THE A.B.C. OF TELEVISION

NEWNES

PRACTICAL MECHANICS

FEBRUARY

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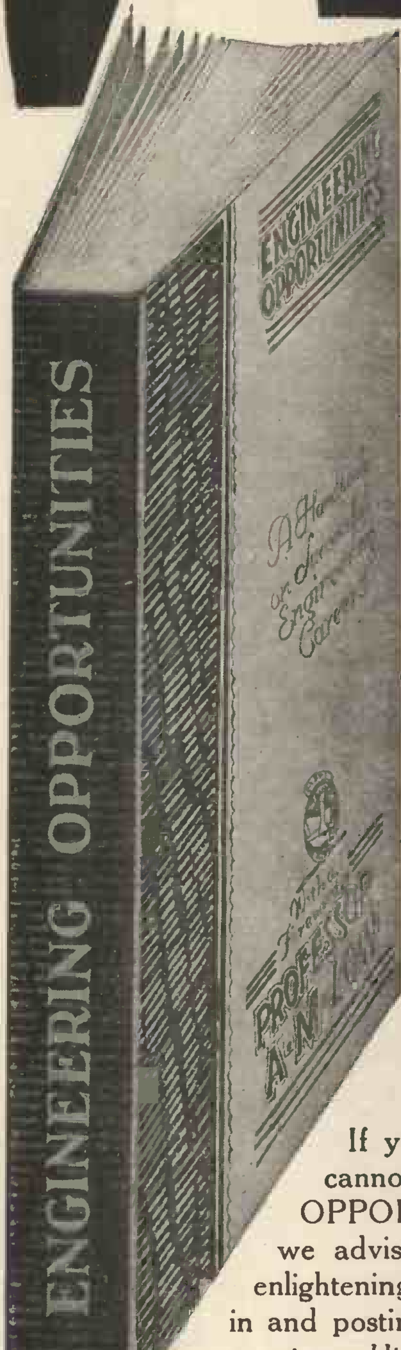

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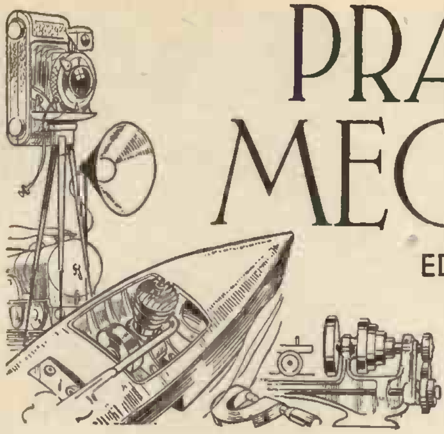

PRACTICAL MECHANICS

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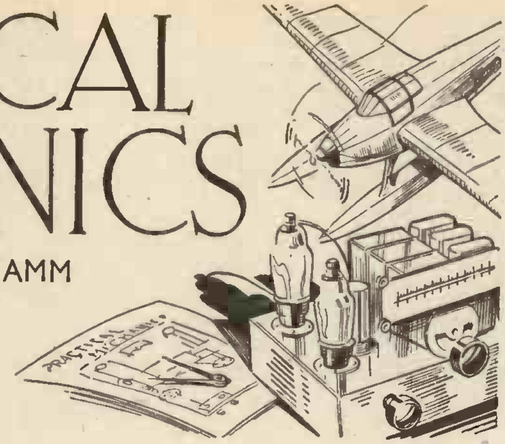


A Cable Railway

A HALF-MILE long cable railway crossing the Seine from the first floor of the Eiffel Tower is the latest idea for the amusement park of the 1937 International Exhibition. Passengers will be carried in aeroplane-shaped cars, the fare being, roughly, 1*s*.

Ever-greens

GOLF greens that turn brown are now being dyed a bright natural green in the United States. The dye costs 2*s*. 6*d*. a green, lasts a fortnight, is not washed out by rain, and does not harm the grass.

The Photo-electric Cell Again

SOUTHEND police and fire brigade have been experimenting with a local man's invention, which detects burglars and fires, and telephones for the proper authority. This is just one more use for the electric eye.

A New Motor-launch

ON the Thames recently appeared a novel type of motor-launch. It is the fastest ever built in England and is destined for the Tigris and the Euphrates for river patrolling. Its estimated fuel consumption is a gallon for every two miles.

An Underwater Expedition

WE learn that Sir Hubert Wilkins, the explorer, hopes to have a submarine specially built for the purpose of making another scientific underwater expedition to the Artic.

Linking the Baltic and Black Seas

THERE is a possibility that the Baltic and Black Seas may be linked by a system of canals. The canals would link the Vistula and Dniester rivers. It is estimated that the cost of the work would be £10,000,000.

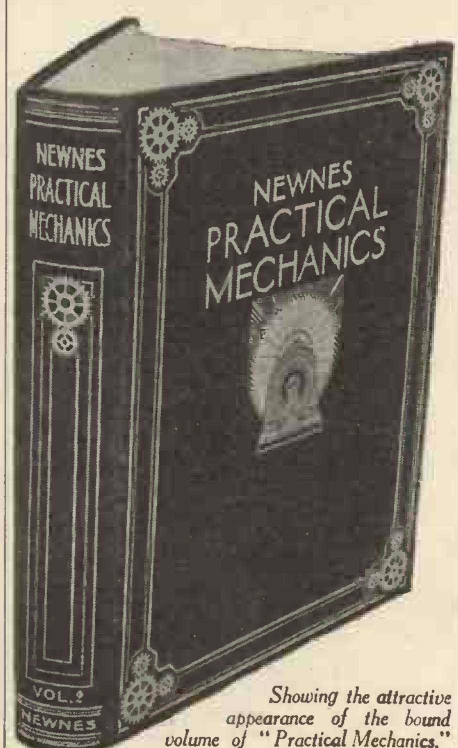
An Italian Motor-flyer

A SPEED of more than 100 miles an hour was reached by a new streamlined motor-train, which recently ended its first trials between Turin and Venice. The train consisted of three carriages locked together to prevent unnecessary wind resistance, and to preserve the streamlining. It was driven by a motor of 1,100 h.p.

Only One Television System

THE Television Advisory Committee are now contemplating standardising the method of television transmission. Instead of two different systems there will be one—simplifying matters for the B.B.C., the radio manufacturers and the listeners. At present each of the two systems is taken alternately and every looker-in has to readjust his apparatus each Monday while the B.B.C. changes studios, transmitters and lighting at Alexandra Palace.

NOTES, NEWS, AND VIEWS



Showing the attractive appearance of the bound volume of "Practical Mechanics."

"Blind Landings"

AT London's premier airport, landings, when visibility is almost nil, are now possible with the aid of a new radio "blind-landing" system.

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Two-day Transatlantic Mail Service

BRITAIN'S hope of starting a two-day Transatlantic mail service this year lies in a £25,000 'plane being completed for the Air Ministry behind locked doors at Hatfield, Herts.

A New Transmitting Station

ACCORDING to Mr. Guillon, the Resident-General, a 100 kw. station is contemplated for Tunis, and the cost of the transmitter will be met by the French Government.

An Electronic "Nose"

THE General Electric Company of America recently announced that they had developed an electronic "nose" having a sensitivity about one-fifth of the human nose. It was developed for detecting minute traces of mercury vapour in the air, and consists of a photo-electric cell and associated apparatus.

Telephones for Russian Villages

OUT of a total of 1,470 village Soviets in the White Russian Soviet Socialist Republic, 1,215 are equipped with telephones, and it is planned to instal telephones in the remaining villages this year. A sum of one million roubles was expended in 1936 on the installation of telephones in the rural districts of White Russia.

New Power Plant in Donetz Basin

THE construction of a huge heat and electric power station with a capacity of 800,000 kw., to be operated on coal dust from the waste of the coal concentration plants in the Donetz Basin, has been commenced in the Stalino district of Donetz. In order to meet the tremendous water requirements of the station (about 200 million litres per hour when working at full capacity) an artificial reservoir of a volume of 52 million cubic metres will be built near the station.

The Cup and the Grip

WHEN one holds a cup of tea it is not always possible to obtain a firm and comfortable grip. An American inventor has designed a cup having at one side of the handle a thumb hole and a rectangular rib slightly greater in length than the hole. This device should prevent many a slip 'twixt the cup and the lip.

Corpatact Devices

THE Corpatact Manufacturing Company of Iver, Bucks, wish to advise all agents and clients who are interested in Corpatact devices, that these can now be obtained direct from the manufacturer and patentee who is the owner of the registered trade mark "Corpatact." All enquiries will have immediate attention.

The Emitron Camera, or Electric Eye, in action at Alexandra Palace.

AN ABC

A Detailed Explan= Language, of the Transmission

BEFORE describing the modern methods of sending and receiving pictures by radio it is necessary to examine the history of television, although it is obviously impossible to cover every phase of its development in a short article of this nature. Stated briefly, it may be said that a picture is illuminated through a rotating perforated disc placed in front of it, with the result that the perforations will pass across the picture in a manner determined by the arrangement of the perforations. Some form of light sensitive device is then so placed that the light reflected from the subject is picked up, and thence converted into electrical energy which is sent out by a wireless transmitter in exactly the same way as the ordinary sound programmes with which we are all so familiar. In the first television systems to be used in this country the disc was perforated with thirty holes and these travelled across the picture from one side to another, thereby dividing the picture into thirty separate lines, and hence was known as the thirty-line system. As each hole travels up the picture it is seen that at any one moment there would only be one small part illuminated, but owing to what is known as the persistence of vision the re-created picture at the receiver end appeared as a complete element and not a series of dots. In order fully to understand the improvement of the modern systems it may be stated that the disc at the receiver end rotated at 650 revolutions per minute and that the actual size of the picture was about 2¼ in. by 1¼ in. and to enable it to be viewed in comfort a magnifying lens was placed in front of the scanning disc.

High-definition Television

In the modern systems the scanning disc is still retained on the transmitting side for many of the broadcasts, although a new type of scanning device is employed for certain direct transmission, as will be described later. In order to provide greater detail there are many more holes in the disc, and the disc is much larger. There are 240 holes, thus giving 240 lines, and there are 25 complete picture movements per second. This means that the disc has to rotate at a tremendous speed, and to enable it to do this satisfactory it is housed in a special chamber from which the air is evacuated. The bearings are water cooled, and to ensure safety against accidents the air pump and the water pump are interlocked with the electrical supply, so that in the event of failure the motor turning the disc is stopped. The actual speed of the disc is 6,000 revolutions per minute, and in the Baird Spotlight transmitter used at the Alexandra Palace two discs are used, one with the 240 holes arranged in four spiral traces of 60 holes each near the outer rim, and the other with a spiral slit which acts as a rotating shutter and thus only permits one hole to come into use at a time.

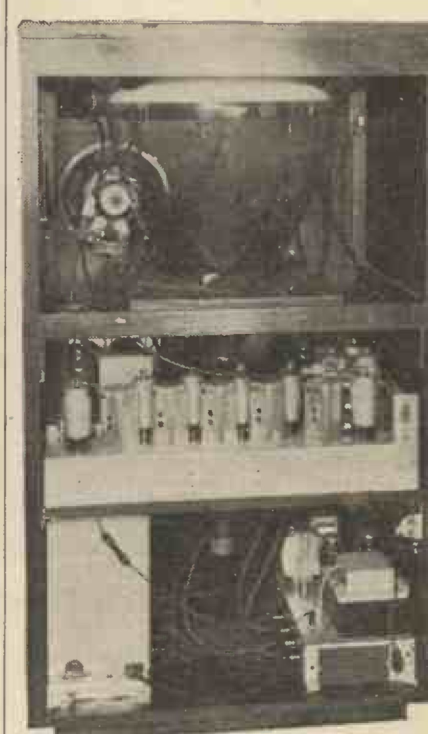
A similar piece of apparatus is also employed by the Baird Company in conjunction with ordinary cinema films, and these pass through a machine very similar to an ordinary cinema projector, but instead of passing through in jumps as in the ordinary film it passes through at a steady speed. The artists in the studio are photographed by an ordinary cinema camera (using a 17·5 mm. film) and the film passes through a tank divided into six compartments, where it is developed, washed, fixed, washed, passed before the scanning discs and so transmitted. There is a lapse of only thirty seconds from the taking of the picture to its radiation from the aerial in the form of electrical energy, and this system is known as the Intermediate Film Process.

Telecine

To add to the entertainment which may be provided in the studio ordinary cinema films may be scanned and broadcast in a manner similar to that outlined above, except, of course, that the developing and other processing tanks are not required. This system of television is now generally used by manufacturers for research purposes, as it avoids the necessity of a studio and living performers, and enables a scene or event to be repeated over and over again, which is ideal for comparative purposes.

The Electric Eye

Alternating with the above apparatus is that supplied by the Marconi-E.M.I. Company, and this is generally referred to as the "Electric Eye." Its technical name is the Emitron Camera, and it is to all outward appearances a cinema camera. It is mounted on a travelling carriage with an operator behind it, and it may be swung in various directions just as in the case of a standard cinema camera. It is provided



This illustration shows the internal arrangement of the Model T.5 Baird Televisor. The large tube which is employed may clearly be seen.

OF TELEVISION

ation, in Non-technical Modern Systems of Television and Reception.

with a lens, and it "takes in" the scene in exactly the same way as a cinema camera, but it converts the scene into electrical energy without the intervention of the film. It is one of the most wonderful pieces of apparatus which can be imagined and enables outdoor events to be televised and, owing to its mobility, it may be run along the ground so that a tour of inspection of a large stationary object may be transmitted or any similar arrangement carried out. The Marconi-E.M.I. apparatus also includes a tele-film unit similar to that already described, but in all of the transmissions employing the Marconi-E.M.I. systems a slightly different arrangement of the picture is given. Instead of a 240-line picture repeated 25 times per second, each picture consists of 405 lines, and each alternate picture is interlaced with the previous one. In this way we obtain the equivalent of a frequency of 50 pictures per second, each picture consisting of 202·5 lines, and the line frequency being 10,125 lines per second. So much for the brief details of the transmitting systems, and now we must examine the problem of reception.

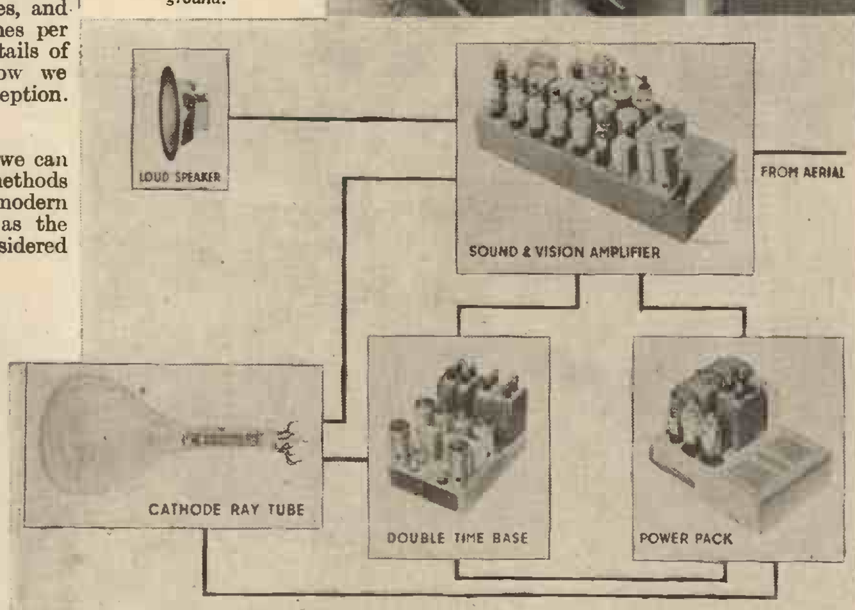
The Cathode-ray Tube

As the definition is now so high, we can take advantage of more elaborate methods of reproducing the picture, and modern television utilises what is known as the cathode-ray tube. This may be considered as a giant wireless valve, as it incorporates filament, cathode, grid and anodes, and an electronic stream from the cathode is employed exactly as in a radio valve. In the cathode-ray tube, however, the electron stream is passed between two sets of plates arranged at right angles to one another, and by applying various voltages to these plates it is possible to move the electron stream. At the end of the cathode-ray tube the glass is brought out to a large surface, and this is coated on its inside with a special chemical which glows under the influence of the electron stream. Consequently, if the stream is drawn steadily from one side to the other it will trace a line of light upon the screen, and the four deflecting plates, as they are called, are connected to a special electrical circuit known as a time base, with the result that the voltages applied to the plates change in a regular order. This causes the spot of light on the end of the tube to travel not only across the screen but slowly downwards, and so a large rectangular light patch appears to the eye. In the modern receiver this is generally about 10 in. long by 8 in. in height, and the number of lines must coincide with those at the transmitter. Elaborate synchronising systems ensure that the spot in the receiver keeps step with the spot at the transmitter, and naturally a slight alteration has to be made at the receiver end in order to adapt it for the reception of the Baird or the Marconi-E.M.I. systems as just described.

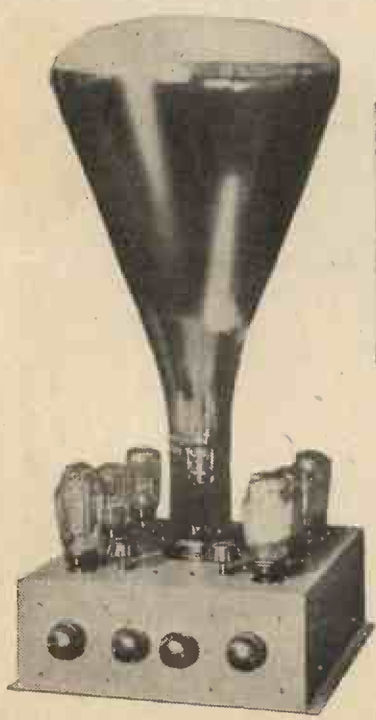
The Vision Receiver

The wireless signals are picked up by a standard wireless receiving circuit, and in order to preserve the high details special forms of coupling are employed and the transmissions take place on a very short wavelength so as to enable a full range of variation to be covered without interference with other stations. At present the

The G.E.C. television receiver removed from its cabinet. The double time-base is in the foreground.



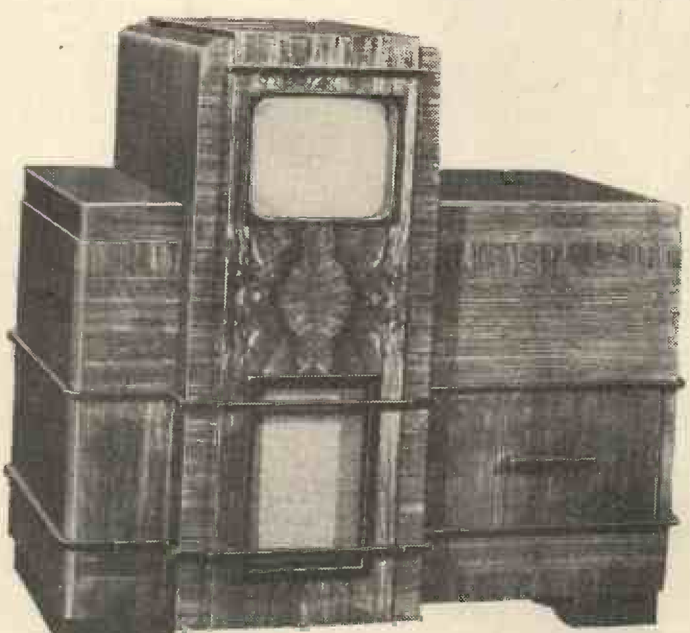
On the left is shown a diagrammatic arrangement of the component assemblies of a G.E.C. television receiver.



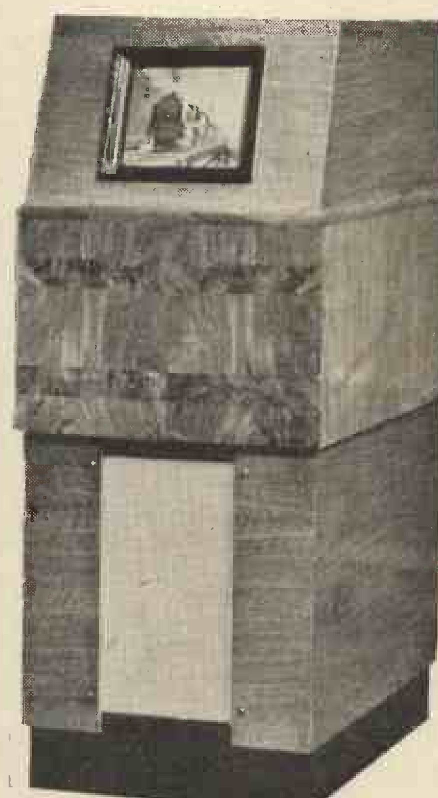
A time-base unit with cathode-ray tube in position, which shows the size of the tube compared with ordinary valves.

The Marconiphone Model 701 has a reflector to enable the vertical cathode-ray tube to be viewed.

The Philips receiver is fitted to a neat chromium stand to increase the height of the viewing screen.



The Pye model shown here incorporates an auto-radiogram. Direct vision is employed.



This is the smaller Ferranti Model, with a directly-viewed screen. A cathode-ray tube is also used in these receivers, a 10-in. diameter tube being provided and the approximate picture size being 9 in. by 7 in., with a colour image described by the makers as "electric light white."

This illustration of a relay of a Mannequin Parade shows the studio technique when the " Electric Eye " is employed. The " camera " is in the centre foreground, and the operator is wearing headphones.

picture is sent out on a wavelength of 45 megacycles, and the accompanying sound is transmitted by standard broadcasting apparatus on a wavelength of 41·5 megacycles. Thus, therefore, to receive both the picture and its accompanying sound, two separate wireless sets are required, but it is possible to arrange that only one tuning control need be used, by adopting a modern superheterodyne receiver. The variations in signal strength coinciding to the light and shade of the picture are applied to the grid of the cathode ray tube and modify the strength of the electron stream, thus giving rise to a variation in the brightness of the spot on the end of the tube and in this way the picture is built up. The sound is fed to a loudspeaker just as in ordinary broadcasting.

