use or sell the improved invention without a licence from the proprietors of the prior Patent.

A Guide for a Bread Board

"Can you inform me as to the validity, novelty, and worth of the following idea, namely, to fix a fence or guide on a bread board, so that the bread may be cut squarely through?

"An ordinary bread knife would be used and two pieces of steel would form a guide through which the knife would work. Also to fix an adjustable stop against which the bread could be held so that the slices would cut off the same thickness." (A. E., Perth.)

The improved construction of bread board to enable a loaf to be more readily cut into even slices of any desired thickness without endangering the operator is ingenious and novel so far as is known from personal knowledge, but it would probably be advisable to make a search amongst prior Patent Specifications relating to such devices.

The invention forms fit subject-matter for protection by Letters Patent, and provided it is novel and can be inexpensively manufactured and efficiently marketed, should have considerable commercial value.

Adapting the Tail Lamp of a Car

"I have an idea which I think will save motorists many pounds in fines for driving without a tail-light.

"The idea is roughly this. Place a small amp. bulb in series with the tail lamp. This would glow through a frosted-glass-covered hole on the dash similar to the engine ignition one on cars to-day. This would save one having to inspect one's rear plate every time one got in or out of the car, for should the bulb fail, the dash lamp would be immediately extinguished and the trouble could be rectified by replacing the tail lamp without being informed by the police that one is committing an offence." (S.A. Dorking.)

The idea of putting a small electric lamp on the dashboard of a motor car in series with the tail lamp so as to indicate to the driver should the tail lamp fail, is not thought to be novel. This idea, it is believed, was suggested in the early days when the use of electric lighting on motor cars became common. The applicant is advised either to search through early Patent Specifications or to make some enquiries amongst motor-car dealers, before spending money in protecting his invention.

An Improved Paper Bag

"Re your offer in 'Practical Mechanics' of free advice from your Patent Expert on readers' ideas, I would be glad of information on the following points:—

"(1) Would the use of luminous paint for a general utility idea be valid, or is the paint under protection?

"(2) Would it be worth the expense to patent an idea whereby paper bags, such as used by confectioners, etc., could be positively and quickly opened? An improved bag of this type would dispense with the unhygienic methods, so often employed, of blowing into bags, or wetting the fingers to open them.

"Wishing every success to your excellent Magazine and its Patent Advice Section. I am sure this Section will fill a definite want." (F. B., Bristol.)

It is not quite understood what is meant by the applicant's first question. If it be intended to mean, is it possible to patent the idea of using a luminous paint for a specific purpose?, the answer is that no invention is required to apply a known paint in known manner for a purpose for which such paints are made; therefore it is not possible to obtain a Patent for the broad idea. It is, however, conceivable that a particular method of applying such a paint in some particular way for a specific object might possibly require sufficient invention to support a Patent. There is now no Patent covering the broad idea of a luminous paint. Luminous paint was originally invented by W. H. Balmain and patented by Ihlee and Horne, and the Patent has long since expired. It is, however, probable that there are existing Patents for luminous paints in which radium salts are employed; the original paint of Balmain consisted of lime and sulphur and was invented before the discovery of radium.

In reply to the second question, the commercial value of an idea for quickly opening paper bags will depend largely on the cost of producing the device necessary to accomplish the object in view, the amount of trouble or time necessary to use the device, and the way it is marketed.

A Device for the Clerk

"I am engaged in clerical work, and have always found trouble when entering from the Credit Book to the Ledger for the pages of the Credit Book to remain open without placing some heavy object upon them.

"I have brought out a device, a matter of 4 in. in length, with springs to grip the back of the book with a spring-like arm to keep open the required page until ready for turning. I would esteem it a favour for your opinion." (A. H., Leamington Spa.)