Television Problems

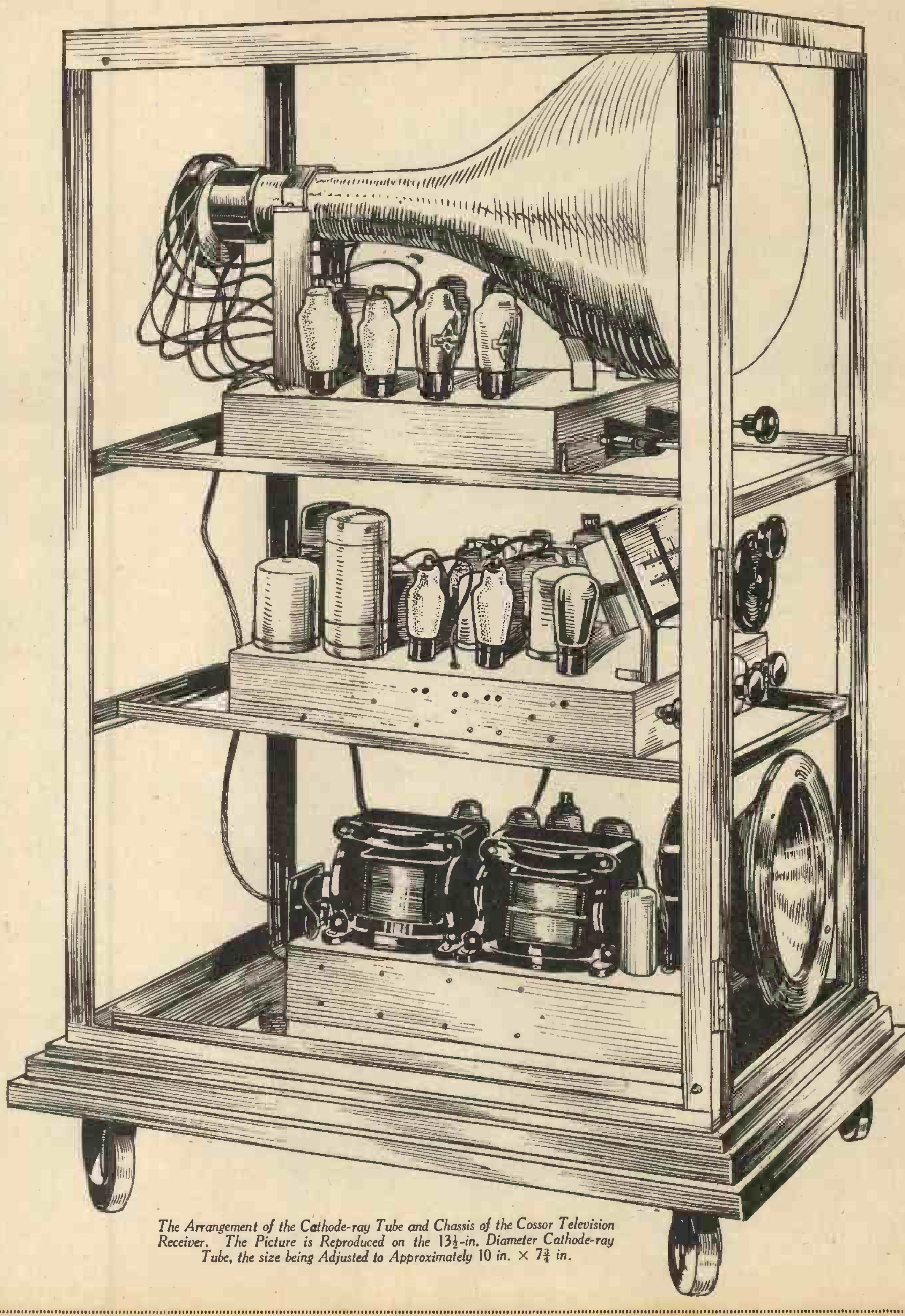
This, then, is a brief outline of the system as at present in use, but there are many problems to be overcome before a perfect picture may be seen in the home. Firstly, the quality provided by the vision receiver must be well-nigh perfect if the picture is to be free from distortion. Where slight distortion may be tolerated in a loudspeaker, any marring of a picture will offend the eye. Owing to the very short wavelength used for the broadcast, interference is experienced from motor-car electrical apparatus such as sparking plugs, and thus the aerial at the receiving end has to be of a special type and erected as far from the roadway as possible. Usually, best results are obtained when the aerial consists of a vertical wire measuring one-half of the vision wavelength, and it is cut in the centre and two wires led away to the receiver. These are sometimes screened to avoid the picking up of electrical interference.

Furthermore, the speed of the spotlight trace on the end of the cathode-ray tube must be exactly in step with the transmitter, and thus the time-base circuit must not only be well-designed and built, but must be placed in such a position that it is free from interference with the remainder of the apparatus. In a modern television receiver, the various parts are usually built as separate units, as this not only facilitates testing, replacements, etc., but also enables the apparatus to be disposed inside a cabinet to the best advantage, both from a point of view of convenience and of electrical efficiency. In the diagram of the G.E.C. apparatus which is shown, it will be seen that the sound and vision receivers are combined on one chassis, the time base on another and the power pack or mains unit on another. Extremely high voltages are employed with the cathode-ray tube, and it is usual to obtain 4,000 to 7,000 volts for the anode, so that very high insulation has to be obtained. The method of connecting these separate units together also has to receive careful consideration to avoid distortion of the picture due to interference from adjacent leads.

In this Marconiphone Television Receiver the reflected method of viewing the screen is employed.

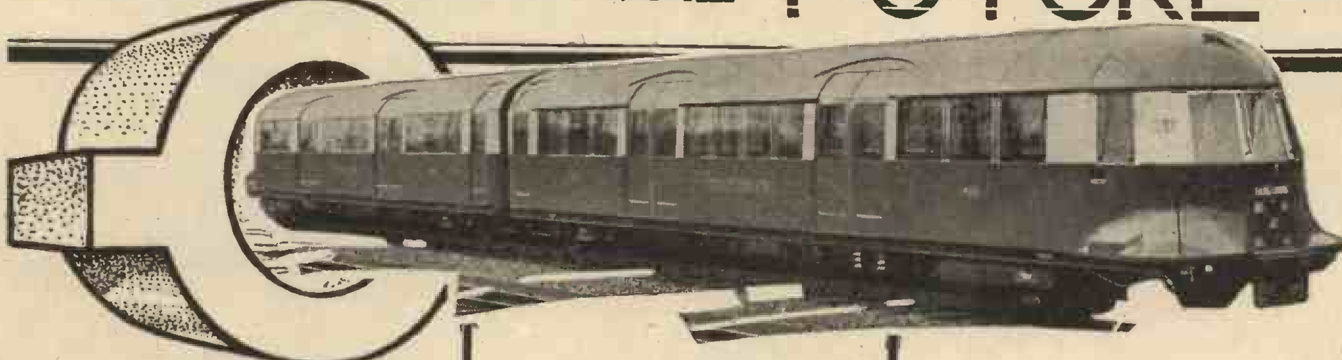
The Future of Television

The end of the cathode-ray tube is generally viewed direct, as the picture is sufficiently large for adequate viewing by quite a number of people, and is sufficiently brilliant to be viewed in the home under ordinary domestic lighting conditions. In one or two receivers the manufacturers have placed the tube in a vertical position and the lid of the cabinet is provided with a reflecting plate or mirror, so that when placed at an angle of 45° the reflected image on the end of the tube may be seen. In one case, a small tube is employed in this way, and a lens is interposed between the tube and the mirror to provide a larger picture. The majority of pictures are brilliant black and white, but it is possible to obtain tubes which give a blue or green picture. So far it is impossible to provide a coloured picture, that is, one in which each part is reproduced in the original colours of nature. Attempts have been made experimentally to split up the scanning trace through filters to give a picture in natural colours, but have not been entirely successful. One method of achieving this object would be a spinning disc in front of the cathode-ray tube suitably divided into the three primary colours, the arrangement being in effect that each picture is framed in each colour in turn, the transmission being so controlled that the " light " portions of each picture are controlled by the colour value of the object or scene to be transmitted. In actual practice, of course, the three primary colours would have to be modified, as the source of light (the cathode-ray spot) is not truly white. There is, however, little likelihood of such an arrangement being adopted for many years to come, and it is also questionable whether the present technique of transmission allows for a sufficiently steady picture to be broadcast to enable the colour to be obtained. Attempts have also been made to project the image from the end of the tube through a lens so that it could be shown in an enlarged form on a screen. No doubt the time will come when the image will be projected stereoscopically and in natural colours, but this appears to be a long way off. Certain mechanical systems are being experimented with, in an endeavour to avoid the use of a cathode-ray tube and its limitations, but no details have been released by the people using these systems and consequently no details can be given other than that a rotating prism is employed in conjunction with a series of mirrors rotating at high speed. Whether or not this will provide the same results as the cathode-ray tube systems remains to be seen.



The Arrangement of the Cathode-ray Tube and Chassis of the Cossor Television Receiver. The Picture is Reproduced on the 13½-in. Diameter Cathode-ray Tube, the size being Adjusted to Approximately 10 in. × 7¾ in.

UNDERGROUND TRAINS OF THE FUTURE



Many Novel Features are Incorporated in the New Electric Trains Shortly to be Put into Service by the London Passenger Transport Board

THERE is probably no transport service in the world which expends so much time and money on progressive development as the London Passenger Transport Board. Thousands of pounds are spent yearly on experimental equipment and a huge staff is constantly working to increase the efficiency of the huge system, and comfort of the passengers. When one travels on the existing underground trains, and notes the efficient and comfortable standard which is maintained, it is somewhat difficult to imagine any possible improvement. The new tube trains, however, which are shortly to be put into service, after exhaustive tests have been carried out, incorporate many new features designed to increase comfort and give increased performance.

More Room

In the tube trains now in use, a special compartment had to be provided to accommodate the electrical equipment. On the new cars, however, this equipment is housed underneath the train in a specially designed cradle and thus the "engine-room" is eliminated and extra space is available for passenger accommodation. A six-car train of the new type will have approximately the same carrying capacity as a seven-car train of the existing stock. Each car will carry 40 passengers and have the usual two occasional seats for use during peak periods.

Improved Acceleration

An existing six-car train has four driving motors, totalling 960 h.p., whilst on the new type twelve motors will be employed giving a total horse power of 1,656. The acceleration will be at the rate of two miles per hour per second and specially designed control system will insure a smooth "get-away."

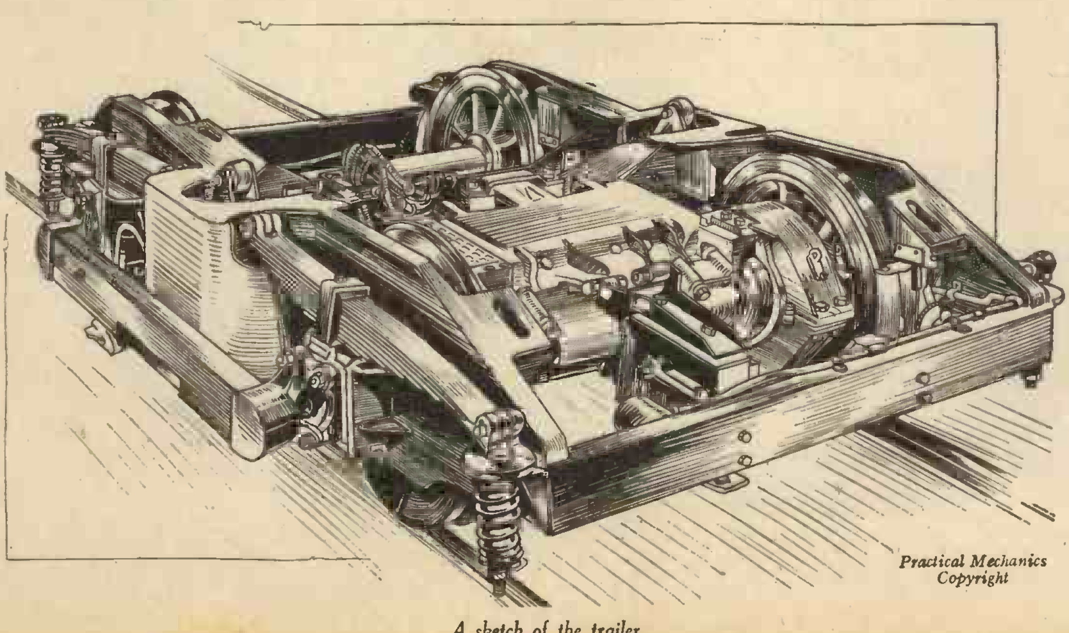
Fifty per cent. of the axles have been motored, this arranging for a greater proportion of train weight to be available for adhesion. A multi-notch system of control is employed which, by cutting out the starting resistance in small decrements, reduces current peaks and allows the accelerating currents to be increased much nearer to the slipping point than has hitherto been possible.

Better Braking

A new braking system has also been devised which gives a rate of retardation of three miles per hour per second. The Westinghouse Brake & Signal Company have co-operated in the production, by designing an entirely new type of brake for independent wheel braking. This system employs eight air-operated brake cylinders mounted on each bogie, complete with automatic slack-adjusters. Electro-pneumatic control is the result of much experiment and the high rate of braking has been made possible by using an automatic retardation controller which keeps the deceleration practically constant over the whole speed range. This type of control allows increased brake cylinder pressures to be used at the commencement of braking when the co-efficient of friction is lowest. This gives a gradual automatic release of pressure as the friction co-efficient increases and the train is brought to a standstill.

The Traction Motors

These motors have had to be specially designed for use in the limited space available. They are rated at 138 h.p., giving a total horse power of 1,656, as already



A sketch of the trailer.

stated. The motors are mounted on the inside axle of each bogie and incorporate a new type of roller-suspension bearing in their design.

The bogies are of all-welded construction, are fitted with 31-in. diameter wheels and the wheel base is 6 ft. 3 in.

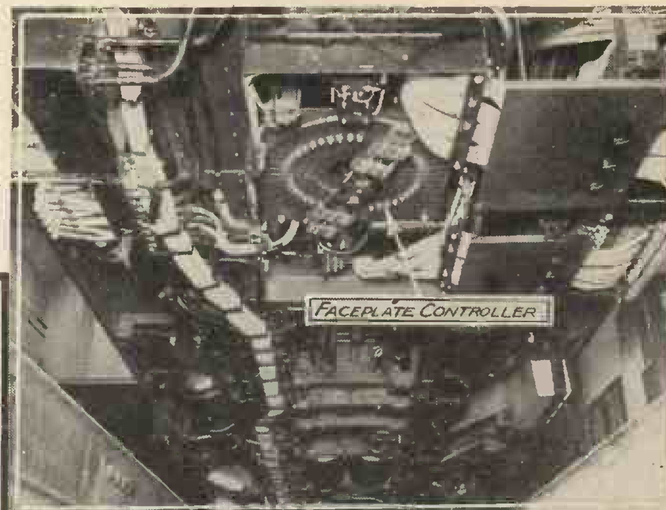
New Body Design

Three of the experimental trains are streamlined to reduce wind resistance when running on open stretches of line. A semi-elliptical nose at each end of the car incorporates the driver's cab, whilst the windows have been brought out flush with the outside panels of the car. The window pillars, slimmer than hitherto and of triangular section, give the general appearance of one long window and give a better outlook. The bodies are carried on a welded steel underframe, the main longitudes of which have been constructed to form air ducts for use with the ventilating plant which is thermostatically controlled. Special gears and wheels with silencing devices have been incorporated and in some cases the car-sheeting has been sprayed with "anti-noise" composition.

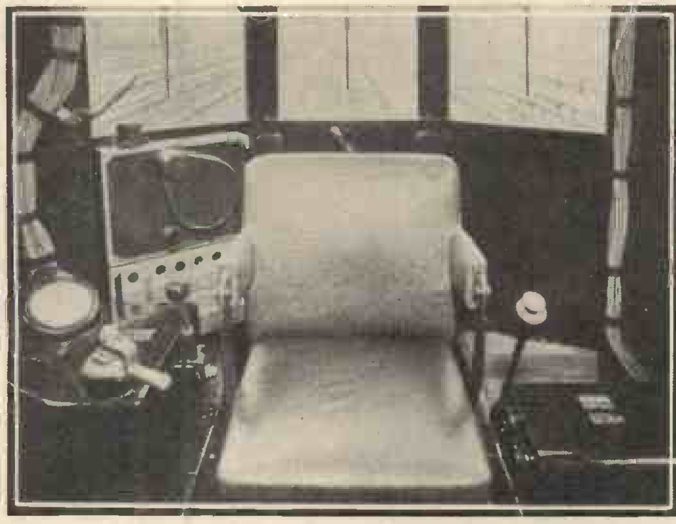
Steadier lighting has been arranged from an independant 50-volt supply, and diffused lighting fittings give adequate light without shadows.

These fittings take the form of fluted oblong shades, housed in chromium-plated frames and are located in a line on either side of the centre roof section.

Each of the new cars is 52 ft. 5¾ in. long, and is fitted with two double and one single air-operated sliding doors on either side. These are controlled electrically from the 50-volt supply.



An underside view of the car which shows Crompton-West faceplate control gear.



(Left) A wide angle of vision is obtained from the driver's cab. The seat has been turned towards the camera for this photograph.

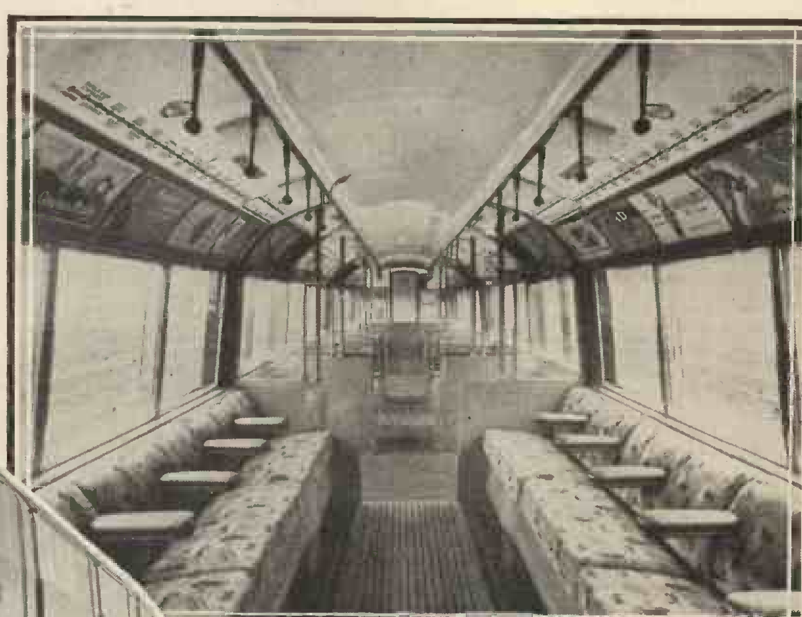
Simplified Operation

On existing stock the cars have to be interconnected by hand and thus a certain amount of delay is caused in coupling and decoupling. The new cars, however, have been fitted with fully automatic couplers which are operated by a push button in the driver's cab. This allows, not only the mechanical, but also the electrical and pneumatic connections to be made without the driver leaving his position.

The semi-circular driving cab, of which a photograph appears, is a vast improvement on the existing type. As will be seen, three large windows give a wide angle of vision and automatic windscreen wipers are fitted.

The driver's seat is situated in the middle of the cab and the "joy-stick" type of control is employed; one "joy-stick" is used for driving the train and the other for braking.

The amount of time, money and thought which have been expended in producing these trains may be gauged, to some extent, by the details given in this article, and it is only due to constant and careful experiment that we can claim, in Britain, to have the finest underground railway system in the world.



(Left) An impressive view of a new train showing the streamlined driving cab.

(Above) This interior view of one of the new cars shows the increased window space. The new lighting arrangement and novel handstraps are two features worthy of note.

Fig. 1.—The 2·4-c.c. "Elf" engine beside Kanga's 25-c.c. engine. Kanga was the first post-war petrol-driven record holder.

Fig. 2.—A three-quarter rear view of the model described showing the clock, and the petrol tank can be seen mounted into the wing.

A Petrol-Driven Model for 2·5-c.c. and 3-c.c. Engines

By C. E. Bowden
The British Petrol Model Aeroplane Record Holder

THE 2·5-c.c. engine and the 3-c.c. engine sizes are now a proved success, and have enabled constructors to make really convenient sized light and portable models.

The 2·4-c.c. " Elf " engine is used in this model. The 3-c.c. " Grayson Gnome " is already on the British market and there are several others that will shortly make their appearance. Now, therefore, is the time to construct one of these really small petrol models. There is the danger, however, of attempting to make too small a model.

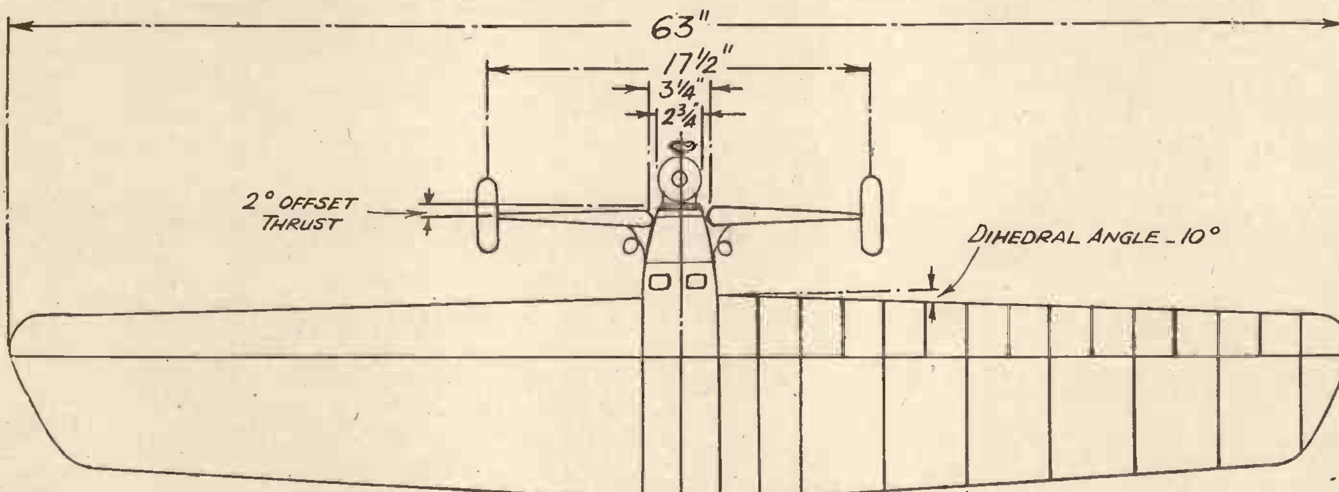
A very small model for these engines can only be made if strength and general durability and the ability to withstand severe knocks is sacrificed.

In America, where the general flying weather is far better, it is possible to produce very light petrol models by the entire use of balsa wood and paper covering. The size of the model can then be brought down, and yet the model will fly slowly, as a light wing loading is still obtainable.

A Robust Model

Here in this country we require a reasonably robust model which means a certain amount of weight. This weight must be supported by a larger wing surface to keep the wing loading low, but we must not have too much weight or our very small 2·5-c.c. engine will not be able to fly the model. We must therefore compromise. The model to be described is a successful compromise, and has proved itself an excellent flying model with good stability in reasonable weather. It is simple to build, and has various features in its construction which help to keep weight down and yet retain a good factor of safety, and a robust model.

The weight complete, ready for the air, is 2 lb., including clock control for duration of flight. A 2·4-c.c. " Elf " engine, obtained from a Canadian manufacturer, is installed, but any good 3-c.c. engine will be a success provided a suitable propeller of fine pitch is fitted which will allow the engine to revolve at about 3,500 to 4,000 r.p.m. It is a mistake to cut the revolutions down on these very small engines. They gain their power on high r.p.m., which allows a good gas seal between piston and cylinder. A fine-pitch propeller of about 12 in. diameter is usually very successful. The " Elf " uses a 12 in. diameter and 6½ in. pitch.



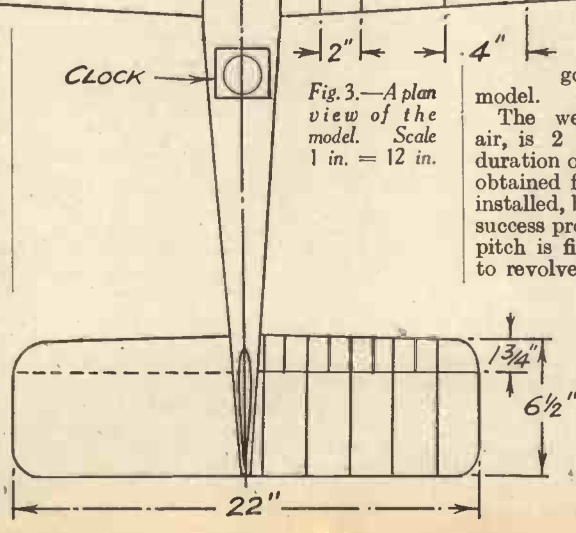


Fig. 3.—A plan view of the model. Scale 1 in. = 12 in.

It is possible to cut down the weight as the Americans frequently do by dispensing with the clock control for duration of flight, and limiting the petrol supply.

But in this country I do not consider that this is desirable owing to its highly populated areas. In the interests of safety, the run of the engine should be controllable to within a second or so of any desired duration. There is then no danger of the model flying ouside the flying field. Furthermore, a definite clock control makes the preliminary test flights safe for the model, as will be explained at the end of this article under the heading "Flying the Model."

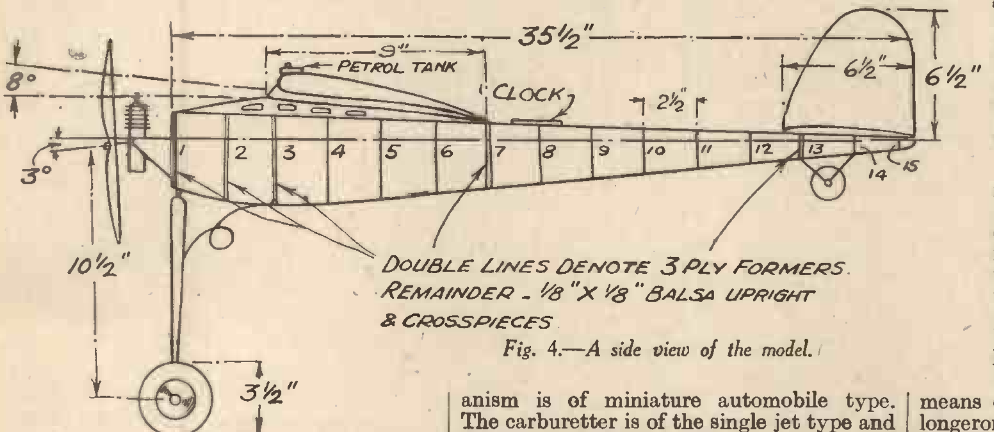


Fig. 4.—A side view of the model.

A model of $1\frac{3}{4}$ lb. sounds attractive, but a controllable machine of 2 lb. is far more satisfactory, and it has been found that the model to be described can fly on about half throttle. This proves that the wing loading is sufficiently light. Actually the model flies quite slowly and glides very well.

It has been designed for stability and ease of construction rather than beauty of line, although in actual fact the model looks quite well.

The Engine

The "Elf" engine was one of the first, if not the first, really small engine of 2·4-c.c. that was put on the market commercially. It has set the fashion for another reduction in size for commercially supplied engines. It is a four port two stroke.

Fig. 1 shows the "Elf" engine, side by side with a 25-c.c. engine, and gives some indication of its minute proportions.

I now have two of these engines, and both are excellent little power producers. There is, of course, no import duty on the engine, as it is of Canadian manufacture. The engine is very carefully made and naturally to very fine limits, and therefore requires careful running in on the bench with frequent applications of extra oil. This can be done whilst the model is being constructed if the little engine and its wooden base upon which it is mounted are screwed down to the bench.

Its chief peculiarity besides the smallness of its size is the fact that three piston rings are fitted to the piston, whereas on most small aero commercial engines to-day, the piston are fitted without rings. The next most noteworthy point about this engine is that a 2 oz. coil and $\frac{1}{2}$ oz. condenser are used, and the coil operates on only $1\frac{1}{2}$ volts with a special miniature Champion sparking plug. The engine will therefore run on two $1\frac{1}{2}$-volt "pencil" flash-lamp cells which, together, weigh 1 oz. The ignition weight is thus cut down considerably, as the ordinary 6-c.c. and 10-c.c. model engine uses at least a 4-volt battery for flight. Actually on my model I have been starting on a ground "bell" battery of $1\frac{1}{2}$ volts, and using a very small 3-volt rectangular 2-oz. battery for flight, because I find this size and shape more convenient for my method of battery installation. This will be explained later on under "Ignition Details." I have not found that the 3 volts of such a small battery has damaged the coil.

The cylinder is an aluminium casting with a thin steel liner. The bore is 0·542 in., the stroke $\frac{19}{32}$ in., and the piston displacement $2\frac{1}{4}$ c.c. The make-and-break mechanism is of miniature automobile type. The carburetter is of the single jet type and fed from a float chamber.

The engine weighs 4 oz. The spark coil and condenser weigh $2\frac{1}{2}$ oz., and the propeller about $\frac{3}{8}$ oz. The engine runs, with the normal standard propeller provided, at about 3,500 r.p.m., when it produces 2·8 lb. per brake horse power hour. The engine runs approximately 40 minutes on one ounce of fuel at this speed, and with the propeller supplied, the engine develops a static thrust of 9 oz. The carburetter has a petrol adjustment screw but no air adjustment. A mixture of petrol and oil between 8 to 1 and 10 to 1 is suitable. The engine is very sensitive when warming up, and requires the spark well retarded. The starting is normally easy provided the minute petrol ducts are kept clean, and the contact breaker points are also kept clean.

The piston is an aluminium casting and has three piston rings.

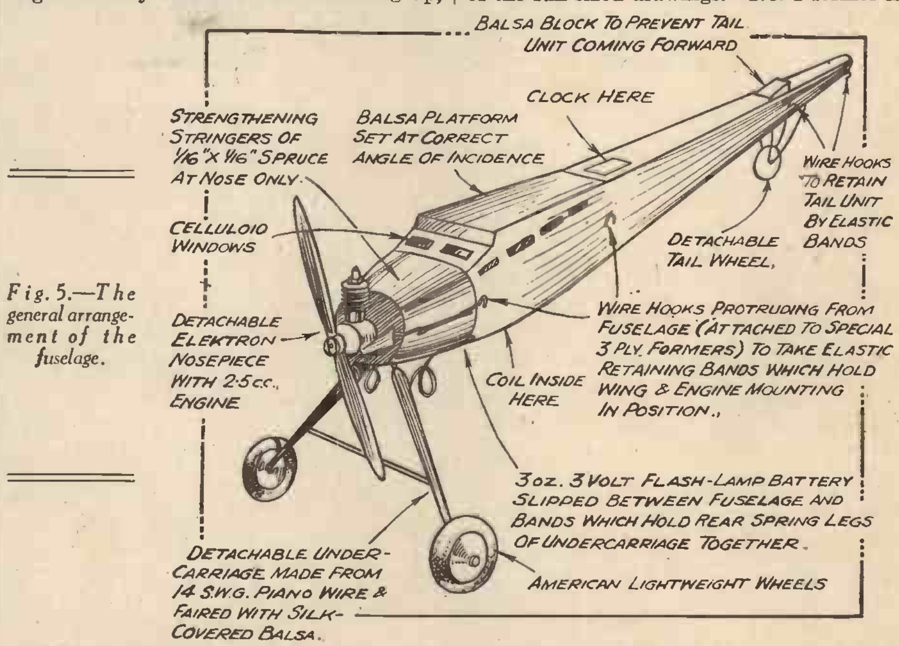


Fig. 5.—The general arrangement of the fuselage.

The Drawing

A full-sized drawing must be made of the model from Figs. 3 and 4, which shows all dimensions necessary. Fig. 5 will also help both at this stage and later when the fuselage and its fittings are being made.

The cheapest way to make this drawing is on ordinary white kitchen paper which can be bought in long rolls at Woolworth's, or any stores. Next a stout board that will accommodate the fuselage side elevation must be obtained. The drawing of the fuselage side view is then placed on this board. The drawing is then covered with greaseproof paper, so that the drawing can be seen through the paper, but the fuselage construction will not become stuck to the drawing by glue. Construction of the fuselage can now begin.

The Fuselage

This is almost entirely made from balsa wood, but, due to its construction, is very strong. It is of rectangular form in order that it shall be simple to construct for the newcomer to model work. The top and bottom longerons are of $\frac{1}{8}$-in. by $\frac{1}{8}$-in. square "medium" balsa wood. These longerons are laid along the longeron lines on the drawing and are kept in place by means of small pins on either side. Two longerons are placed in position top and bottom, one above the other, so that both sides of the fuselage are made simultaneously.

Now $\frac{1}{8}$-in. by $\frac{1}{8}$-in. balsa uprights are glued in position everywhere except at No. 1, 3, 7, and 13 formers (see Fig. 4). At these special positions 3-ply wood formers are placed because these are the points where wire fittings and strains occur. These 3-ply formers, except No. 1, are all cut from $\frac{1}{16}$ in. thick 3-ply and well fretted out in the centre for lightness. They are of rectangular shape and their dimensions can be drawn out from the side elevation and the plan view of the full-sized drawings. No. 1 former is made from $\frac{1}{4}$ in. thick 3-ply as it is the nosepiece and has to withstand extra strain.

Before fitting these 3-ply formers, all the uprights must be glued in and the glue set hard. To keep the bottom set of uprights from sticking to the top through any excess of glue, little slips of grease proof paper are pushed between the bottom and top longerons where the uprights meet the

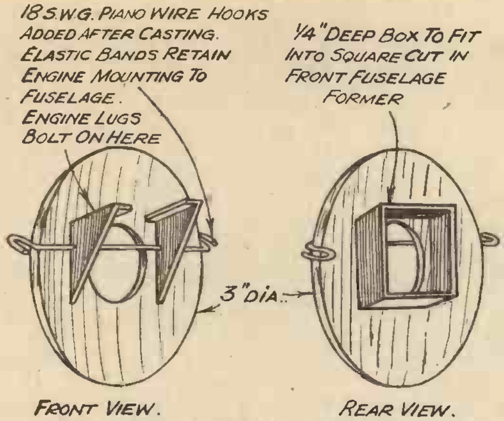


Fig. 6.—A front and rear view of the wooden pattern for a cast elektron mounting for the "Elf" or other 3-c.c. engine.

longerons *after* the bottom set of uprights are glued into position. The top set of uprights can then be glued into position. After all are set hard the pins can be removed from either side of the longerons, and the two fuselage sides can be separated.

The rectangular 3-ply formers can now be inserted and lightly bound and glued to the longerons in their correct positions. Leave fitting No. 1 or nosepiece former until we have discussed its special shape and construction under "Engine Mounting." A streamline rail end to the fuselage is made from a small piece of solid balsa wood.

The Engine Mounting and Fuselage Fittings

The engine is mounted on a detachable nosepiece which is an electron casting. Fig. 6 shows details of this mounting, whilst Fig. 5 will show it in position on the fuselage.

This mounting will save endless damage to both the engine and the fuselage for it is kept in position to the fuselage by rubber elastic bands, and can be knocked out if the model makes a bad landing or strikes any object that it was not intended to fly into.

It will be observed that the mounting is located to the circular No. 1 former by a raised square built integral on its back plate which fits into a square cut out in the No. 1, ¼ in. thick, 3-ply circular former. There are wire hooks on the mounting and wire hooks bound on to the No. 3 former (3-ply). Elastic bands of just sufficient tension to take the engine thrust keep the mounting hard up to the nose former.

The idea is simple, but extremely efficient, for not only does it prevent damage if the rubber tension is correct and the mounting can knock out, but it allows the engine to be withdrawn in a moment for adjustments, and it also allows alteration of thrust line and offset thrust to be made when testing the model by inserting wood packings of various thicknesses until the necessary corrections are made. This will be explained later under "Flying the Model."

There are two methods of making this mounting. No. 1 method, although it may sound more difficult, and perhaps the only real difficulty in the whole model, is far the best method.

A casting is made in elektron which is a very light alloy, 40 per cent. lighter than aluminium alloy.

A simple wooden "pattern" is made up in 3-ply wood $\frac{1}{16}$ in. thick as in Fig. 6. The pieces of wood are glued and pinned with very fine model nails.

The pattern is then sent off to the Birmingham Aluminium Casting Company, Smethwick, Birmingham, who will make up four or half a dozen castings for a shilling or two each. These castings can be used for future engines, and the nosepieces are standardised so that engines will be interchangeable on the other models that the constructor will doubtless make.

If the constructor thinks that this casting method is too expensive or not worthwhile, it is possible to make a similar nosepiece up with brass brackets bolted up to a 3-ply circle and a 3-ply square bolted up to the rear of the circle. This method is satisfactory, but not so rigid, of course, as the brass brackets may bend and become damaged. It is also heavier.

The rest of the model is comparatively plain sailing.

Now look at Fig. 5, and it will be seen that there are various wire hook fittings that must be attached to the 3-ply formers by binding with thread and glue. 20 s.w.g. piano wire will do for these.

First of all there are the hooks looking forward from No. 3 former. These allow elastic bands to hold in the engine. Then on the same former there are hooks looking upwards. Also at former No. 7. These hooks accommodate elastic bands to keep the wing in position. At former No. 13, there are similar hooks to keep the front end of the tailplane in position, whilst there is a single hook right at the stern of the fuselage to keep the stern of the tail down by means of a band from this hook to a hook fixed to the bottom end of the rudder or fin.

These wire hooks are all located about 1½ in. from the top run of the fuselage so that no unsightly bands go round or crush the fuselage, and yet there is sufficient elastic band to cause a springing effect, to prevent damage to either wing or tail unit if it receives a blow.

The undercarriage is detachable (see Fig. 9). Therefore two brass, or better still, if obtainable, two duralumin tubes are bound across the bottoms of formers Nos. 1 and 3. These are also glued, and have to accommodate 14 s.w.g. wire prongs. Two smaller tubes are bound across the fuselage at formers 13 and 14, for the detachable tail wheel. Finally a wire hook is placed pointing downwards on each side at former No. 7. An elastic band passed from these hooks and around the bottom of the fuselage will keep the little rectangular battery for flight up to the bottom of the fuselage.

A few strengthening stringers of $\frac{1}{16}$-in. by $\frac{1}{16}$-in. spruce are placed around the nose between Nos. 1 and 3 formers. These help to merge the rectangular fuselage into a rounded nose (see Fig. 5.)

(To be continued.)

Fig. 7.—A view of the model in flight.

Fig. 8.—The finished model, showing the clock mounted just behind the wing.

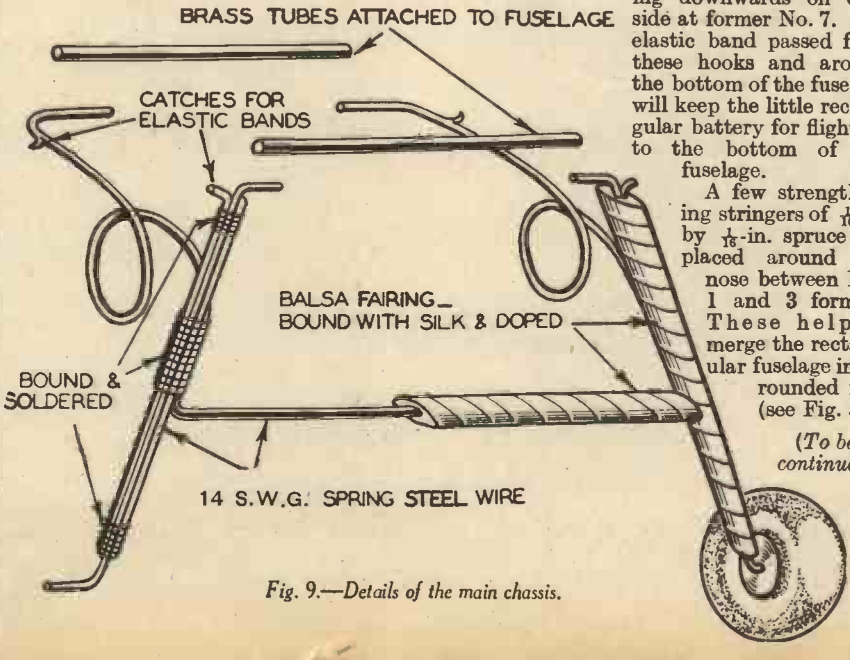
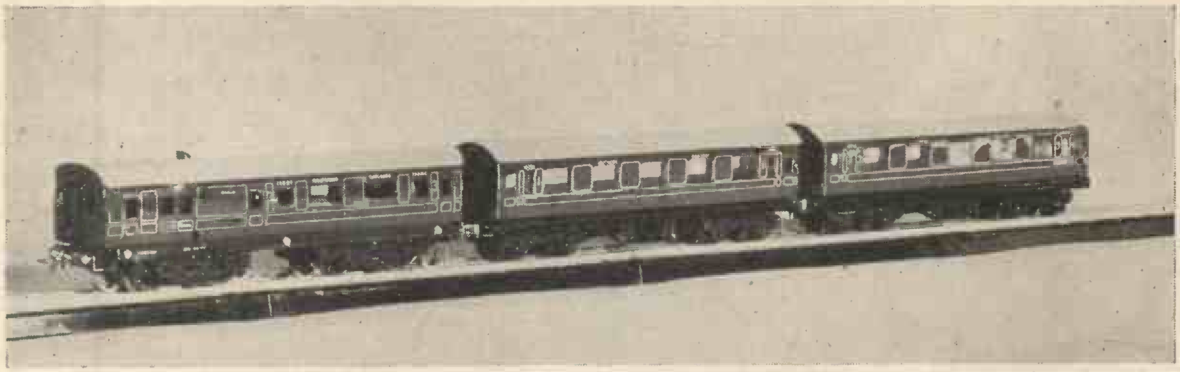


Fig. 9.—Details of the main chassis.

THE LATEST IN TWIN TRAINS



A Southern Suburban electric train.

Further Developments in Gauge "OO"

QUITE a new interest has been created in the interesting hobby of model railways by the advent, last year, of an entirely new system of small gauge electric railway, introduced by Messrs. Bassett-Lowke, Ltd., of Northampton.

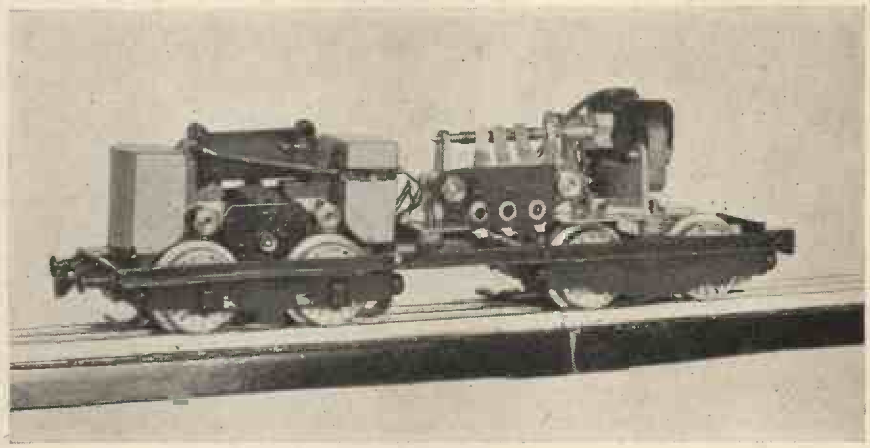
New Methods of Construction

This railway, known as the Trix Twin Train, is "00" gauge of ⅝ in. between rails, and incorporates many new methods of construction. The locomotives are propelled by specially designed electric motors working off either 14 volts a.c. or 12 volts d.c., with a system of wiring the track and control whereby two trains can be operated on the same track at the same time, reversing, stopping and starting, the common return being made through the centre rail. The track also has the special feature of being mounted on a moulded Bakelite base with neat snap connections, making it rigid when built, yet easily detachable for transport and packing.