The proposed arrangement for keeping open an account book at the required page may possibly form fit subject-matter for protection by Letters Patent, but as the inventor has given only very meagre particulars of the device he intends to employ, it is not possible to express a definite opinion. Such a device, however, is not thought to have very much commercial value in view of the fact that loose-leaf account books, in which the trouble to be overcome does not arise, are rapidly displacing the bound books.

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.

Photography and Space-ship

"I WOULD be glad if you could tell me the name and price of a substance that will remove emulsion from a cinematograph film. Also I am studying the possibilities of space-ships and would like to know—

"(1) The expansion of oxygen on changing from a liquid state to a gaseous one at N.T.P.

"(2) The volume of oxygen at N.T.P. that an average man consumes in a given length of time." (D. A., Barnard Castle.)

A weak solution of caustic soda will remove the gelatine emulsion from photographic film. Alternatively, the film may be well soaked in cold water and then immersed in hot water, when the gelatine will pass into solution.

Starting from the data that 1 litre of oxygen at 0° and 760 mm. weighs 1·429 grams and its density when liquefied is 1·13, a simple calculation shows that 1 c.c. of liquid oxygen on vapourising will occupy a volume of about 790 c.c.s at 0° and under 760 mms. pressure.

The average man will consume about 3·5 litres of oxygen per minute.

Signals for 00-gauge Railway

"I should be pleased if you can tell me whether the following is practical. I have built an 00-gauge model electrical railway and I want the signals to work the trains and not *vice versâ* as in the usual practice with model railways. My voltage is 6, amperage 60, from the supply, and motors take 1 to 2 amps. Is it possible for me by working a switch in the signal box to switch on the current to the bell-magnet and also to the live rail, and what wire should I want for bell-magnet or solenoid? I have a fine-wire resistance for preference, as I do not want a big amperage to go through the magnet. Will the current taken by the motor rob the magnet or *vice versâ*?" (F. L. C., Willenhall.)

The only drawback in your scheme is that the bell-magnet will overheat while the current of the section (and therefore of the magnet) is on. Your idea of a resistance in the amperage might prove excellent, though we haven't tried it. Yes, certainly the current used by the magnets robs the motors to that extent, and we find that when the magnets are in use there is often a distinct slow-down of the locos. Our idea is to experiment with the resistance, which sounds a good idea. But according to your wiring scheme you would need a resistance in each section. Preferably, we would wire the magnets straight from a resisted lead from the battery.

Converting a Petrol Engine into a Gas Engine

"I have purchased a small petrol engine of about 180 c.c. capacity and have attempted to convert it to a gas engine, but up to now I cannot get it to start. The engine is a four-stroke with push-rod rocker-operated exhaust valve and automatic inlet valve. Ignition is by a Ford coil and dry batteries. I have timed the engine as for petrol, spark just before T.D.C. and exhaust closing a shade before suction stroke commences. In place of the carburetter I made a gas mixing chamber out of 1¼-in. copper tube with screw-operated air valve. I am using a standard M/cycle 3-point plug, which gives a good spark. If you can give me any information on the above, I shall be greatly obliged." (R. C., Stockport.)

Since engine timing and ignition timing seem accurate enough for all practical purposes, it is quite evident that the fault lies in the carburation system employed.

Now, considering that the engine operates on a four-stroke cycle and consists of one cylinder only, it is quite evident that during three strokes gas is being wasted, that is, it is leaking away out of gas mixing chamber. The inlet of gas should be properly controlled by a cam-operated valve which admits gas to the mixing chamber as the inlet valve to cylinder opens. Unless such a system is employed, economical running is impossible; moreover, there is danger in leaking gas. Further, instead of gas being led direct from the main to the engine it should be passed into a gasbag or reservoir, from which when fully inflated the engine should draw its supply. The direct lead from the gas main is hopelessly inadequate for the sudden force of gas at high velocity which the engine requires.