Accessories

Twin train accessories include goods vehicles of every type, overbridges, signals, electrically controlled points, buffer stops, and, last but not least, an excellent range of station buildings.

Mr. C. Grasemann, Publicity Officer of the Southern Railway, was quick to realise the potentialities of this novelty and, in collaboration with him, Messrs. Bassett-Lowke Ltd. have just placed on the market an actual scale model, representing one of the new electric trains, which will run on the London-Portsmouth service, when the electrification of this line is finished in June or July. This model outfit consists of motor coach, two trailing coaches, an oval of track, controller and connection, complete in a distinctive box, and costs 55*s*. To maintain the correct outline and detail of the new "Southern Electric" the electric motor and reverser had to be entirely redesigned, the motor being incorporated in the front bogie of the coach and the reversing mechanism in the rear bogie. The result is most successful and the general appearance and outline most realistic.



The motor-coach chassis showing the motor and reversing mechanism.

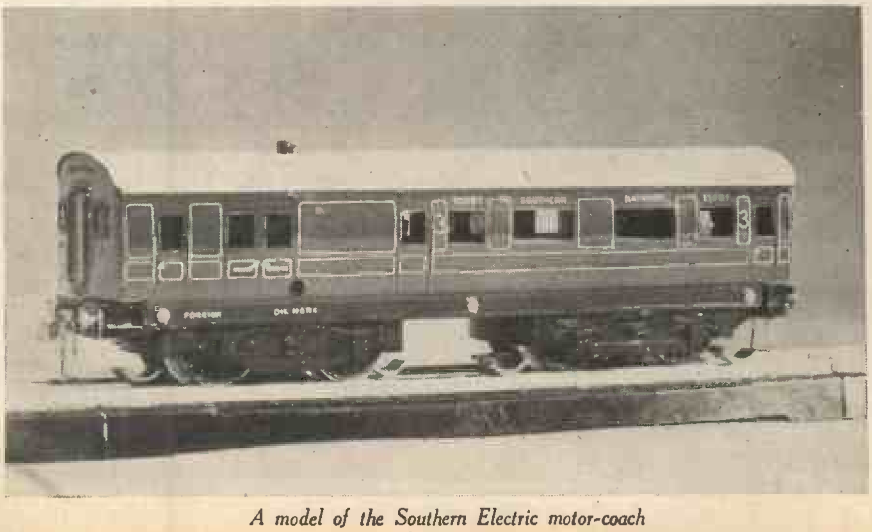
Restaurant Cars

Besides the 1st-class coach and the brake third supplied in the set, Messrs. Bassett-Lowke, Ltd., are also making Restaurant Cars and 1st and 3rd class Composite Coaches. All the vehicles are bogie ones fitted with automatic couplings, and are nearly 7 ins. long. The general arrangements are standard with the steam train sets now on the market, but this model is the first attempt to give a real scale appearance to the "00" gauge Twin Trains. The set is made up in an attractive box covered with green enamelled paper and a multi-coloured label specially designed by the Southern Railway Company.

Unique Trains

This is one of the most unique trains sets ever placed on the market and should do much to popularise the well-known electric system of the Southern Railway, which already has 1,396 miles of track electrified and 2,294 electric vehicles in service.

This fascinating model set is now obtainable from Northampton or from the retail Branches of Bassett-Lowke, Ltd., at 112, High Holborn, and 28, Corporation St., Manchester. All the leading toy dealers will also have this new line on show.



A model of the Southern Electric motor-coach

Fair Comment

The Theft of Cycles

TWO officers from Scotland Yard recently called at my office, not to arrest me as perhaps many of my enemies might wish, but to ask my assistance in drawing the attention of cyclists to the great increase in the theft of bicycles, and to ask their co-operation in making it easier for the police to restore those bicycles, when they are found, to their rightful owners. Thousands of bicycles are stolen every year, and in many cases once the thief has achieved the object of the theft, namely, to escape from the police, or to escape from the scene of another crime as quickly as possible, he abandons it.

In many cases the police are unable to identify the machine from the meagre description which the owner gives to the police in the district in which its loss is reported. It is of little use to tell the police that you have lost a B.S.A. bicycle. They probably have hundreds of them. It is necessary for you to give the frame number, description of the condition of the bicycle, and a list of accessories. A good deal of this trouble could be avoided if every owner of a cycle kept a note in his diary, and at home (to avoid any possibility of it being mislaid), of the frame number. Additionally, he should write his name and address and the frame number on a postcard, using ink or an indelible pencil, roll it, place it in the seat pillar tube and plug the end of the latter with a cork.

My associated paper *The Cyclist* has dealt with methods of foiling the cycle thief in recent issues, and I regularly receive letters from readers of it asking my assistance in the recovery of a bicycle which has been stolen.

The Army, the Navy and the Air Force

OWING to the shortage of recruits for the services I understand that conditions of service are to be made considerably easier in the future. In the past it cannot be denied that the Army and the Navy have not held out much attraction for recruits. You do not expect armchairs and feather beds when you join one of these services, but a good deal of the brusqueness of the Sergeant Major is unnecessary and has acted as a deterrent. A little power given to a man who has risen from the ranks will sometimes turn his head. The justice meted out to a private with a grievance has often been of primordial character. All that is to be changed, and those readers who are on the threshold of a career should bear in mind that both of these services offer excellent opportunities to men of the right physique who do not object to the necessary discipline and who are not squeamish. The Air Force is a branch of the service which in the future will probably become the senior service. The opportunities in the Air Force are numerous. I shall be glad to advise readers as to the best methods of entering any of these services.

The Truth

MY views are not necessarily yours, and it is quite possible, as I indicated when I started this feature, that you will disagree with me at some time or another. I mention this because a reader wrote to me the other day violently disagreeing with my remarks about inventors.

Letters from readers are always welcome, and I carefully read and reply to all of them. Those, however, who threaten to discontinue their purchase of the paper unless I publish more matter about a certain subject, or refrain from expressing criticisms leave me quite cold. It is the correct function of a periodical to criticise, to comment, and even to advise. At a period when it seems almost indecent to tell the truth, the press of this country is still a free press, though it may be muzzled in political directions. A technical journal is not fettered nor shackled in this way; and when you disagree with my point of view, it is always wise to remember that quite often I disagree with you!

Contributions from Readers

ON my desk is a note from a reader who wants to enter journalism. He thinks that by taking my advice and by my influence his entry to the street of ink could be rendered more easy than by treading the thorny paths of provincial journalism and encountering the hard knocks of adversity which are the lot of the struggling scribe. My advice is that there is no royal road into any profession, nor is there any reliable means of avoiding the drudgery from which valuable experience is gained. To those who aspire to write for technical papers I would say this: Get a job in a factory, become apprenticed, apply the knowledge you have gained at school, spend at least five years in this way, gain experience with a variety of firms, and then you will be able to write for the information of others. A youth of seventeen cannot be expected to do more than regurgitate the knowledge he has gained at school, and editors have no need to buy such material, which cannot bear the stamp of authority.

GALTON'S WHISTLE

BY V. E. JOHNSON, M.A.

WITH THIS TYPE OF WHISTLE IT IS POSSIBLE TO DETERMINE THE LIMIT OF AUDIBILITY OF THE HUMAN EAR

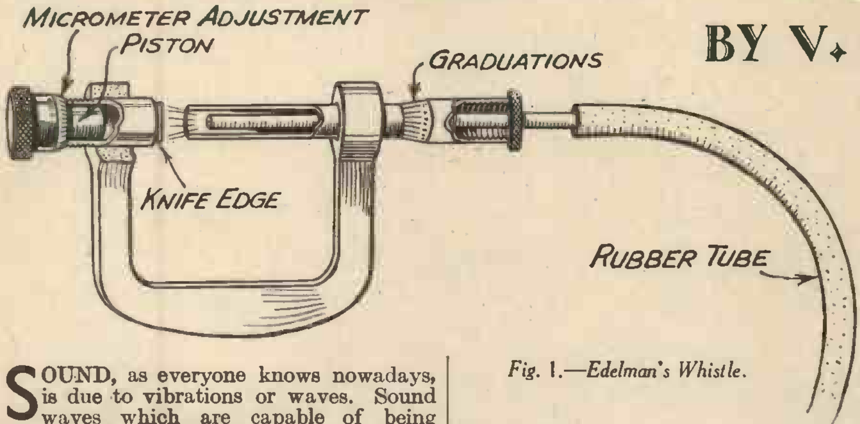


Fig. 1.—*Edelman's Whistle.*

SOUND, as everyone knows nowadays, is due to vibrations or waves. Sound waves which are capable of being heard by ordinary human beings range from about 60 to 40,000 semi-vibrations a second, whereas those undulations which we know as heat, begin at 65,000,000 vibrations, whilst visible colours range from 400 to 900 trillions.

Let us consider, very briefly, the compass of the notes given by one of the best known musical instruments—the organ—which occupies the whole field of audible vibrations, nearly 10 octaves; the piano has about 7 octaves. The pipes in an organ vary immensely in both length and breadth, and a Galton's whistle is nothing more or less than a minute organ pipe.

For special purposes, pipes have been constructed varying in length from 20 metres to 0·5 millimetres and in frequency from 8 p.p.s. to 100,000 p.p.s.

Now the limit of audible sound vibrations vary considerably in different people, many people being incapable of hearing the chirp of a grasshopper or the twittering of sparrows, whilst there are others who claim to have heard specially constructed tuning forks giving vibrations of about 70,000 a second. These intensely shrill notes produce an undefinable uneasiness in a person which lingers for some time. There is little doubt that some animals hear sounds quite inaudible to human beings. Human audibility also varies with age.

Pure Notes

In experimental acoustics, first importance attaches to those sources of sound which emit pure notes, consisting of a single fundamental tone unaccompanied by harmonics or overtones (see Fig. 2). The flute and diapason pipes of an organ give the nearest approach to purity. Tuning forks, when vibrating in their simplest manner, give remarkably pure notes, and another extremely good example is an ordinary tin whistle.

Galton's Whistle

In order to determine the limit of audibility in human beings and as far as possible in animals, Galton devised a miniature organ pipe in the form of a whistle provided with certain adjustments, blown by means of a rubber pressure ball similar to that used on scent sprays (see Fig. 3).

Experiment with Whistling Kettle

If you happen to possess a whistling kettle try the following experiment. Half-fill the kettle with water and place it on a gas-ring, with the gas turned half on, and leave it until the kettle is whistling shrilly. Then slowly turn the tap full on, noting the rise in note until it becomes quite inaudible. This experiment will illustrate, in a very intensified form, what you actually hear with a Galton's whistle

A Very Simple Type of Galton's Whistle

Obtain an ordinary penny tin-whistle—it must be one that whistles with all the holes closed. Cut the whistle in two, just above the top hole, and discard the bottom half. Next, take a piece of metal rod which will just go in the bottom (unfortunately these whistles are slightly tapered) and push it into the whistle, blowing gently and evenly through the whistle at the same time.

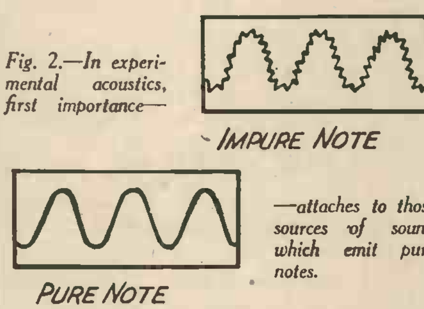


Fig. 2.—In experimental acoustics, first importance—attaches to those sources of sound which emit pure notes.

It will be found that the note rises as the column of air is shortened.

Now construct a similar whistle, somewhat longer, out of tin, copying the whistling production part of it. The whistle must be the same bore its entire length, and you will now be able to push a close-fitting *metal* rod up it as far as the whistling aperture. You will now have a true Galton's whistle in its simplest form, more especially if the bore of the cylinder is not *more than* a quarter of an inch—the less the better. Now fit a piece of rubber tube and two rubber balls, one of which should be enclosed in netting (see Fig. 3). Next fit on to the end through which the moving piston travels, a screw piston and a micrometer gauge and you can measure the length of the column of air and the pitch of the note depending on it.

The instrument as thus described can be purchased from scientific instrument makers for a little under a pound.

An improved instrument with a much finer tube and capable of going in a case which would fit in a waistcoat pocket and fitted with a scale, showing the pipe length and frequency, can be purchased for two pounds.

You can graduate your micrometer as you like, but usually it is, I think, graduated in centimetres (the distance between two consecutive threads on the piston screw) and millimetres, *i.e.* ten divisions on the turning head.

The best way of calibrating a Galton's whistle is probably by means of what is known as the Cathode-ray oscillograph for which see *Newnes Television and Short Wave Handbook.* If the whistle be used with a standard air pressure, you can obtain reproducibility in the pitch of the note emitted, provided the temperature remains or is kept constant. Sounds above human audibility can be detected by means of the sensitive flame method.

Edelman's Galton's Whistle

This very scientific whistle is a type of small organ pipe consisting of a very short cylindrical pipe with a sharp edge, upon which is directed a blast of air from an annular nozzle. The pitch of the note can be varied by moving a piston at the closed end of the pipe—by means of a micrometer screw shown on the left in Fig. 1. The distance of the nozzle from the pipe requires adjustment to suit sounds of varying pitches and the micrometer on the right is used for accurately setting this position. So far as human audibility is concerned only a few nozzle settings are necessary.

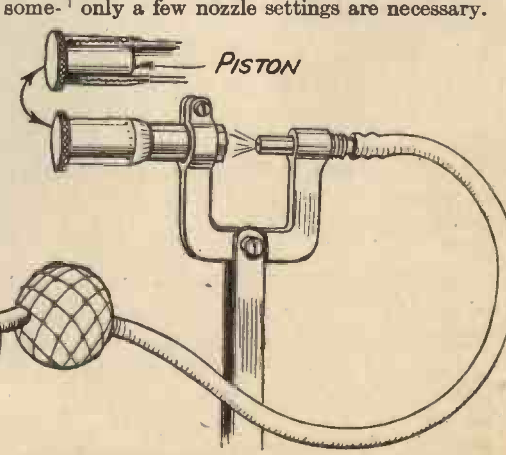
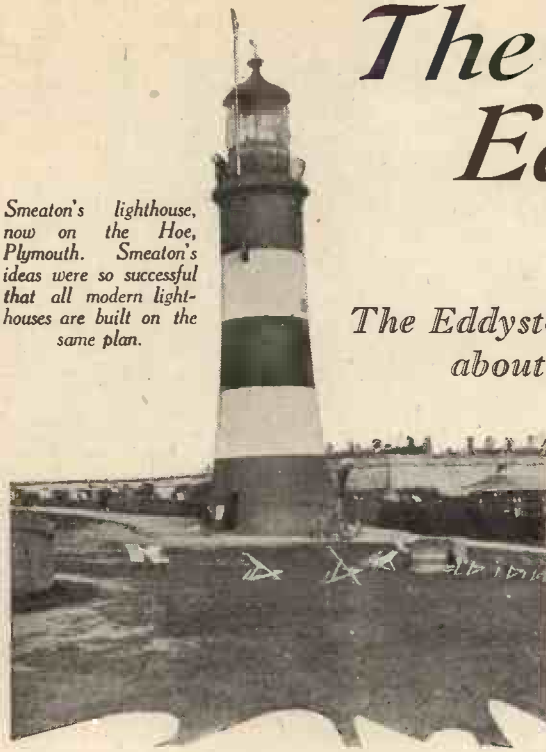


Fig. 3.—Galton's miniature organ pipe in the form of a whistle which was blown by means of a rubber bulb.

The Conquest of the Eddystone Rock

By G. Long, F.R.G.S.

The Eddystone is the highest summit of a vast Reef of Rock, about Fourteen Miles South-west of Plymouth



Smeaton's lighthouse, now on the Hoe, Plymouth. Smeaton's ideas were so successful that all modern lighthouses are built on the same plan.

THERE are few more splendid examples of human skill, courage, and inventive genius than the building of the Eddystone lighthouses. The work was one of enormous difficulty and danger, and, even when completed, disaster again and again overwhelmed the slender tower in the midst of the waters, but in spite of this there has been a warning beacon on this deadly reef for nearly three centuries, and thousands of lives have been saved thereby.

The Eddystone is the highest summit of a vast reef of rocks, which lies in deep water right in the track of shipping, about fourteen miles south-west of Plymouth.

When the wind blows up the Channel these rocks become the centre of a frightful vortex of raging waters from which no ship could hope to escape. The need for a lighthouse was fully understood for many years before a man could be found with the skill and courage to build one.

Difficulties

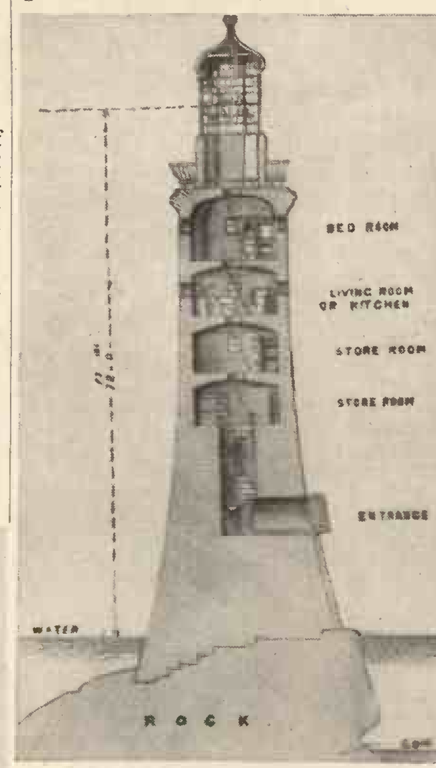
The difficulty was twofold. The lower part of the tower had to be built below high-water level, and even at low water the rocks are swept by rollers which completely cover it, so that the workmen had to wear life belts, and cling to iron stanchions for dear life. Only three hours' work a day is possible at this stage of the work, and that only in very calm weather. If in spite of all this the foundations were successfully laid, they would immediately be subjected to a stupendous battering from the waves. Great waves rush in at a speed of sixty miles an hour and exert an enormous pressure on the work. On the coast of the mainland a pressure of three and a half tons to the square foot has been recorded, and there is reason to think that this tremendous figure has often been exceeded on the exposed Eddystone reef.

The first of the Heroes of Eddystone was Henry Winstanley, a country gentleman living at Littlebury, Essex. He was an amateur scientist, and an eccentric genius who loved practical jokes, as his friends knew to their cost. A guest kicked an old slipper on his bedroom floor, and immediately a ghost rose before him. In another room there was a trick chair, which flung out its arms and held fast the visitor who sat in it. It was no doubt owing to this eccentric twist in his character that we owe the remarkable shape of Winstanley's Lighthouse, which, as can be seen in the illustration, is more like a Chinese pagoda than anything.

Started in 1696

He started in the summer of 1696, and succeeded in fixing twelve iron tie-rods in the rock before the autumn gales stopped all work. The next summer a solid, round pillar was constructed, 12 ft. high and 14 in. in diameter, and bound to the tie-rods. In the third summer the pillar was enlarged by two feet at the base, and carried up to a height of sixty feet. Supposing that this was lofty enough for safety, Winstanley and his men determined to remain on the tower to finish the work, but the waves rose to the summit of the tower, so that they were almost drowned and their provisions were all spoiled. They were rescued eleven days later. The fourth year was spent in enlarging the structure, but its wide, open galleries and fantastic projections could not resist a great gale. In spite of this it stood for seven years, and the builder was so proud of his work and so confident in its strength that he rashly said he would like to be beneath its roof in the greatest storm that ever blew.

Winstanley's lighthouse, which, as can be seen, is rather like a Chinese pagoda.

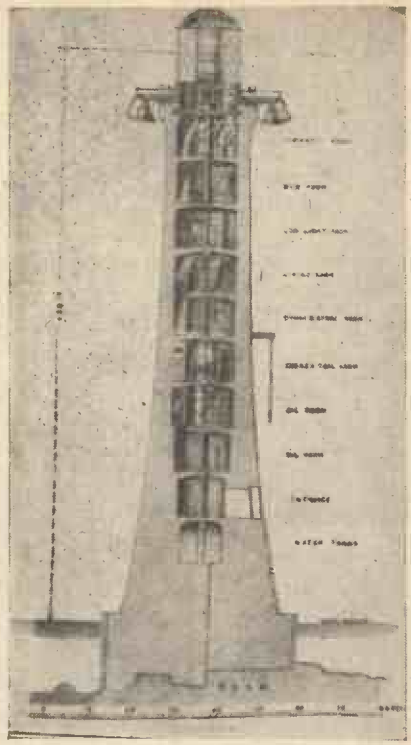


A section of Smeaton's lighthouse.

His wish was fulfilled in November 1703. A frightful gale raged all night, and Winstanley and the keepers were swept away. No vestige of the tower remained.

A Constructive Genius

Three years later John Rudyerd began another. Although he was a silk mercer by trade, he seems to have been a constructive genius. He determined to build a tower which should offer as little resistance to the wind as possible, so instead of a polygon he chose a circle for his plan and made the exterior of the tower quite smooth. It was 92 ft. high and took four years to build. Instead of twelve tie-rods he had thirty-six, each sunk from twenty to thirty inches deep in the rock. The rods were perforated with holes, 252 in all, by which they were clamped to the timbers with jagged spikes. The lower part of the tower consisted of oak beams and courses of stone, all joined to each other by iron clamps. The upper part was all timber.



A section of the present Eddystone lighthouse.

Rudyerd's Lighthouse was an absolute success so far as resisting the winds and waves was concerned, but it was destroyed by another element—fire.

It was completed in 1709, and in December 1755 the top of the building caught fire through some mishap with the candles used for lighting. The keepers tried to extinguish the flames with buckets of water, but it is no easy task to carry water to the top of a ninety-two-foot tower. They were driven down stage by stage, and finally had to get on the rock, whence they were rescued by a boat which put off from Plymouth when the fire was observed. One of the keepers died twelve days after, and when a post-mortem examination of his body was made, a mass of lead weighing nearly half a pound was found in his stomach. He had swallowed the molten lead when trying to put out the fire.

John Smeaton

The third lighthouse on the Eddystone Rock was built by John Smeaton, and work began a year after the second had been destroyed. Smeaton decided that the two previous towers had been deficient in weight, and he announced his intention of building a tower so solid that the seas should give way to the lighthouse, and not the lighthouse to the sea. Also it must be fireproof, and so would be built of *stone*.

It might be mentioned that Smeaton's ideas were so successful that all modern lighthouses are built on the same plan. When working out his design he kept before his mind the outline of a stately oak tree.

Every foundation-stone was dovetailed to the rock and also to its neighbours, and as the courses rose every stone was locked to its fellow and a hard plug of marble projected into the course above. As the foundation and lower part of the tower were constantly swept by waves before the cement could dry, Smeaton's greatest fear was that the cement might be washed out of the joints before it could set.

He overcame this difficulty by two clever ideas. In order to make certain that no stone could be moved by the utmost force of the waves, he inserted a number of oak wedges in grooves between the stones, which when wetted by the sea-water would lock everything solid. All joints were filled up with cement and covered outside with plaster of Paris, which set hard quickly and kept the water out of the cement.

During the first summer nine courses of masonry were laid, and at the end of the next the solid part of the tower was completed, 35 ft. above the base.

The whole job was finished during the fourth summer, the lantern being 72 ft. above high-water level.

Smeaton had three narrow escapes during the progress of the work. Once he was nearly drowned when his boat was caught in a tremendous storm, once he fell over the rock and dislocated his thumb, and finally he was almost smothered. A charcoal fire was being used within the tower for melting lead, and Smeaton was overcome by the fumes. Fortunately his men found him, and dragged him into the open air, where he was revived with buckets of cold water. Smeaton's Lighthouse still stands, but it is no longer on the Eddystone Rock.

Rocked Dangerously

It successfully resisted the wind and waves till 1882, when it had become unsafe through the undermining by the waves of the rock upon which it stood. The tower remained solid but the rock was breaking away, and the lighthouse rocked dangerously in gales.

A bigger and better Eddystone Lighthouse was then built by Mr. J. N. Douglas, Chief Engineer to Trinity House, who had already built the magnificent "Wolf," and "Bishop" Lighthouses. Mr. Douglas had the advantage of working in the age of steam machinery, and so easily surpassed Smeaton's great achievment.

The new Eddystone Lighthouse contains 2,171 stones; that is, 4,668 tons of masonry. Smeaton's contained only 988 tons, and had four living-rooms. The new tower has nine living-rooms, each larger than those on the old tower, and is 130 ft. high, as against 70.

A sketch showing Smeaton's lighthouse and its successor—now on the Eddystone.

Lighting Facilities

Electric light was proposed, but was rejected because it was thought there was insufficient space for the engines and dynamos, and it was feared that the vibration would endanger the tower. Oil lamps were installed in 1882, with an illuminating power of 250,000 candles, or about six thousand times as much as Smeaton's original light.

If we stand on Plymouth Hoe to-day and look far out to sea, we can on a clear day see the slender pencil of the New Eddystone rising above the water, and if we turn shorewards we can see Smeaton's old lighthouse, standing on the historic Hoe. The lower part, or solid stump, remains on the reef, but the upper part has been carefully rebuilt on shore, and is a favourite venue for visitors, who can climb to the top for a penny and see for themselves how magnificently the stones have been dovetailed together, so that after nearly two centuries it is as solid as when it was built.

RELIABLE STOP WATCHES

STOP watches are so useful in almost every sphere of activity—wireless, motoring, flying, turning, racing—that it is a wonder that more people do not own them. If you develop the stop-watch habit you will increase your knowledge and can give reliable information about speeds and times instead of making wild guesses.

One of the stop watches in the Arnold range.

The speedometer of a car is not the most reliable means of testing accurately the speed of a car, the distance it takes to pull up, its rate of acceleration, but a stop watch in infallible. Because of this we should like to draw the reader's attention to the fact that A. Arnold & Co., 19 Clerkenwell Road, London, E.C.1, is a specialist in stop watches of all types, sizes and prices, from a few shillings to several pounds, in chrome, nickel, silver and gold, for the wrist or the pocket, and in a variety of case styles.

It is always wise to deal with a specialist. You cannot expect to buy a reliable stop watch at a general stores. The firm mentioned have been specialists for many years in all types of timers, from the simple stop watch with or without fly-back, to complicated split-seconds chronographs with Kew A certificates costing several pounds. They supply a variety of dials for various purposes—sports, mechanical, dog racing, medical, etc., accurately calibrated for the purpose required. Whatever stop watch you require A. Arnold & Co. have it. Drop them a line at the address given, and explain your requirements. They will send you illustrated lists and a quotation by return.

MASTERS OF MECHANICS

No. 18. A Romance of the Weaving Industry

The True Story of Joseph Mary Jacquard, Originator of the Jacquard Loom

HAVE you ever stopped to wonder how the highly complicated and many-coloured designs which are woven into textile materials of all descriptions are produced by mechanical means? Time was when the weaving of a design into cloth meant the expenditure of a truly enormous amount of hand-labour and, with the best will in the world, a hand-weaver and his necessary two or three assistants could only weave a design of a very simple and restricted pattern into cloth.

Nowadays, woven fabrics of silk, cotton, wool and other materials can be obtained with all varieties of complex designs woven into them. Such materials are turned out mechanically by means of Jacquard looms, or, as the latter are more simply termed in the Lancashire weaving towns, "Jacquards."

A Jacquard loom is really not a loom at all. Rather it is a mechanical contrivance which is mounted over a weaving loom and which, by modifying the automatic operations of the latter, causes a pattern of a predetermined design to be woven into the cloth which is turned out by the loom.

Many Different Patterns

"Jacquards" are nowadays of many different patterns, and since the recent introduction of mass-scale artificial silk and rayon weaving they have tended to become still more complicated in mechanical design. Nevertheless, their fundamental principle remains the same in all cases.

It is not easy to explain the precise working of the present-day "Jacquard" in merely a few words. The reader, however, will doubtless be aware of the fact that in ordinary or "plain" weaving the shuttle (which carries the "weft" or crosswise thread of the fabric) is caused to pass under alternate strands of the "warp" or lengthwise threads of the fabric which, in the modern loom, are mechanially raised for this purpose. If, however, we arrange matters so that not all the alternate "warp" or lengthwise threads of the fabric being woven are raised at the same time, but only some of them, it will be obvious that a pattern will be formed in the finished material.

A Series of Cards

This is precisely the operation which the Jacquard attachment to the loom performs. A series of cards bearing perforations are passed through the Jacquard portion of the loom. These perforations cause a number of wires to be raised automatically and the wires, having hooks at their lower ends, raise the "warp" threads of the material which is being woven. The shuttle passes under these raised threads. Consequently, a design is woven into the cloth, the design being determined by the exact number and arrangement of the perforations in the card.

A player-piano does much the same thing, but, of course, instead of translating an arrangement of perforations on cards into a woven pattern, it converts a perforation "design" on a roll of rough paper into audible sounds.

In the Jacquard loom, the necessary perforated "cards" are all fastened together to form an endless band. The passage of all the cards through the Jacquard attachment to the loom causes the complete design to be woven into the cloth. Since, therefore, the Jacquard cards form an endless band when passing through the loom,

Joseph Mary Jacquard, from a portrait in the Town Hall at Lyons.

it follows that the design is repeated on the woven cloth again and again until the loom is stopped. The woven design is produced entirely automatically, at a high speed, and more or less infallibly, since only an injury to the Jacquard "card" can interfere with the correctness of the woven design.

The inventor of this simple and almost fool-proof system of mechanical pattern weaving which is now in universal employment was a poor man of Lyons, in the south of France, Joseph Mary Jacquard, by name. He was born at Lyons on July 7th, 1752, and he died near that famous town on August 7th, 1834, in a humble cottage of his own choice.

Poverty

Jacquard's parents were poor country folk, who had come into Lyons to pick up a living by silk weaving. At the age of twelve the young Jacquard found himself placed in a bookbinder's workshop and under the severe necessity of having to earn his own living. He had had little education. True it was that he could read a little and could manage to write his name and tot up figures, but the spectre of dire poverty had walked more than once through the Jacquard home, with the result that the youthful Joseph Mary (the feminine "Mary" was—and still is—not infrequently applied to male children in Latin countries), had found the task of learning how to assist at a silk-weaving loom of far more urgency than that of imbibing the art of the alphabet.

One of the characteristics of inborn genius is that it will grow and find an outlet under the most unfavourable conditions. It was thus with Joseph Mary Jacquard. Doubtless, also, his early training in hand-loom manipulation which he received from his parents accentuated his natural mechanical ability not inconsiderably. The young Jacquard quickly showed an intense love for mechanics and for all constructional matters. In his childhood days he amused himself for hours on end by building up houses, castles and other quaint models out of cardboard and brown paper. Then he would make carts with wheels and put model horses between the shafts, and finally he tried his hand successfully at the construction of simple types of mechanism.

When Jacquard left the bookbinding establishment to take up a job with a firm of printing-type makers, we are told that he invented a number of useful tools for the making of types, a fact which stresses the originality of mind of the youngster.

Jacquard was not very old when his father died. A year or two later his mother died, also, and he was left an orphan with practically no means.

A Failure

At this time, he fitted up for himself a workshop complete with two or three second-hand hand-looms, and therein he tried to run a business in the weaving of silks. The business failed, however, and, to make matters worse (or was it better?) Jacquard had by this time managed to fall hopelessly in love with a pretty young girl from the surrounding country.

The young pair decided to face the stern realities of life together. They married, and, perhaps, it was the best thing they ever did, for, although poverty and distress still came their way, Jacquard and his wife assisted each other mutually, and in the end fought their way to success.

The first thing Jacquard did after getting married was to drift into a condition of almost hopeless penury. After many trials he managed to get a job as a labourer in a neighbouring lime works, and his wife helped matters on considerably by making straw hats at home, and afterwards by opening a shop for the sale of them in Lyons.

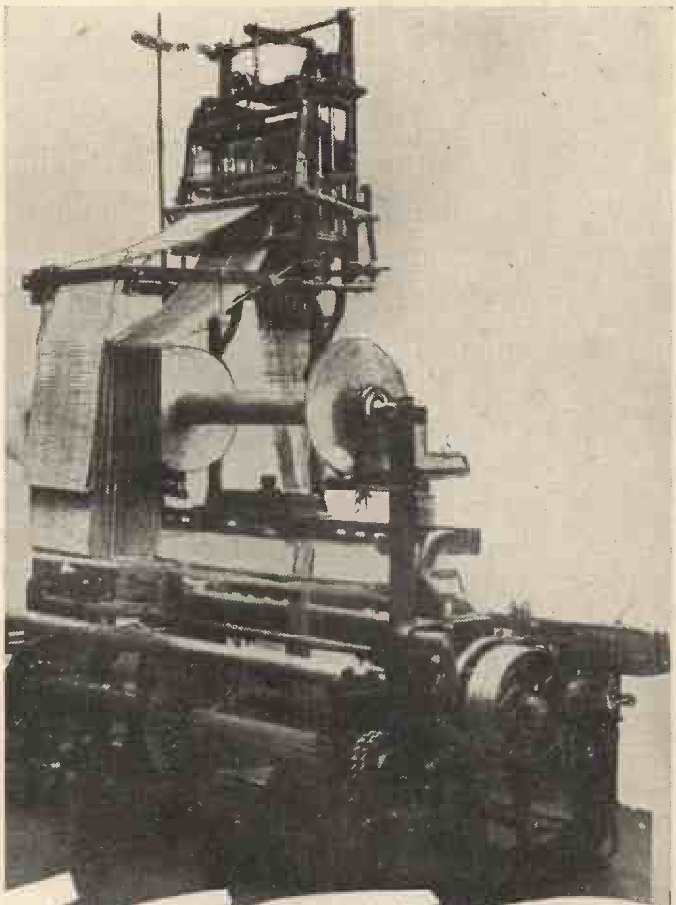
And so the years passed on. Jacquard still, in his spare time, worked away at mechanical hobbies, his one object being to invent a mechanical loom which would revolutionise the system of weaving silk, which was then employed at Lyons. He dreamt of great inventions and of comfortable affluence, but they were, at the best, dreams, and he found that they led him nowhere.

The French Revolution

Then, with dramatic suddenness, the French Revolution broke over Europe. The Reign of Terror came upon the fair land of France, and Jacquard, together with his seventeen-year-old son, found himself a soldier. His son was killed, and when peace came once more upon the country, Jacquard made his way back to Lyons as best he could to find his wife, now utterly impoverished, still toiling away at her straw-hat making, in an old and wretched garret in the town.

It was at about this time that Jacquard saw in a newspaper a paragraph in which it was stated that the Society of Arts of London offered a substantial prize for any persons who could produce a machine for the weaving of fishing nets. This announcement stirred up the old desires within Jacquard. Somehow or other, he gathered a few materials and tools together and settled down to the invention and construction of such a machine. Eventually he succeeded at his task. His machine some time afterwards found its way to Paris, where it attracted much attention. The great Napoleon got to know about it, and he summoned Jacquard to Paris in order that he might see what sort of a fellow this unknown Lyons weaver might be.

Napoleon instructed the Director of the Conservatory of Arts and Trades in Paris to find workshop accommodation for Jacquard in the Conservatory buildings. Here Jacquard was set to the task of constructing a larger model of his net-weaving machine. It was whilst he was on this job that he one day had the opportunity of closely examining an elaborate machine which was being used for the weaving of a highly patterned shawl for the use of the Empress Josephine, the wife of Napoleon.



A modern Jacquard pattern-weaving loom. Note the series of perforated " cards" upon which the woven pattern depends.

An Expensive Job

" Rather an expensive job that, Sir," exclaimed the shrewd Jacquard to the Conservatory Director, after examining the machine.

" As a matter of fact, it is," replied the official, " that shawl has cost us twenty thousand francs already."

Jacquard whistled, " Twenty thousand francs! Why, over in that corner are some bits of things which I could make into a machine to do the job at a cost of less than five hundred francs."

The Director of the Conservatory of Arts and Trades was an indulgent person. Perhaps he thought that twenty-five thousand francs *was* too much to pay for the weaving of a silk shawl, even though it was to be worn by she who was said to be the most beautiful woman on earth. At any rate, Jacquard was given *carte blanche* in the Conservatory workshops, and within a few months he had produced his first pattern-loom, the world's first simple mechanical device for automatically weaving a pre-determined pattern into silk or other fabrics and the contrivance upon whose basic principle the operation of all the present-day " Jacquards " are essentially based.

Jacquard's first loom was but a crude affair of wood, iron and cardboard, but it worked and, what is more, it worked reliably and successfully.

Thus result of it all was that Jacquard returned to Lyons with a pension of a thousand francs, a pension which was subsequently raised to six thousand francs. Although, however, Jacquard had apparently achieved one of his life's ambitions and had become a successful inventor, he was still to face further severe trials. The population of Lyons rose up in anger against him just as, in England, gangs of workers revolted against the introduction of machinery and mechanical devices into industrial processes and operations.

A Ten Years' Free Patent

The operatives of Lyons wrecked all Jacquard's machines, burned his house and even threatened his life. In sheer terror he had to fly from the town. But the Municipal Council and the Chamber of Commerce at Lyons were Jacquard's supporters and, at length, the popular prejudice against the inventor was overcome. Jacquard settled down to the making and erection of his pattern-weaving looms. He obtained from Napoleon a ten years' free patent for his invention and, at his modest request, a royalty of fifty francs on each machine he built.

Said Napoleon as he signed the royalty document for the inventor: " Well, here, at least, is one contented individual who is satisfied with little ! "

Satisfied with Little

Napoleon's observation was a correct one. Jacquard, indeed, *was* satisfied with little. He chose to live in a small rural cottage at Oullins on the outskirts of Lyons, and it was in that abode that he eventually ended his days. In vain the rich cotton manufacturers of Manchester and of other Lancashire towns begged and entreated Jacquard to forsake his Lyons' citizenship and to come and settle down among them, sharing with them the benefits of his invention.

Perhaps such appeals were based upon "spider-and-fly" principles. Perhaps, on the other hand, they were not. At any rate, the fact is that Jacquard, as the saying is, " was not having any." Having achieved most of his ambitions, having attained a moderate competence, he retired from his active labours, and the world at large heard no more of him.

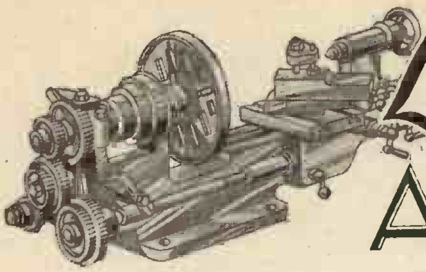
Memory Still Cherished

Even to this day surprisingly little has been written in the history of invention concerning the strange, eventful life-story of Joseph Mary Jacquard and the creation of his pattern-weaving loom. But there is one little spot on the face of the globe in which his memory is still cherished. It is the town of Lyons. There, in this justly famed silk-producing neighbourhood, the name of Jacquard is held in high honour, and deservedly so, for the epoch-making invention of this truly modest and humble genius has contributed wealth untold as well as additional fame to that noted French town.

On the roll of mechanics and inventors, Joseph Mary Jacquard occupies a high place. His pattern-weaving loom, although based upon simple principles, is a complicated piece of mechanism, even in its earlier forms, and there is no doubt of the fact that in those early and troubled days, before mechanical and constructional principles had obtained for themselves a scientific basis, no other mind than that of a genius could have conceived and no other hands than those of a born mechanic could have worked out the fundamental idea upon which every Jacquard-operated loom in the world, no matter how complicated its modifications may be, is basically constructed.

Acids from Vegetable Fibre

SUGAR is being produced from wood in Germany, and within the last year a big factory has been built in the East End of London for the production of citric and tartaric acids from vegetable fibre. These acids are, of course, used to meet the needs of the fruit drink industry and the manufacture of baking powders, amongst other requirements. The firm concerned formerly met the whole of their demand by treating wine lees. The advance is a notable one for biochemistry (the chemistry of living organisms), which in the next few decades is going to make discoveries outrivalling those of organic chemistry in the last century.



Lathe Work FOR AMATEURS

MACHINING A CRANKSHAFT

MANY mechanics find a difficulty in machining the crank pin journal of an engine crank-shaft. The following method will be found accurate and effective without the need for any more special jigs than are absolutely necessary.

The first process is to turn the main shaft itself and its bearings. When mounted between centres for this operation the pressure of the centres and the turning tool have a tendency to spring the crank out of line. This is shown exaggerated in Fig. 1. The two throws, *A* and *B*, tend to close towards each other at the crank gap at *C* with the result that the main journals *D* and *E* will be out of line with each other when the crank is released from between the centres.

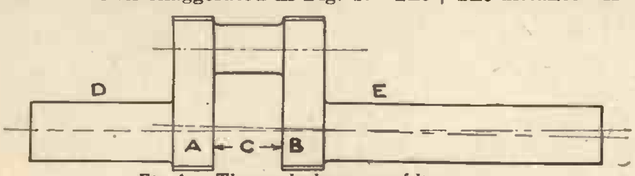


Fig. 1.—The crank shown out of line.

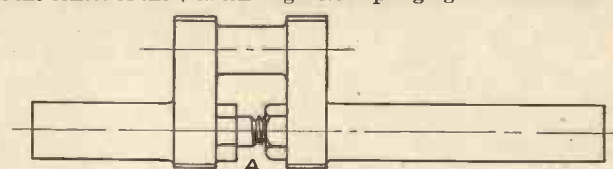


Fig. 2.—The crank should be packed as shown.

The Crank should be Packed

To obviate this, the crank should be packed as in Fig. 2 between the throws or webs and a suitable packing will be a large nut and bolt, the head of the bolt and the face of the nut being turned flat so that the pair fit snugly between the crank webs, as shown in Fig. 2. The bolt and nut should be of good size and should be adjusted so as to put no strain on the crank webs. The pressure of the centres should be light, and to prevent the bolt and nut falling, their faces and the inside faces of the web may be tinned and the lot heated with a blow pipe sufficiently to melt the solder and hold the bolt and nut from slipping.

This should be done with the crank inert, i.e. with no end pressure on it. Afterwards it may be mounted between the centres and can be tightened (if and as, it gets loose in wearing on the centres) by the back poppet hand wheel in the usual way as if it were a solid bar between the centres.

The crank-shaft should be finished, at this first chucking, on the journals and on the end faces of the webs. The rounding each side of the webs should be completed for the bearing, and any reduction at the ends or threaded portion for flywheel, pulley, etc., turned down and screw cut.

The crank is now ready for turning the crank-pin. Two iron bars cut from a bar of rectangular (not square section) are prepared. They may be of rough stuff, but of good substantial section. One of these is shown in plan and side view in Fig. 4. The distance "*A*" between the centre of the hole *B* for the crank-shaft, and the centre of the countersunk hole for the lathe centres should be exactly the length of the throw of the crank to be machined.

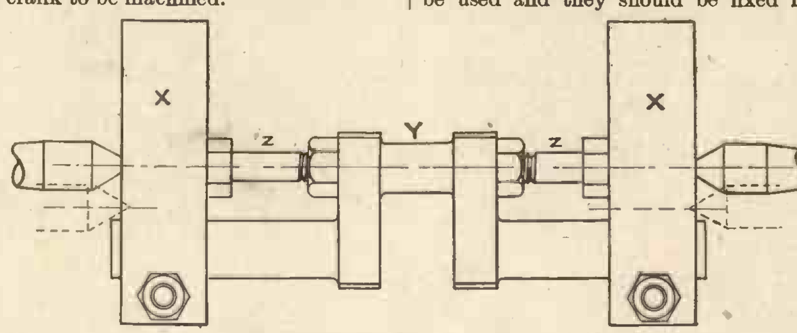


Fig. 3.—The crank ready for chucking.

Aligning the Crank

The hole *B* should be just a fraction under the crank diameter at its end. One may have to be smaller than the other according to the design of the crank ends. The part *C* which projects on the side opposite the crank-shaft hole, should be as long as the lathe will swing, so that the two bars will, as near as possible, balance themselves. The bars are attached to the crank-shaft ends by clamping them on the shaft by the nuts and bolts *D* and *E*, and the rig will then be as shown in perspective in Fig. 6.