We suggest that querist makes some form of gasbag, replaces the carburetter on his engine and starts the engine on petrol. When it has warmed up a little the petrol should be turned off and a pipe connected to the gasbag inserted in the air intake of the carburetter. The engine should certainly continue to run thus. Of course, in the case of a four-cylinder engine automatic inlet of gas is scarcely a necessity as fuel is constantly drawn through the throttle. The gas-mixer shown in sketch seems to be satisfactory enough; it is the gas supply which is most probably the fault.

Preparation of Nitroglycerin

"In what proportions must sulphuric acid-nitric acid-glycerin be used to produce satisfactory nitroglycerin?

"If the above ingredients are wrong, can you tell me how to make it?

"I am enclosing a stamped addressed envelope." (D. M., Bristol.)

Fuming nitric acid	12 parts
Conc. sulphuric acid	20 ,,

Mix carefully, adding the sulphuric to the nitric acid very slowly and with constant stirring. A spray consisting of 4 parts glycerin and air is now injected into this mixture. After standing a few hours nitroglycerin forms on the surface, whence it is decanted and transferred to a vessel containing water. Here it is well washed and again allowed to stand until complete separation has occurred. The oily layer is now run off and well mixed with a solution of sodium carbonate to neutralise any adherent acid which would render the compound highly unstable and dangerous. Finally, the separated nitroglycerin is filtered through flannel to remove attached water.

Water Softening

"I shall be pleased if you can let me know where to get the material used in the base exchange water-softeners. I am sure that a description of how to construct a water softener in 'Practical Mechanics' would be appreciated by countless readers." (A. H., Eton)

The material usually employed in the method of water softening referred to is permutite—sodium-silico-aluminate, a coarse, insoluble sand through which the hard water percolates, exchanging in its journey its objectionable calcium radicle for the sodium of the permutite. The sodium salt now in solution does no harm and gives an added "softness" to the water. After twelve hours' use the permutite has lost practically all its sodium content and is exhausted. It is then renewed by covering it with a 10 per cent. salt solution for about a further twelve hours, and is then again ready for use. Only salt which is inexpensive is consumed, and the calcium chloride solution formed in the renewal process is thrown away. By this process not only are calcium salts removed, but also salts of magnesium, iron and manganese with other elements. The life of a permutite charge is over twenty years.

The sodium-silico-aluminate (an artificial zeolite) can be obtained from most large drug houses.

"Lithography for the Amateur"

"In the March issue of 'Practical Mechanics' there was an article entitled 'Lithography for the Amateur.' The writer pointed out that it was possible for amateurs to use zinc plates as a means of reproduction. This I believe necessitates a good deal of apparatus and plenty of experience. As we are anxious to reproduce illustrations of a line type in our school magazine, we are wondering which would be the best method of reproduction—stone or zinc. We have a book entitled 'Printing and Book Crafts for Schools' (Frederick Goodyear, published by Stokes), in which a simplified process of preparing zinc blocks is described, but there is no reference to printing from stone slabs. I would like to ask several questions.

"(1) Which process would you recommend as being the simpler?

"(2) Which process would give the greater accuracy?

"(3) Are litho stones difficult to mount for printing in a machine?

"I would be obliged if you would supply me with the name and address of a firm dealing in printers' supplies. I enclose a stamped addressed envelope for reply." (J. Binks, Castleford.)

(1) The process you should use for reproducing line sketches will depend upon the method of printing. If the illustrations are to be printed along with the type in your magazine, it will be necessary to prepare zinc line blocks. This is rather a complicated procedure for an amateur, but they can be obtained for about 7*s*. each, made from your own drawings by a photographic process. Any process engraving firm will do this work. Your drawing must have firm black lines to reproduce well. The lines may be drawn as thin as you please as long as they are black; if grey, the lines may be broken or lost altogether.

The advantage of printing from a stone is that you can draw direct on to the stone and then print from the same stone, without using photography or etching into relief. If this process is used it would be best to print the illustrations on separate sheets of paper and paste them by the edge into the magazine.

(2) Both processes will give reasonably accurate results.