To ensure alignment of the crank, the first thing is to ensure that both bars are alike, and to make sure of this they should be drilled while clamped together making sure that the drill is square with the face of the metal.

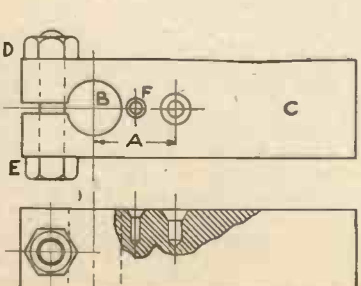
To ensure that the centre on the bars (by means of which the shaft will be centred in the lathe to turn the crank journal) are in line, the lot assembled should be laid on a surface plate and a scriber should be used standing on the plate and registering against the centre holes in the ends of the crank-shaft, and with this, a line should be scribed on the outside of the crank webs packing these up on the surface plate so that the scriber scribes a line along the centre of the webs, this line being as *A-B* in Fig. 5.

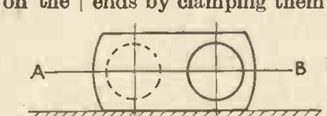
The clamps screws on the bars should then be fully tightened up using a drop of oil on the threads of the bolts to ensure getting a good grip, but seeing that no oil gets on the crank where it is clamped in the hole in the bars.

Springing of the Crank

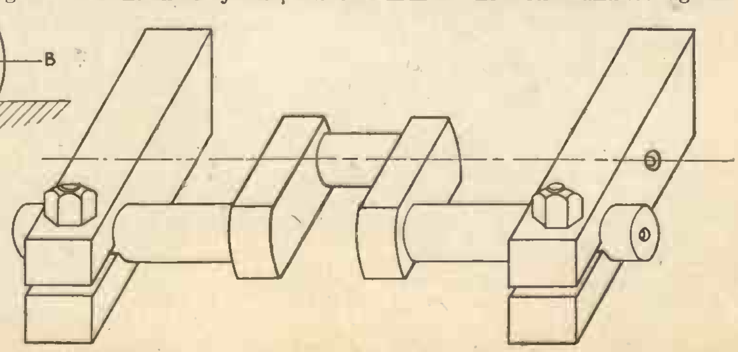
Then the same precaution should be taken against springing of the crank between lathe centres as was taken when turning the main shaft and journals. Longer and bigger bolts Z and Z nuts should be used and they should be fixed in the same way.

The crank will now be as in Fig. 3, and ready for chucking between centres for turning the crank journal. Before actually chucking it between centres pack it up on the surface plate with the crank up and with the scribing block test that the crank shaft ends are the same distance from the surface of the plate all along. Then turn it a quarter turn so that the crank webs on the bars *X X* are horizontal and test again.





Figs. 4 to 6.—(Left) A plan and side view of one of the crank-pins. (Above) Details of the webs. (Right) A prospective view of the rig.



Then it may be chucked between centres and the crank journal *Y* turned to size and with rounded shoulders and the insides of the two crank webs or throws faced. If a nice finish to the ends of the crank-webs is desired, mark a centre on the line on which the centres are marked on the ends of the bars *XX* equal distances from each, drill a centre hole here, and countersink it, in each bar as at *F* in Fig. 4, and then, the whole rig being as in Fig. 3 mount it between centres and turn the ends of the crank webs so that they appear as in Fig. 7 where *A* is the new centre on which the whole rig is chucked (shown dotted in Fig. 3) and the curves *B* and *C* are the new turned finish to the ends of the crank webs.

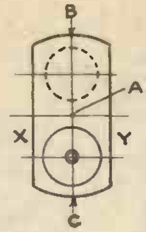


Fig. 7.—The ends of the crank webs.

It will be seen that the whole of the machining of the crank-shaft has been done in the lathe except the front and back faces *X* and *Y* in Fig. 7.

If the crank-shaft is small enough to be swung on the face plate of the lathe, with the gap-piece of the bed removed, these faces can be machined by clamping the crank flat against the face plate and facing (surfacing) one side, then reversing it and facing the other. The result will be a completely machined crank with no hand work upon it at all.

AN ADJUSTABLE BORING BAR

A DEVICE FOR BORING EXTREMELY ACCURATE HOLES

WHEN boring very accurate holes—such as the bores of small steam cylinders, pumps, etc.—an adjustable boring bar mounted between the lathe centres and passing through the cored or roughly drilled hole is found to give the best results on small work and where an horizontal boring mill is not available.

The work is bolted down on the saddle with the axis of the bore coinciding with the axis of the lathe centres and the boring bar, driven by the headstock mandrel, is rotated while the work is fed up by the saddle feed. The drawing shows an adjustable bar, *A*, with interchangeable cutters *B B* shown in edge view at *J*, below. These cutters are made of $\frac{1}{4}$ in. cast steel plate to the shape shewn and fit in a $\frac{1}{4}$ in. slot bored and filed in the bar central with its diameter. For smaller and larger bars the cutters will be thinner and thicker respectively. Quarter inch is suitable for a 1 in. bar, $\frac{3}{16}$ for a $\frac{3}{4}$ in. bar, and $\frac{3}{8}$ in. for $1\frac{1}{2}$ in. bar. The size determined on, will be the size most suitable for the type of work in hand. With the 1 in. bar shown, the minimum size bore which can be made is $1\frac{7}{8}$ in., and the maximum $2\frac{3}{8}$ in., using the cutters shown. But with sets of wider cutters bores up to 3 in. may be machined; cutters of varying width being provided in steps of $\frac{7}{16}$ in. which will allow an overlap in size between one set and another and an allowance for grinding.

Shape of the Cutters

The shape of the cutters and the cutting angle is shown in the drawing and the edge view of one of the cutters below. The cutters are held in the slot at one end by the sleeve *G* which pushes over the bar and is located by the taper pin *H* passing through both. The other ends of the cutters are held by another sleeve *D*, which screws along a thread on the outside of the bar *A*. The end of this sleeve has a flared interior—cone shaped—which engages with the ends of the cutters. By moving it to the right by screwing it along the bar, the cutters can be expanded outwards, and both, of course, equally. To hold the cutters firmly in the outward position, and to the effective cutting diameter determined by the position of sleeve *D*, the internal cone ended spindle *C* is provided. This has a screw thread at the end *E* which engages with an internal thread inside the bore of the bar. A slot at the end allows this spindle to be screwed forward or backward in the bar.

The effective diameter of the cutter's cutting edges *K K* having been set, by the position of sleeve *D*, the spindle *C* is screwed up and the taper end is thus forced between the two cutters and wedges them firmly in the taper end mouth of the adjusting sleeve *D*.

Fine Adjustment

An extremely fine adjustment can be made by slightly slacking *D* and tightening *C* which will increase the cutting size; while similarly, by slightly slacking the spindle *C* and tightening up the sleeve *D*, the effective diameter will be decreased.

In order to provide a good surface centre for the end of the bar and also to allow access to the slot in the end of spindle *C* for adjustment the steel plug *F* is fitted at the end and made a good fit in the internal thread in the bar facing up to a faced surface on the end of the bar. This is removed to make the size adjustment by a screw driver in the slot in the end of the spindle *C* and *E*.

The Bar

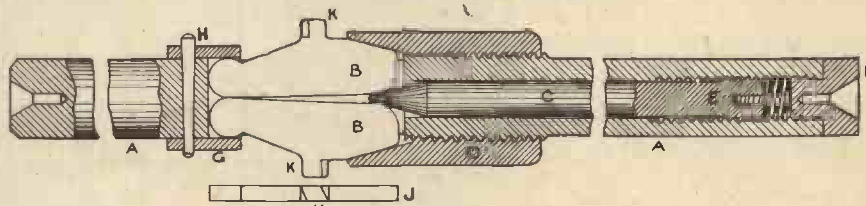
The procedure in making the bar is to take a piece of Bessemer round bar of a diameter just over the diameter of the thread, and centre bore each end so that it runs true between centres. Then cut the slot for the cutters by drilling along a scribed line from each side of the bar and then cutting out with a cross-cut chisel and filing the slot to size with a flat file. Then run a drill, say $\frac{1}{4}$ in. in the three-jaw chuck, and feed the bar up to it by the back poppet headstock centre; drilling for an inch at a time, and then opening up with a larger drill. Now drill again with the quarter drill by soldering it in a brass holder of the size of the larger drill, and so on till the bore comes out into the slot. The brass holder acts as a guide in the enlarged hole. By repeating this procedure with longer drills, the through hole may be bored concentric with the outside of the bar—i.e. axial with it.

The bore, for a 1 in. diameter bar should be $\frac{1}{2}$ in. and this, just cleared with a very slightly oversize drill, will give the tapping size (·508 in.) for a Whitworth standard $\frac{5}{8}$ in. tap by means of which the thread can be cut in the 2 in. at the end of the bore. This will be done later after the bar has been chucked between centres and turned parallel to 1 in. diameter, except for the part which takes the thread for the sleeve *D*. This should be $1\frac{1}{8}$ in. in diameter and should have a thread, Whitworth shape, but ten threads to the inch.

The Plug

The plug, *F*, should be turned and fittted, and the spindle *C* which should be $\frac{1}{2}$ in. in diameter with an end diameter, for $\frac{3}{4}$ in. of $\frac{5}{8}$ in. Whitworth to fit the tapped end of the bore of the bar should be turned. The tapper end of this spindle should have an included angle of 30 degrees and should be case hardened at the taper end, and at the threaded end after being slotted for the screw driver. It may be made of Bessemer steel. If made of cast steel it should be hardened each end and tempered to a full golden straw colour.

The sleeve *G* will be turned from a piece of bar. It is $1\frac{5}{16}$ in. diameter, 1 in. long, and 1 in. internal bore. A hole is drilled through it and through the bar and opened out taper by a taper reamer to fit a standard taper pin *H*, which is $1\frac{1}{2}$ in. long, $\frac{3}{16}$ in. top diameter and taper $\frac{1}{4}$ in. to the foot which is a standard taper and for which there is a standard reamer.



Details of the adjustable boring bar.

The Screwed Sleeve

The screwed sleeve *D* is bored out of a piece of $1\frac{5}{8}$ in. bar and screw-cut inside to match the thread on the mandrel. Its flared end is bored to an included angle of 30 degrees—the same angle as that of the spindle *C*. The cutters are shaped out of $\frac{1}{4}$ in. cast steel and should be cut to shape. The circles at the end are $\frac{1}{2}$ in. in diameter. The shape can be taken from the drawing and enlarged. Three widths will be required, i.e. six cutters as previously shown. They should be hardened and tempered, the cutting edges at *K* should be let down to a golden straw colour by laying the dead hard cutters on their backs (the edges which meet the taper spindle) on a red hot bar and watching the colour come up to the tips *K*. When *K* becomes golden colour, quench, the bulk of the cutter will then be purple and blue.

The outside of the screwed adjusting sleeve *D* may be knurled with a knurling tool to provide a grip, or a couple of flats may be filed across to provide means of rotating it with a spanner, or a couple of dead end holes, $\frac{1}{4}$ in. in diameter may be drilled in the side so that it may be screwed up tight with a pin spanner.

MODEL AERO TOPICS

By F. J. Camm

Wanted—More Clubs

I SUPPOSE it is true to say that I receive more correspondence on the subject of model aeronautics than any other person associated with the pastime. That is due in some measure to my long association with the movement which goes back for nearly a quarter of a century, and in part to the large amount of writing I have done on this subject. I hope it will not be immodest of me to say that the hobby in this country owes its present position very largely to my efforts in keeping interest alive and maintaining enthusiasm for the subject. I am consulted by schoolmasters and parents and by other followers of the hobby, and my letters come from all over the country. Where enthusiasm for a subject is widely spread it is surprising to total up the number of clubs and find that there are so few of them. I suggest that the time has arrived when there should be a club in every district, and this can only be brought about by co-operation with and by the National body, the Society of Model Aeronautical Engineers. If you are keen on model aircraft, I recommend you to endeavour to form a club in your district, and with that idea in view I give some notes on the formation of such a club.

In the first place you should send a notice to your local paper asking those in your district who are interested in the subject to get into touch with you. You should also send this notice to me and to any other paper which deals with model-making.

At this meeting, the first thing to do is to decide on the name of the club, making quite sure that this does not duplicate that of an existing club: and also to elect the Secretary, the Treasurer, the Press-Secretary, and the Committee. The next thing to do is to decide upon the rules and the annual subscription. The latter should not be too small, for the style of a club is cramped when funds are low. If possible, have your membership cards containing the rules printed. Next, decide upon the meeting-place, and, if possible, find a club-room. Where funds permit build a club-room, and equip it with a bench and tools. Proceed to draw up a calendar of fixtures, such as flying meetings, lectures, visits to factories, and so on. Arrange competitions and try to send representatives to the national competitions, for a list of the fixtures of which apply to the S.M.A.E., 2 Scutari Road, Dulwich, S.E.22. Local people can often be persuaded to put up the prizes, and it is particularly necessary to persuade some important local residents to become President and Vice-Presidents. They will also, upon acceptance of this position, contribute to the funds. Don't forget the social side; arrange dances and concerts so that the ladies can be present. An annual dinner can do much to promote the interests of the club. You will not be able to hold the members together unless the programme is carried out intensively, and it should be made a rule that the members must regularly attend the meetings. It is of very little use endeavouring to run a club with five or six members. There is a tendency on the part of certain interests to organise clubs, and whilst these may serve a useful purpose in encouraging the very juvenile members of the pastime, I think that all clubs should be entirely free from trade interests.

Do not let your programme be over-ambitious, and try to persuade the beginner from attempting models outside his knowledge and experience until he has built simple models and obtained skill.

Classes can be run by the more experienced members for the benefit of the unskilled. Later on the construction of full-size gliders can be undertaken.

Mr. G. W. Macdonald's miniature engine which, under test, has achieved a speed of between 2,000 and 3,000 revolutions per minute.

A Miniature Petrol Engine

MR. G. W. MACDONALD of 55, Bellwood Street, Glasgow, S.2, has sent me details of a miniature engine which he has constructed and which he tells me has under test achieved a speed of between 2,000 and 3,000 revolutions per minute. He writes:

"With reference to various articles which have recently appeared regarding miniature petrol motors, I have been tempted to have a shot at one and enclose herewith a photo of the result, which may be of some interest to your readers.

"The castings are in aluminium, from my own patterns, done by a local firm. Crankshaft, connecting-rod, and contact-breaker of silver steel, also the cylinder liner. Bore $\frac{13}{32}$-in., stroke $\frac{13}{32}$-in. The entire engine is simplicity itself to build, and providing one takes reasonable care in marking out the parts no trouble should be experienced.

"I fitted originally a piston of light alloy, turned and filed to shape from the solid, but found it unsatisfactory, as the extra clearance when cold made starting difficult, in fact the whole thing had to be warmed up before it could be induced to kick. I am now fitting a steel piston which will allow high compression when cold.

"I would state that the plug is also of my own manufacture, made from a piece of mild steel flex, screwed $\frac{1}{4}$ in. 40 T.P.I., and fitted gland for the insulator, which is a piece of $\frac{5}{32}$-in. glass tube, the electrode sealed in with 'Hermitite' compound.

"The contact-breaker is a simple type operated from a cam attached to the propeller; the whole unit may be swung round the main worming freely.

"This little engine has given me a great deal of pleasure and I can see no reason why a similar type could not be employed for aero work. Naturally a lathe is indicated, I would say that my own equipment is anything but elaborate. I use a cheap 3-in. lathe as advertised in your magazine and with care turn out quite an accurate job.

"Should any readers desire any further details of this engine I will be pleased to help."

Club Fixtures

I SHALL be glad if Model Aero Clubs would send me details of their fixtures so that I can, where necessary, arrange for a representative to report their meetings. I should also be pleased to receive photographs of any interesting models built by members of clubs and to pay for those I publish.

Indoor Meetings at the Albert Hall

THE Council of the S.M.A.E. has passed a ruling that these meetings be opened to affiliated club members only and that there should be no smoking.

Competition Programme for 1937

THE S.M.A.E. is fixing its competition programme for 1937, which entails several alterations. It is understood that considerable difficulty has been experienced in hiring a room for Council meetings.

"Aeroplanes—How, Why, and When," by R. Barnard Way. Price 3/6, 128 pages, including 200 sketches. Published by Cassell and Co., Ltd.

IT is the ambition of every boy to be able to fly an aeroplane, and to judge by the rate of progress in design it seems quite possible that those ambitions will be achieved. But whether they are or not, boys both young and old are fascinated by aeroplanes. This book by R. Barnard Way is, though not comprehensive, full of interesting matter. It explains how flying became possible. It tells of those early pioneers who more often than not lost their lives trying to fly. The book then goes on to show what progress has been made in all branches of aviation, terminating in descriptions of long-distance records, and the 'planes that made them. To enhance the value of this book in the eyes of its readers, 200 sketches are included. These show early and modern aeroplanes, the construction of one of these machines, and the operation of the petrol engine.

Taking into account the necessary brevity of this book, it is very informative, and useful.

Taking Aerial Photographs with a Kite

A FASCINATING HOBBY

This illustration shows the size and type of kite used.

AERIAL photography sounds a difficult task if you do not possess your own aeroplane, but if you can build a box-kite at least 6 ft. in height, and you possess a suitable camera, it is quite simple.

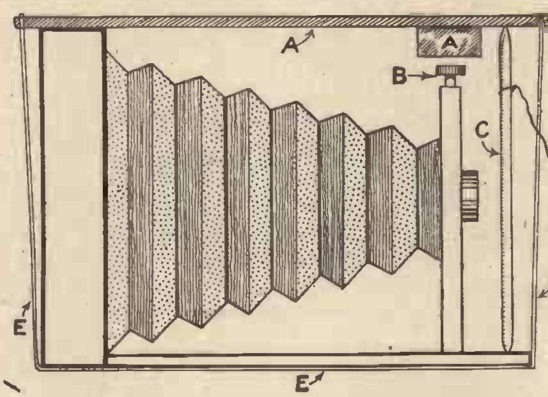
Making the Kite

You will require four 6-ft. bamboo canes, as straight as possible, and six shorter lengths, for cross pieces, about 4 ft. 6 in. long. Eight yards of calico, or some light-weight tent cloth, will serve for the covering material. It is advisable that the cloth should be closely woven, to hold the wind, otherwise it will be necessary to give it a coat of aeroplane dope after the kite is made. You will need some thin string or wire for staying the frame-work, and at least 60 yards of good strong cord. The best kind of cord is that sold at fishing shops and ship-chandlers for conger-eel fishing and the like. It costs about 5*s*. for a double hank of 120 yards. The photograph will illustrate the construction of the kite. Sew the covering material first in two parts for top and bottom. A seam shows in the picture. Make sure that the join of the cloth is absolutely square and then proceed to assemble the struts. A knowledge of lashing will be useful for making a neat job of the framework, which is made absolutely rigid by staying from corner to corner systematically. The framework may be strengthened so that a camera may be mounted about the central axis of the kite, that is, roughly pointing down the string. Different types of camera will require different mountings, and ingenuity must be used, but in all cases the centre of the kite will be found the most suitable place, because here the movement is at a minimum when flying.

Mounting the Camera

Perhaps before the camera is mounted in the kite it will be advisable to have a little flying practice. The cord should be attached to one corner of the kite in an irregular Y formation, so that the ground strain is applied just above the central axis. Different wind velocities seem to demand different flying angles and the matter is one for experiment.

A team of four is essential for handling the kite. It should be remembered that a kite of this size has a very great pulling power, and if the cord gets tangled round someone's neck there may be unpleasant results. Two members of the team should concentrate on the "take-off" of the kite. They hold it firmly by the outer ribs so that they may run a short distance with it before throwing it up. At least forty yards of cord is laid along the ground at a small angle to the direction of the wind. The "pilot," who holds the cord, and manipulates the flight of the kite, is advised to wear a pair of old gloves. The fourth member of the party will supervise the paying out of cord, and prevent any tangling of that which lies on the ground.



Showing how to arrange the shutter mechanism of the camera.

Flying the Kite

The great point to remember in flying a big kite is that it is not really flying when you have to run along with the string. One should try to rise above treacherous ground currents at the first attempt, and if the kite will not remain in the air at a height of 200 ft., the wind is probably not strong enough for flying. When you are certain that you know how "to take-off," and how to make a good landing, which can only be achieved with practice, you may mount your camera in the kite. It is advisable to arrange the mounting in such a way that the struts project a little farther than the camera, thus avoiding damage in the event of a crash.

Working the Shutter of the Camera

There are various ways of releasing the shutter of the camera. The best way is to have the shutter released by a separate and lighter string, operated from the ground. If the shutter of the camera is operated by simply pressing down a button, a very easy device may be arranged. A short wooden arm is pivoted across the top of the camera, and a downward movement provided by a few turns of elastic round the camera. The arm is held in position by a wedge, which when removed causes the arm to drop on the button and work the shutter. The idea can be adapted to suit most types of camera, but the sketch will explain how the writer used it.

The lighter string is secured to the wedge, and it will be found useful to leave a short loop on this string, and then fasten it to the framework by two turns of cotton thread. This prevents a premature release of the shutter, which may be caused by the kite tugging on a gusty day. It is also useful to prevent any jarring of the camera at the moment of exposure, for when the string is pulled from the ground the first action is to break the thread, and in the appreciable fraction of a second before the wedge is pulled clear the kite has time to recover from the twitch.

When taking your aerial photographs it should be the duty of those responsible for "throwing" the kite to unwind and keep an eye on the exposure release string. It must be kept clear of tree tops or obstructions, and should be paid out fairly slackly. In fact, a team of four will have their work cut out to watch every detail and make a successful photograph. The member of the party detailed to make the exposure must watch his opportunity. When he feels that the camera is pointing at the object to be taken, and a little practice will make him expert at this, he will watch the kite, pulling the string when he is sure of steady flight.

An illustration of an actual photograph taken with a kite 600 ft. up

ENGINE STETHOSCOPES

The Stethoscope is an Instrument that is used for the Detection of Faint Sounds, the most Familiar Type Being the Medical Stethoscope.