(3) Litho stones cannot be printed in an ordinary letterpress machine as used for printing from type. A litho printing press is adapted to hold the stone.

By A. MILWARD

The services of a professional Patent Expert are available free to every reader. He will advise you on the validity, novelty, and value of any idea you may have. No charge is made for this service, but the Query Coupon appearing in our advertisement pages must be enclosed with every query.

SOME EARLY PATENTS FOR INVENTIONS

(continued)

AS a matter of fact, Giovanni Battista della Porta in a treatise published in 1601 pointed out that condensation of steam in a closed chamber may be used to produce a vacuum and suck up water from a lower level. Whether Savery was aware of this treatise is not known, although it must be borne in mind that Savery was an educated man, a Captain of Engineers in 1702, and surveyor to water works at Hampton Court in 1714. Now military engineers in those days were the precursors of the civil and mechanical engineers of the present day, and presumably had ready access to works in connection with their profession.

During the first Parliament of James I., "a committee of grievances," under the chairmanship of Sir Edward Coke, was appointed. This committee cancelled many of the numerous monopoly patents, but the King granted still more, and after many Bills had been introduced and compromised by promises and Orders in Council by James, the Statute of Monopolies was finally passed in 1624, which made all monopolies illegal except such as might be granted by Parliament or were in respect of new manufactures or inventions. Parliament has never exercised the privilege of granting monopolies to any individual, but the granting of licences to deal in tobacco, spirits, wines, etc., are directly traceable to the monopolistic privileges of Parliament by this Act, so likewise is the passing subsequently of special Acts of Parliament to enable railway companies, gas and water and other companies to enjoy certain privileges in the nature of a monopoly.

A Machine for Winning and Draining Land

Among the earlier Patentees is the name of Sir Hugh Myddleton (1560–1631), who in 1621 obtained a Patent, No. 19 of 1621, for a machine for winning and draining land. Sir Hugh Myddleton, however, is better known to fame as the projector of the New River. The London Corporation, having obtained authority from Parliament to bring water into London from Chadwell and Amwell, Hugh Myddleton, who was brother of Sir Thomas Myddleton, Lord Mayor of London, and who traded as a banker and goldsmith, offered to undertake the project. Owing to opposition and rapacity of the owners of the land through which the river was to be carried, he was forced to appeal to James I. for money to carry through the scheme. James I. paid half the costs for a half share of the profits. The river is about thirty-eight miles long, and was completed in 1613.

Thomas Newcomen

Before leaving the subject of early steam engines, it may be as well to deal with another well-known inventor, Thomas Newcomen, who did so much to improve Savery's invention that his engine, commonly known as the "Atmospheric Engine," remained the model for pumping engines for nearly three-quarters of a century. Thomas Newcomen, a native of Devonshire, was born in 1663, and, whilst an ironmonger or a blacksmith at Dartmouth, got into correspondence with Dr. Hooke on Papin's invention relating to steam engines. Papin suggested the first cylinder and piston steam engine in 1690, and although his engine was not practical because he proposed to use one vessel to serve both as boiler and cylinder, yet it contained valuable suggestions for future inventors. However, Dr. Denis or Dionysius Papin, by reason of his achievements, deserves a moment's digression. He was a French physicist, born in 1647, and became an assistant to Christian Huygens (1629–1695), the celebrated Dutch mechanic, astronomer and physicist, who is usually credited with the invention in 1656 of the pendulum as applied to clocks. Papin came to London in 1674 and was afterwards employed by Robert Boyle, who nominated him for election to the Royal Society in 1680. In 1681 he disclosed to the Royal Society his "Digester," which is inseparably connected with his name. Now this "Digester" was fitted with a safety valve, so that there is no question that the safety valve steam boiler was first invented by Denis Papin. In 1698, it may be noticed that in a letter to G. W. Leibnitz, the celebrated German philosopher, Papin, who was then residing in Germany, said he was engaged on a little carriage which he had constructed to be propelled by the "force of fire" (steam engine). In 1707 he constructed a boat which was manually propelled by paddle wheels and which he assayed to travel from Cassel to the mouth of the Weser, a matter of some 300 miles, but on reaching Munden, some twenty-one miles from Cassel, his boat was confiscated by the Weser boatmen as interfering with their privileges. He died friendless and penniless in London about 1712.