A simple type of stethoscope consisting of a thin metal disc secured to the end of a wooden rod.

THERE are various types of stethoscopes which are of particular use in locating the approximate source of abnormal noise in a car engine. Of these, the very simplest type consists of an ordinary lead pencil, one end of which is placed against the cylinder block, the opposite end of the pencil being held to the ear. An ordinary medical stethoscope of the old-fashioned "single earpiece" pattern may be used in an exactly similar manner, the smaller end of the instrument being pressed against the cylinder block.

A Simple Stethoscope

Quite an excellent engine stethoscope may be made by securing a two- or three-inch disc of thin metal, as, for example, the bottom cut out of an old can, to a wooden or metal rod, which should be a foot or more in length. The end of the rod is pressed lightly against the cylinder block, the ear being held close up against the metal disc at the upper end of the rod. By means of such a simply-contrived instrument, the approximate location of any unusual engine noise may readily be ascertained. It is essential, however, that this type of stethoscope be held lightly between the first or second finger and the thumb and that it only be pressed lightly in contact with the cylinder block or other part of the engine. If the pressure and grip applied to the stethoscope is a heavy one, many of its vibrations will be damped out and the instrument will not be as effective as would otherwise be the case.

An engine stethoscope of very high sensitivity and of great convenience in use, may be made with very little trouble from an old wireless headphone earpiece. The magnet windings of the earpiece are removed and a metal rod or pin is soldered to the centre of the diaphragm. To the end of this pin as soldered a length of coiled wire at the opposite end of which is soldered a thin metal rod about a foot in length, which should preferably be tapered.

The "Headphone" Stethoscope

This "headphone" stethoscope will detect unwanted noises in even the quietest running engine. More than that, it will pick up abnormal sounds from the gearbox and from all types of bearings.

In use, the pointed end of the stethoscope rod is held firmly yet lightly against the engine part and the earpiece is applied to the ear. Naturally, the ordinary noises generated by the running of the engine part under examination will be picked up by the stethoscope and magnified in the earpiece, but imposed upon this rhythmic background of noise will be any unusual sounds whose presence will disclose some irregularity in the engine part under examination. It takes a little practice to work with any type of engine stethoscope, but very quickly the correct "grip" of the instrument is almost automatically obtained and the normal "background" of noise gives little trouble to the engine examiner.

A car engine stethoscope made from an old headphone earpiece.

Failure of Lubrication

It is interesting to apply an engine stethoscope to a bearing which is known to be well oiled and immediately afterwards to a bearing which is suspected of running without adequate lubrication. The difference between the two bearings, as revealed by the stethoscope, will be a startling one and, with practice, it is possible for an individual to tell by means of a stethoscope whenever the slightest failure of lubrication occurs at a bearing.

It is, however, in the examination of unwanted cylinder noises that the car engine stethoscope finds its greatest use and a small amount of practice with such an instrument will readily enable any car owner to ascertain immediately whether any particular engine cylinder is firing normally or not.

THE WONDERS

Marvellous Facts about one of

A hook of solid mercury suspending a 7-lb. weight. The mercury has been frozen in liquid air.

MOST readers will be aware of the fact that when air is strongly compressed and, at the same time, subjected to powerful cooling influences, it no longer remains gaseous, but condenses to a thin and perfectly clear liquid. All gases, in fact, can, by compression and cooling, be condensed to liquid form and even frozen solid.

In the production of liquid air, the air is pumped into a strong steel apparatus containing a large number of coiled steel tubes. After the air has attained a certain degree of compression, it is automatically allowed to expand suddenly. In expanding, the compressed air is very strongly cooled, and after this compression and expansion process has been repeated two or three times, the temperature of the air becomes so low that the air condenses to an almost water-white liquid—"liquid air."

A Remarkable Substance

Liquid air constitutes one of the most remarkable substances known to science, mainly on account of the fact that it provides a source of "concentrated cold." We all know that water boils at a temperature of a hundred degrees (Centigrade) above its freezing-point. But the temperature of liquid air is nearly twice as much below the freezing-point of water as the boiling-point of the latter liquid is above its freezing-point.

To be precise, liquid air boils at a temperature of — 194° Centigrade. Since air in its ordinary gaseous form is a mixture of twenty-three parts (by weight) of oxygen to seventy-seven parts of nitrogen, so, also, air in its liquefied form comprises a mixture of liquid oxygen and liquid nitrogen in like proportions.

Liquid nitrogen boils at a temperature of thirteen degrees below the boiling-point of liquid oxygen, so that when liquid air is kept it is the nitrogen which boils away first. Hence, liquid air gradually becomes richer and richer in oxygen and, as it does so, it acquires a beautiful pale sky-blue colour, the characteristic colour of liquid oxygen.

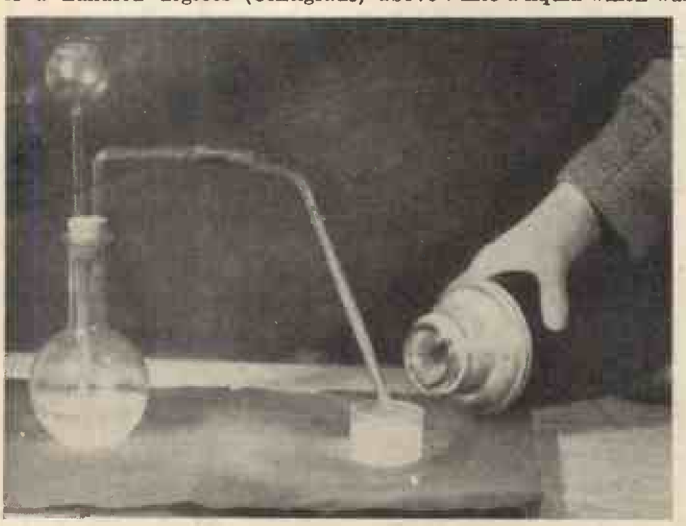
Stored in Vessels

Since the temperature of liquid air is approximately 210 degrees below the average temperature of the objects which surround us (*i.e.* 15° C.) it might be imagined that it is impossible to store and utilise this marvellous liquid. As a matter of fact, however, thanks to the production of suitable vacuum vessels constructed on the ordinary thermos-flask principle, liquid air can be kept in such containers for a space of three or four days, for the vacuum-lined walls of the containing vessels prevent the heat of the surroundings from warming up the liquefied air within the vessels. Stored in a silvered vacuum vessel of the ordinary thermos type, liquid air evaporates but slowly and at the rate of about 15 per cent. of its bulk in every twenty-four hours. Hence it will be evident that liquid air, provided that proper precautions are taken, can be handled and experimented with just like other liquids.

Great care has to be taken not to allow the hands or any part of the flesh to come into contact with the liquefied air. To dip one's finger into a vessel of liquid air would be very much akin to plunging one's finger into a liquid which was boiling at twice the temperature of boiling water. Liquid air coming into real contact with the skin is capable of giving a most severe frostbite. One experimenter, in fact, during the space of a few hours managed to contract a liquid air frostbite and a severe burn from a bunsen burner on the same hand. It is interesting to record that the burn on the hand healed over within a week, but that the liquid air frostbite took three weeks to heal.

A spectacular experiment. A yale key tied to a piece of string has been cooled in liquid air and then immersed in a tumbler containing hot water. The key has frozen hard to the sides of the glass with the result that the entire tumbler of hot water can be lifted up and held in mid air. Note the coating of frost on the lower half of the string.

Liquid air represents air in a very concentrated form. About 100 cubic feet of air are required to produce 1 gallon of the liquid which occupies a space of some 231



Carbon dioxide gas (CO_2) is frozen solid as it streams into the glass dish around which liquid air is poured.

A close-up view of the dish containing solid carbon dioxide.

OF LIQUID AIR

he Coldest Materials Known

cubic in. It can be shown that liquid air occupies only $\frac{1}{748}$th of the space filled by the gaseous air. Consequently, when liquid air evaporates it expands to 748 times its liquid volume. In view of this fact many proposals have been made to employ liquid air as a source of motive power. These, however, have come to nothing, mainly on

A wooden box containing a 4-lb. weight suspended by a liquid air-cooled piece of frozen metal to its outer side.

account of the impracticability of storing and handling large amounts of liquid air. At the same time, it may be mentioned that liquid air has been used as an explosive in combination with other materials, and it is interesting to note that its use in conjunction with other substances as a rocket fuel for interplanetary travel has been seriously proposed.

The Coldest Substance

To the average reader, however, the chief interest about liquid air will naturally be its intense cold. Indeed, liquid air is one of the coldest substances of which we know. True it is that liquid hydrogen and liquid helium are still colder than liquid air, but these liquids have, up to the present, been produced in only relatively small amounts, whilst liquid air is nowadays a comparatively inexpensive commodity.

If we take a stout copper wire and plunge it into a vessel of liquid air, the liquid air surrounding the wire will boil violently, and with a hissing noise similar to that produced when a red-hot wire is plunged into a bath of cold water. After a few seconds, however, the wire will be cooled down to the temperature of the liquid air, that is to say, below − 194° C. If, now, we take the wire out of the liquid air and immediately plunge it into a mass of ordinary motor oil, the latter will freeze to a hard waxy yellow mass for at least half an inch around the wire and we may then withdraw the wire which will have attached to it the thick mass of almost instantaneously-frozen oil. Oil is a difficult material to freeze solid, and this sudden and complete freezing of the oil surrounding the liquid air-cooled wire demonstrates very strikingly the extremely low temperature of the liquified air.

Frozen Mercury

Small tubes containing liquids such as glycerine and alcohol, which only freeze at very low temperatures, have their contents completely frozen within the space of a few seconds when they are lowered into liquid air. Mercury or "quicksilver," the well-known metal which is liquid at ordinary temperatures, freezes instantly when covered with liquid air, and in the solid condition looks just like freshly-made solder. It is, indeed, possible to place mercury into an "S"-shaped mould and then to freeze it solid with liquid air and afterwards to employ the frozen mercury as a hook upon which to suspend a heavy weight. The mercury will remain in its frozen condition for several minutes before it begins to soften under the heating effects of the surrounding air.

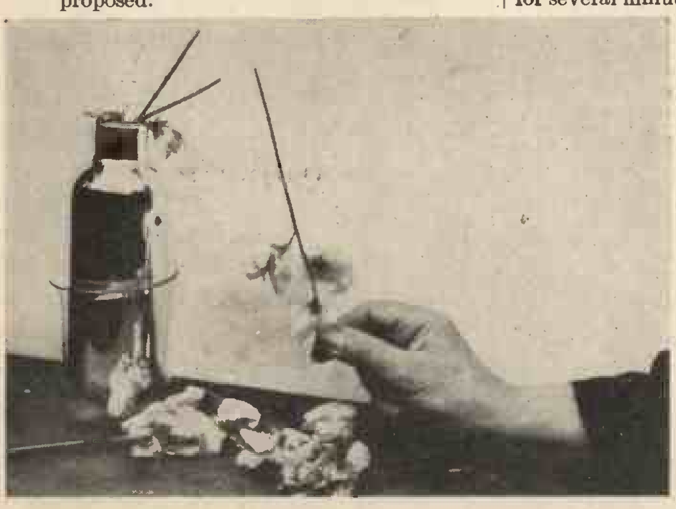
A cylinder containing liquid air. Notice the "fumes" of the liquid caused by the freezing of the moisture in the surrounding air.

If we pour liquid air from its vacuum container into an ordinary vessel, the liquefied air will boil with extreme violence until it cools down the vessel to its own extremely low temperature. The liquid air, too, will freeze the moisture in the surrounding air and render it visible in the form of a white cloud or vapour. That is the reason why liquid air always gives off clouds of "white smoke" when it is poured from one vessel into another.

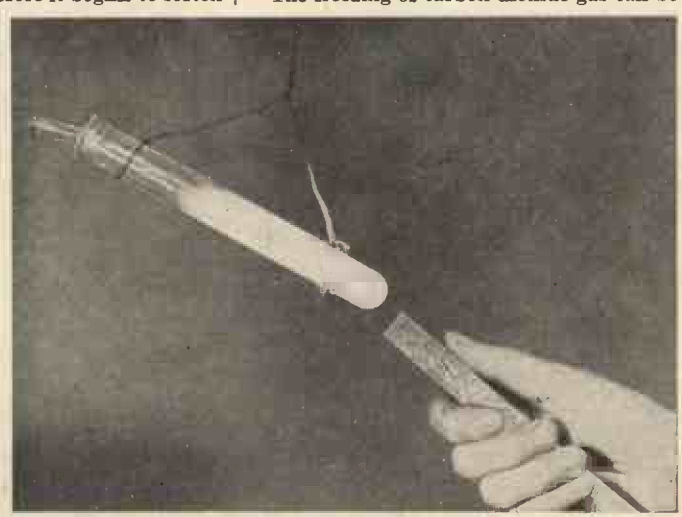
An Experiment

If we pour a quantity of liquid air into an ordinary kettle and put the kettle on to a bright red fire, the liquid air will be ejected from the kettle spout in a stream three or four feet long. If, now, we lift the kettle from the fire, we shall see that its underside has on it a thick coating of a material which looks like snow. This is actually the carbon dioxide gas produced by the combustion of the fire, and frozen solid by the intense cold of the liquid air.

The freezing of carbon dioxide gas can be



Flowers immersed in liquid air become as brittle as thin glass. Here is a frozen blossom being held up by the tip of its petal.



Showing the magnetic nature of liquid oxygen. A suspended tube of oxygen-rich liquid air being attracted to the pole of a bar magnet.

A piece of wire cooled in liquid air and then immersed in a vessel of oil immediately freezes the oil around it into a hard mass. Here is frozen oil on the end of the wire.

shown with even small quantities of liquid air by generating the gas by the action of hydrochloric acid on marble fragments in a flask provided with a glass delivery tube. The latter tube dips into a small glass vessel, and around the latter a small quantity of liquid air is poured from its vacuum container. Almost instantly, the carbon dioxide gas issuing from the delivery tube of the flask condenses to a white powdery solid which lines the inner sides of the glass vessel or dish and, in time, fills the latter. This is the well-known "carbon dioxide snow." It constitutes a gas which has actually been solidified by intense cold.

The carbon dioxide snow will subsequently pass off into a gas when removed from the influence of the liquid air without going through its liquid stage. Incidentally, this remarkable "solid gas" has a temperature not far short of $-100°$ C.

When a piece of rubber tubing is plunged into a bath of liquid air, it becomes as hard as cast-iron and as brittle as the latter. A rubber ball frozen in liquid air and then hurled against a brick wall will break into a thousand fragments. Flowers immersed for a second or two in liquid air become as brittle as glass and can then be reduced to a fine powder!

Extraordinary Behaviour of Frozen Ivory

Ivory behaves in a very curious and quite unexplained way when cooled down to the temperature of liquid air. At this extremely low temperature it becomes brightly phosphorescent after it has been exposed for a second or two to the light of an arc lamp or to the rays of burning magnesium. This mysterious behaviour of ivory constitutes quite a good method of distinguishing the genuine from the spurious article.

If we tie a small metal article, such as a key, on to the end of a piece of string, and then immerse it in a vessel of liquid air so that it is cooled down to the temperature of that liquid and, immediately afterwards, lower the metal object into an ordinary tumbler of *hot* water, taking care to see that the object makes contact with the glass, we shall almost immediately hear a sharp click. The metal article will freeze fast to the walls of the tumbler and we shall be able to suspend the tumbler of hot water on the end of the string. This remarkable fact of a metal article being frozen fast to the wall of the tumbler by a thick layer of ice and yet at the same time being surrounded by hot water, demonstrates very strikingly the enormously low temperature to which liquid air is able to reduce any object immersed in it.

Another experiment of the same nature may also interest the reader. A small metal object is secured to the end of a length of string and then lowered into a vessel of liquid air. A few drops of water are then poured into a small concavity made in the outer side of a wooden box and the liquid

Liquid air being poured from one vessel to another. Note the ring of frost around the edge of the upper vessel.

air-cooled metal object is then lowered into the little pool of water thus formed. A click is heard. The water freezes instantly, and the box can be lifted up on the end of the string even although it may weigh a few pounds. Such, indeed, are the cooling powers of liquid air.

Liquid Oxygen

Liquid oxygen is a magnetic substance,

and after liquid air has been allowed to evaporate slowly for some time, and has thus become richer in liquid oxygen, the magnetic properties of the latter liquid can be demonstrated in quite a simple manner. A quantity of the liquid air, which is rich in oxygen, is placed in an ordinary test tube, or, preferably, in a small vacuum-lined cylindrical vessel, which is provided with a vent tube to allow the escape of air from the continuously evaporating liquid. The tube or cylinder is suspended freely, and in a nearly horizontal position by means of string or wire and a magnet or an electromagnet is brought near to it. The tube or cylinder of liquid air will be found to behave just as if it were a piece of iron, swinging round to the magnet pole and adhering to it.

If a small piece of sponge is saturated with liquid air and a light is applied to it, the sponge will shatter itself in all directions with a miniature explosion, whilst if a roll of newspaper is dipped in liquid air and then thrown on to a fire it will burn with the well-known rapidity of gun cotton.

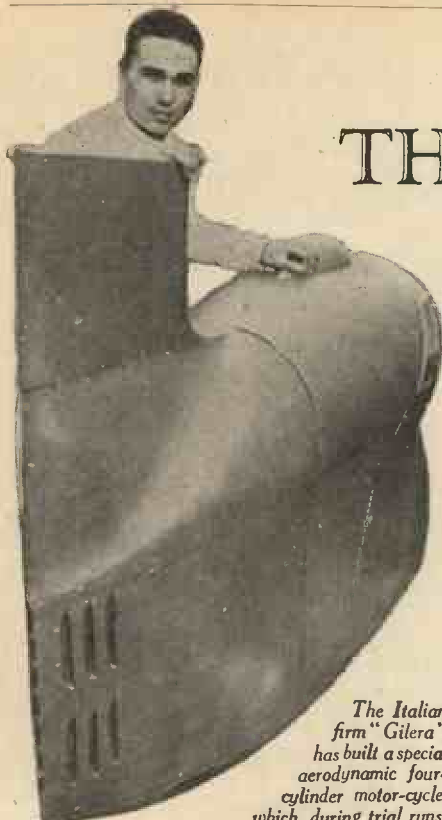
Perhaps the most remarkable experiment of all which can be performed in connection with liquid air is to place a quantity of the liquid in a cylindrical vessel which is suspended a foot or two above the work-bench. The vessel is connected to a vacuum pump, and the latter is turned on so that the liquid air is made to boil vigorously in a vacuum.

Pouring a quantity of liquid air from its vacuum-lined container.

So intense a degree of cold does this vacuum boiling of liquid air produce that, under these conditions, the actual air of the room will condense without any pressure on the outer sides of the cylinder, and will drop off the lower end of it on to the bench, there to re-evaporate at once into its former gaseous condition.

Liquid air cannot be contained in ordinary stoppered bottles, for its evaporation would result in the stoppers being blown out violently within a few seconds, if, indeed, the actual bottles themselves were not shattered by the expanding air. Even brass and copper tubes cannot contain liquid air without bursting. As we have already seen, this remarkable form of "concentrated cold" must always be stored in vacuum-lined vessels, in which containers it will remain for three or four days before it evaporates away completely.

THE MONTH IN THE WORLD OF SCIENCE AND INVENTION



The Italian firm "Gilera" has built a special aerodynamic four-cylinder motor-cycle, which, during trial runs, has reached a speed of nearly 190 m.p.h.

1937 Paris Exhibition

AN International Exhibition will be opened in Paris during the Spring of 1937. One of the principal features of scientific interest is to be an electrostatic generator which will be the largest in the world. Two brass balls, each 10 ft. in diameter, will be supported on insulating columns 32 ft. in height and the balls will be charged with electricity to a potential of about 5,000,000 volts by the action of a friction generator consisting of endless belts of rubberised cotton.

A 10-ft. Spark

When fully charged, a spark will leap across the 10-ft. gap between the spheres, but visitors will be protected from stray sparks by a large lattice-work cage of metal which will be built round the apparatus.

The operators who control the display will actually sit inside the two metal spheres, where, strangely enough, they will be perfectly safe.

New Aviation Fuel

TO obtain the greatest possible power from petrol fuel, it must have a high "octane number," i.e. it must not detonate in a high compression engine. Hitherto high octane ratings have been obtained by adding tetraethyl lead and "iso-octane" to the petrol, but the latter is very expensive and only available in small quantities.

A 15 per cent. Saving

A new fuel has been announced, however, in which the high octane number is obtained by blending isopropyl ether and tetraethyl lead with the petrol. Isopropyl ether is comparatively cheap and plentiful and it is stated that the new fuel will show a saving of 15 per cent. in fuel consumption over ordinary commercial grades.

Absolute Zero

THE absolute zero of temperature, -273·13° C., has not yet been reached, and probably never will be, but scientists have got within one sixth of a degree of the limit. At the absolute zero, all heat ceases to exist and all motion of molecules stops, according to present theory.

Low Temperatures

These low temperatures are obtained by first using liquid air to cool liquid hydrogen and then liquid hydrogen to cool liquid helium. The liquid helium is used to cool a cell containing a solenoid which surrounds the material to be finally cooled. The material is strongly magnetised by the solenoid and when the heat of magnetisation has been absorbed by the helium, the cell is evacuated and the magnetic field removed. In demagnetising, the material cools itself still further until the lowest temperatures yet attained are reached.

Abbot's Solar Engine

NEW facts regarding the solar engine invented by Dr. C. G. Abbot, of the U.S.A., have recently been published. The experimental machine which has been constructed consists of three long parabolic metal reflectors which closely resemble a popular type of electric fire. Along the focus of each parabola is placed a glass tube, half an inch in diameter and six feet in length. This tube is filled with a liquid known as "Aroclor," a chlorinated diphenyl compound which is darkened by the addition of lamp black.

The liquid, whose boiling point is 662° F. is kept circulating by a pump, and after leaving the heater tubes it enters a "heat-interchanger" where it gives up its heat to water which is caused to boil and so generates steam.