To return to Newcomen, who in 1705 in collaboration with his assistant, John Calley, or Cawley, invented his "Atmospheric engine," and the first engine was erected at Wolverhampton in 1712. In Newcomen's engine, steam from a separate boiler was admitted to a cylinder beneath a piston, which was attached to the one end of a beam pivoted at its centre. The rod of an ordinary pump and a counter weight were attached to the opposite end of the beam. After the steam valve admitting the steam to the cylinder was closed, a jet of cold water entered the cylinder and condensed the steam therein. The piston, due to atmospheric pressure, was consequently forced down to operate the pump. Steam on being re-admitted to the cylinder expelled the condensed waste through a valve. The piston was kept steam-tight by a layer of water on its surface.

(Continued overleaf.)

Originally, condensation was effected by cooling the outside of the cylinder, but an accidental leakage of water past the piston showed the advantage of injecting water into the cylinder. Owing to the success of Newcomen's engine, he was soon assailed by Savery, who complained that Newcomen's engine was an infringement of his Patent No. 356, and he was probably right, so in order to prevent litigation, they entered into partnership.

Diverse Inventions

As will be seen from the foregoing, a single Letters Patent was often granted for a number of diverse inventions, and such a one is that granted to John Allen, M.D., No. 513, dated August 7th, 1729.

John Allen was born probably about 1660, was extra licentiate of the College of Physicians and practised at Bridgewater, in Somersetshire.

The inventions comprised in this Patent were (1) "A new invention for heating and boiling water or other liquors with far less expence of fuel than by the common methods now in use." This boiler comprised a rectangular vessel within which was built the fire grate, the products of combustion being carried through a horizontally-arranged undulating copper tunnel which terminated in a vertical shaft. This tunnel gradually tapered from its larger or grate end to its smaller or shaft end. It is noteworthy that Allen appreciated the use of lagging to conserve the heat, because he states "a case of boards may be fitted round the boiler filled with sand to keep in the heat." In a modification of this boiler, he describes a cylindrical vessel having a grate at the bottom, the products of combustion passing through a copper worm or a helically-coiled pipe within the cylinder before escaping to a shaft.

Allen was also probably the first to suggest a forced draught furnace, because he says "If this should not be found to have draught enough of air barely by the admission of it at the grate, a large pair of bellows may be made use of to force the fire as may be found necessary." (2) "New invention for the application of powers (never before made use of such purposes) to give motion to engines, whereby a ship may be navigated in a calm and some other great works performed where much force is required." This invention consisted in propelling a ship by forcing water or other fluid under pressure through a tube in the stern of the ship. He particularly describes an apparatus (which he describes as a "Pneumatick engine") for forcing air under pressure through the stern of a ship. This apparatus comprised a pair of cylinders, each provided with valved pistons. The rods of the piston were alternatively reciprocated by chain and sector mechanism operated by men pulling a horizontally arranged pole. This, so far as I am aware, is the first Patent covering the reactional form of jet propulsion for ships. Allen also proposed to place his boiler (see 1 above) within a ship and utilise the steam either for jet propulsion or for working a steam engine (probably Newcomen's), which was to be used to operate his "Pneumatick engine." (3) "A new method of drying malt in such a manner that no smoak of the fuel affects it and the Beer brewed therewith is rendered more wholesome and pleasant." This invention consisted in laying the malt to dry on a tray above boiling water instead of directly heating the malt and allowing the fumes or smoke of the fuel to pass through it. Allen further foreshadowed utilising the explosive force of gunpowder for giving motion, not only to ships, but for giving motion for other purposes.