A ½ h.p. Steam Engine

The steam is used to drive a ½ h.p. steam engine, and with steam at 200° C., the maximum theoretical efficiency is about 40 per cent. It is stated that in regions with ample sunshine, the plant will compete with coal costing three dollars a ton. It has been calculated that if a solar engine could be constructed equal in area to the lake which is now formed behind the new Boulder Dam, it could generate as much power as the water turbines which are to be driven by the waters of the lake.

A machine that would be a boon to record-attempt pilots in a hurry to refuel and be off, is the new streamlined petrol, oil, and air tank now in use at Reading Airport. The tank holds 450 gallons of petrol, 25 gallons of oil, and can produce unlimited supplies of air. It can fill a plane with petrol in a few minutes. The streamlined petrol re-fuelling machine is shown re-fuelling a plane at Reading.

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A Model G.W.R. Broad Gauge Locomotive—Part II

By E. W. Twining

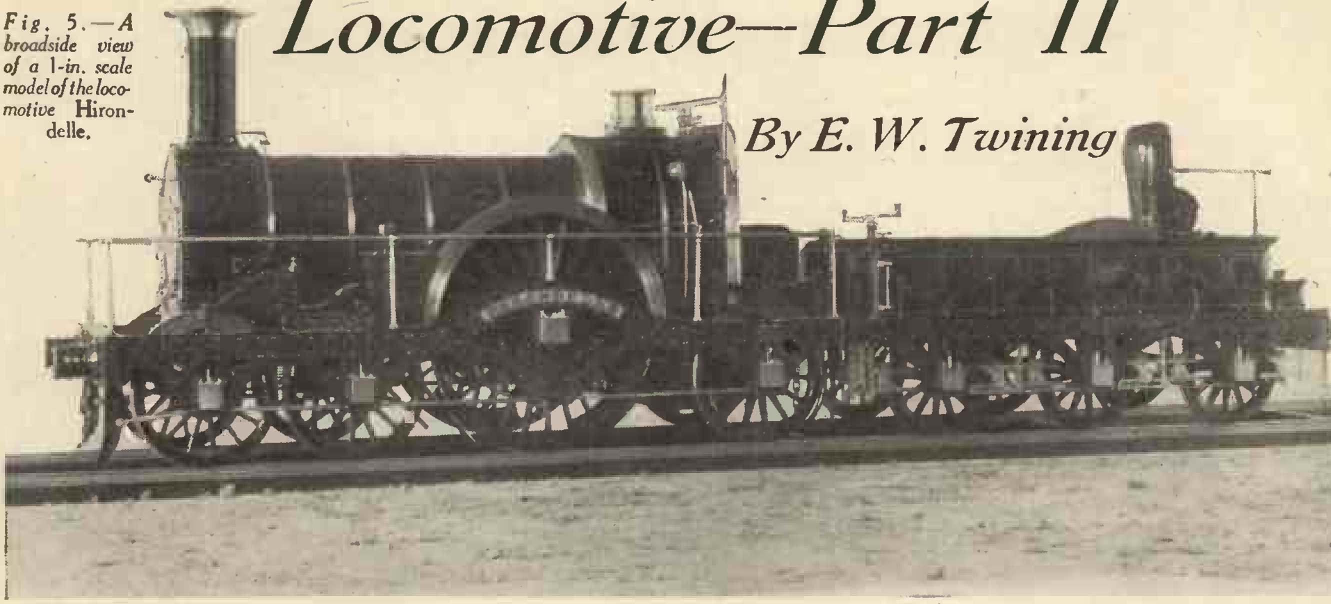


Fig. 5.—A broadside view of a 1-in. scale model of the locomotive Hirondelle.

AS a headpiece for this article I have selected what is practically a broadside view of my own 1-in. scale locomotive *Hirondelle.* The engine only is a facsimile of what the *Lord of the Isles* was like in the middle 1850's, after the chimney and sand-boxes had been altered.

When this model was commenced, at just about the time when the *Lord of the Isles* was broken up, it was intended to be a replica of that engine, and it was not until it was nearing completion, ready for the name and for the tender to be put in hand, that I decided to change to a different engine. The reason for this was that I did not like the iron-framed type of tender which the *Lord of the Isles* throughout its existence had behind it. This iron framing was quite different from that of the engine; it was the same as many of the engines built prior to 1851. Why Daniel Gooch changed I do not know, but his other tenders, which were not in all cases later than that of *Lord of the Isles,* had sandwich framing, the same as that of the engines. This tended to greatly improve the appearance. It gave uniformity throughout, and so I adopted the name of one of the other engines—*Hirondelle*—because of its euphonious nature. This matter of the tender I shall deal with later, and shall give drawings of both the types.

A Comparison

I said in my first article quite a lot about changes in the appearance of *Lord of the Isles,* and that is why I illustrate my model in order to show the form of details which the *Lord of the Isles* once had and which were different when it was broken up. The reader can compare the photograph of the model with the view already given at the head of the last article showing *Lord of the Isles,* and compare the two tenders. Of course, if he has fully made up his mind to build *Lord of the Isles* and no other, he will reconcile himself to anything unpleasing about the tender, but if he allows, as I did, æsthetic considerations to influence him he will not be tied down to other details which were peculiar to the *Lord of the Isles,* and can adopt the name of any of the other engines which he cares to put on the model, a list of which names I have already given. Similarly, too, he can adopt any period that he likes. It was for this purpose that I gave all the necessary details of other periods.

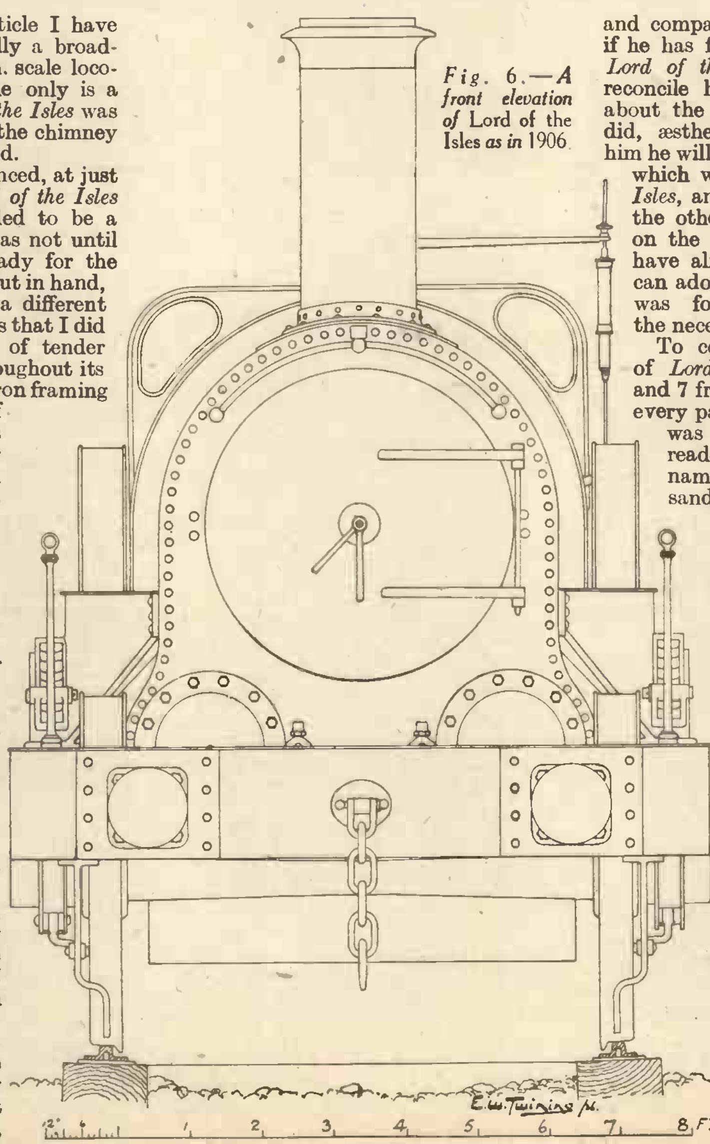


Fig. 6.—A front elevation of Lord of the Isles *as in* 1906

To complete the scale-drawn views of *Lord of the Isles* I give in Figs. 6 and 7 front and back elevations, showing every part as it was when the engine was broken up. Should the reader decide to adopt another name, another period, and the sandwich-framed tender, I give for his use in Fig. 9 an elevation of the smokebox front with the door secured by clamping handles, which, by the way, is strangely enough quite recent locomotive practice. This old form of door on the broad-gauge engines was hinged at the bottom. It must be noted that the front plate of the smokebox was secured not by rivets but by square-headed bolts, the nuts being on the inside.

Difficulties in Building

The methods to be followed will have to be quite different from those usual to the construction of a model of a more modern engine. In such modern locomotives the frames, cylinders, axles, motion, etc., are built as a chassis, and the boiler, a separate unit, is put on afterwards. This cannot be done in the *Lord of the Isles* and others of its class because the whole principle of construction in the prototype was different.

The main purpose served by the outside sandwich frames was to carry the boiler and machinery, and those outside frames took up none of the working stresses. There were inside frames which extended only from the back of the cylinders to the front corners of the firebox. In these there were horns and axle-boxes, and all the thrusting and pulling of the pistons and the shocks of the reciprocating masses were taken up by these frames. It is true that there was a light spring underneath the driving axle, attached to inside the axle-boxes, but the main object of such spring was to take part of the load acting vertically should the driving axle fracture.

Now this means that the engine (and by engine I here mean cylinders, motion, valve gear, and inside frames, etc.) cannot be built separately from the boiler for the reason that, as already mentioned, the frames are actually attached to the boiler. My own model is correctly built and follows the prototype, but to simplify the job for the reader I have endeavoured to find a way of getting over the difficulty, but without success. It would be possible to carry the inside frames along past the firebox to the rear buffer beam, but at the front they cannot be made to pass the cylinders, for there is no means of separating the cylinders from the smokebox: besides which, could the frames be carried to the front buffer beam they would be bound to show, since there is clear space between the front cylinder covers and the buffer beam. Had all this been possible then the inside and outside frames could have been constructed together with stretchers between them, and the cylinders and motion attached to the whole chassis.

Four Bearings

In the model I am going to provide four bearings only for the driving axle, two outside and two inside of the driving wheels, but in the full-size engines there were five bearings. There was a central pair of horns riveted to the inside of the boiler barrel. Three other attachments were also made to the boiler: these included motion plates carrying the slide bars, the swinging links supporting the expansion links and eccentric rods, and a central bearing for the reversing shaft. All these I am omitting.

In the original there were two separate motion plates, right and left, each bolted to their respective inside frames and riveted to the boiler. They were not joined together in any way, but in the model I am leaving them clear of the boiler and joining them together. A cross-section showing this detail will appear later. From the motion plate I am carrying backwards brackets for the valve-gear suspension links, whilst the reversing shaft is to be provided with two bearings only secured to the frames. All these modifications will considerably lessen the

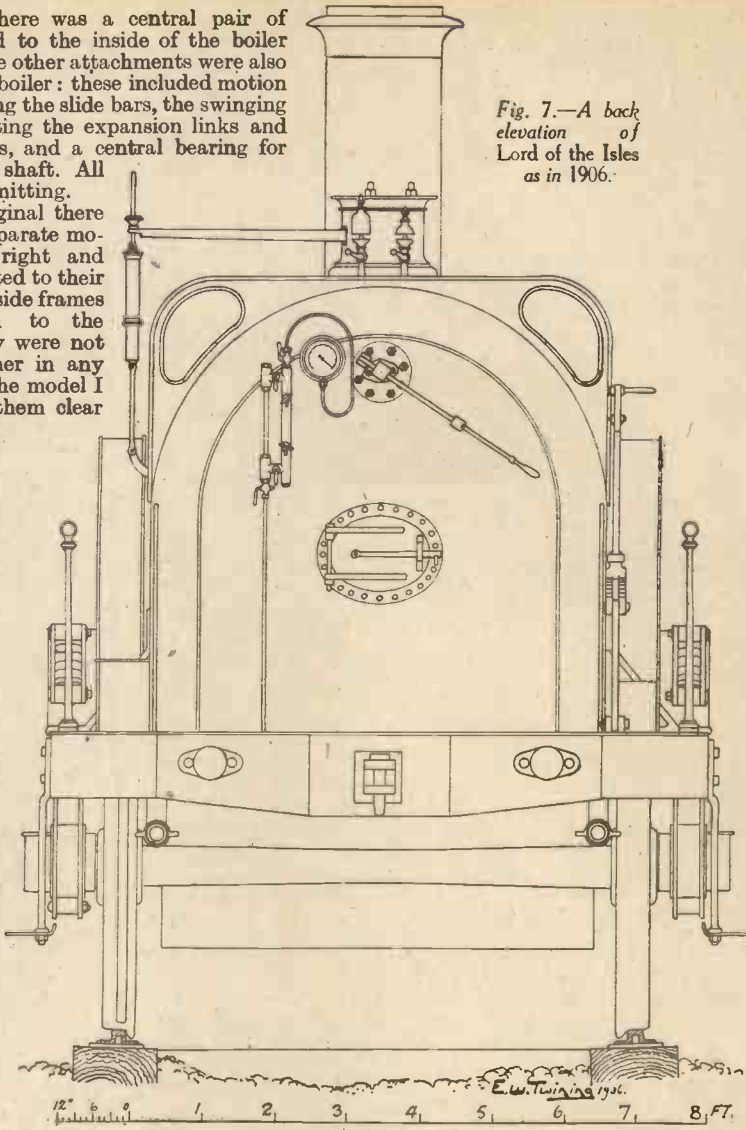


Fig. 7.—A back elevation of Lord of the Isles *as in 1906.*

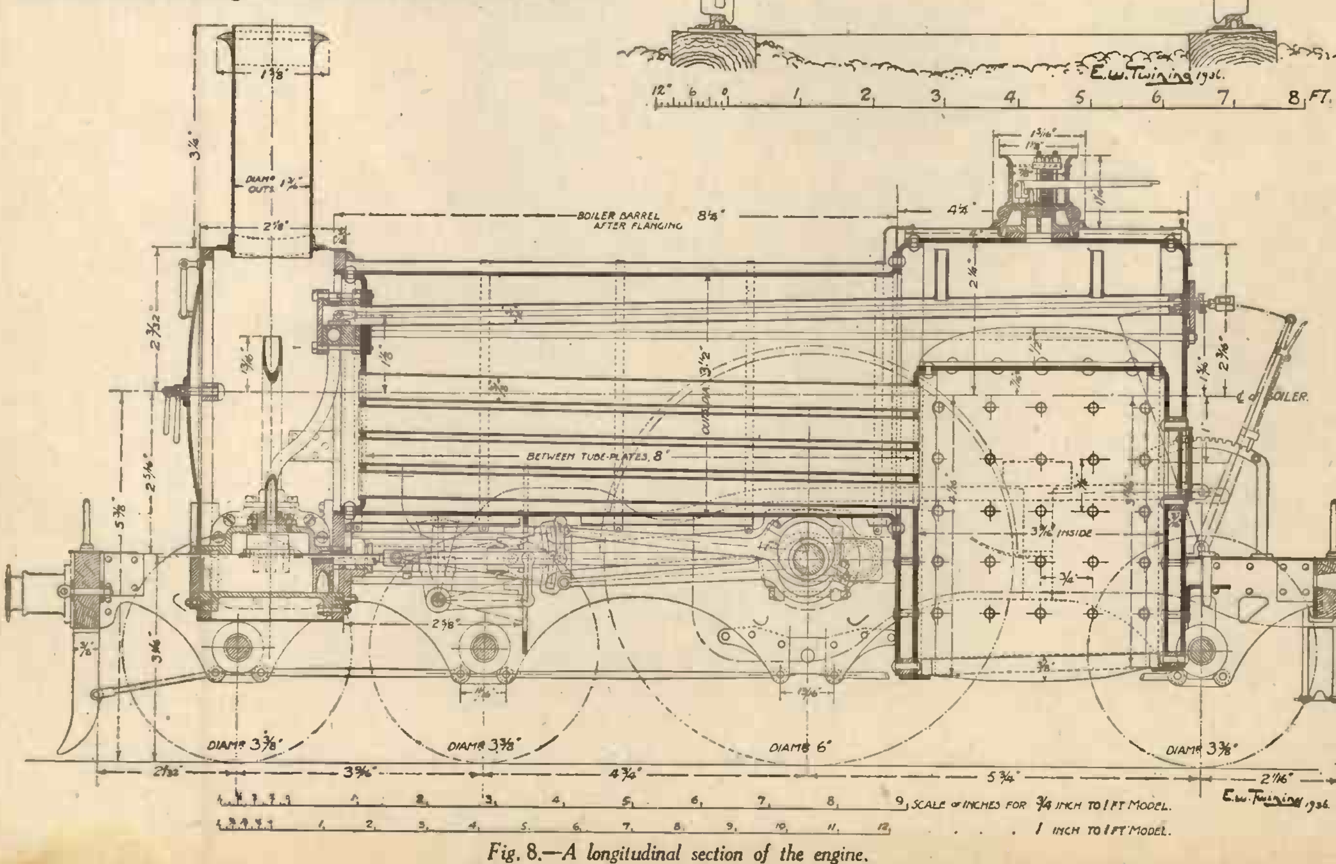


Fig. 8.—A longitudinal section of the engine.

difficulties of building this model, which difficulties lie not so much in the actual making of all the parts but in assembling them.

Other Details of Construction

The next, and perhaps the most important, drawing to which I must refer is the general arrangement showing the whole engine in longitudinal section, Fig. 8. If the reader is familiar with drawings of these old broad-gauge engines (they were published in Treadgold's *Locomotive Engines* in 1850) he will recognise from an examination of Fig. 7 that I have very considerably modified parts of the engine other than those mentioned. All these, however, are internal and they will affect the outside appearance in not the slightest degree: they all tend to simplify construction.

One of the chief of these departures from correct practice is the connection between the smokebox and the boiler barrel. Here I am providing a strong gunmetal casting which is bored out to fit perfectly over the end of the copper tubular barrel. Its profile follows the lines and curves of the smokebox, and is further bored out to receive spigots on the back cylinder ends. It thus provides a very rigid attachment for the cylinders. Cast upon this plate are lugs, two of them extending backwards, to which the inside frames are bolted, and four of them projecting forwards into the smokebox. As a matter of fact, these forward lugs will be flush with the inside of the smokebox wrapper plate and the plate will be cut away around them. To these lugs, two on each side, will be riveted the brackets which support the boiler and cylinders on the outside frames. On the prototype engines there were six supporting brackets, two of them in the middle were long and riveted to the boiler barrel. They came immediately in front of the driving wheels, and after *Lord of the Isles* had the big sandboxes placed so that they distributed sand immediately forward of the drivers the brackets were hidden by them. These brackets I am doing away with; they will be quite unnecessary in the model. The remaining pair of the prototype six were, of course, on the sides of the firebox. These will have to be retained in the model.

Drum-head Type Tube Plate

The front tube plate will be of the drum-head type; that is to say, it will be circular, flanged and recessed into the barrel. This arrangement will give us a little more room in the smokebox for the regulator and steam pipes. To the model locomotive builder this type of regulator will probably be new. It follows fairly closely the originals; at any rate, it is of the same type. As will be seen, the valve is controlled by a rod extending the whole length of the steam-collecting pipe, and the regulator handle is of the push-and-pull form for closing and opening. The handle is shown in Fig. 7, but as I proceed I shall doubtless find it necessary to give a little detail drawing of it.

Steam-collecting Pipe

In the full-size engines the steam-collecting pipe was horizontal instead of being inclined as shown. Furthermore, it was close up to the top of the boiler barrel and was perforated with tiny holes on its uppermost side throughout its length. It has not been practicable to follow the same arrangement in the model because we are compelled to place the regulator box lower down, so at the back end over the firebox I have carried two smaller pipes upwards from the steam-collecting pipe with their upper ends close to the highest point of the steam space. These two tubes will be silver-soldered in the main pipe, which means that the steam-collecting pipe will have to be inserted before the drum-head front tube plate is put in position. After the boiler is riveted up, the ends of the steam-collecting pipe will be expanded and flanged over.

As I have said, only the experienced locomotive model-maker is advised to undertake the building of one of these engines, and he will know how to set about the construction of the boiler. I would merely mention, however, that it is intended that the firebox shall be inserted after the shell is riveted together, and that the flue tubes, of which there are 20, having a diameter of $\frac{3}{8}$ in., are inserted, expanded and beaded afterwards. For supporting the flat crown of the firebox I have adopted roof girders, which can be either of *T* section steel or cast gunmetal riveted to the firebox plate. There are three of these which will be shown later in a cross-section.

The Valve Gear

Since the prototype engines were, as everybody knows, designed by Daniel Gooch, afterwards Sir Daniel, it follows as a matter of course that the valve gear of all broad-gauge engines built at Swindon during his term of office were fitted with the valve gear which he invented and which is known by his name. It is of the radial type with fixed oscillating expansion link. The eccentrics and link differ from the Stephenson gear only in the fact that the curvature of the link is turned the opposite way. The link does not rise and fall, but is carried in suspension links which vibrate an amount equal to twice the lap of the valves. Between the expansion link and the valve spindle there is a radius rod, exactly as in the Walschaerts gear. This radius rod can be moved by the reversing gear to any point above or below the centre of the expansion link. With the crank on either the front or back dead centre, movement of the radius rod upwards or downwards produces no movement of the valve, and it will thus be seen that in all positions of the reversing lever the lead of the valve is constant. In this it differs from the Stephenson gear, and has the same merit as the now-so-popular Walschaerts gear.

The Gooch gear was never received with very much favour in this country, though it has been extremely popular in Continental locomotive practice. Apart from constant lead the operation of the gear was very much easier, since the driver had not to move the whole weight of the eccentric rods and expansion links. The only disadvantage, if there was any, was the angularity of the drive between the eccentric, which was in gear, and the valve spindle; though, as will be seen from my drawing, Fig. 8, the angles were comparatively fine. In the full-size engines Gooch provided guides for his valve spindles behind the point of attachment of the radius rods to the valve spindles; that is to say, behind the valve rod cross-heads. These bearings were carried up from a bar running across between the bottom slide bars, to which it was bolted. In the model I have thought these supports for the cross-head unnecessary.

(To be continued)

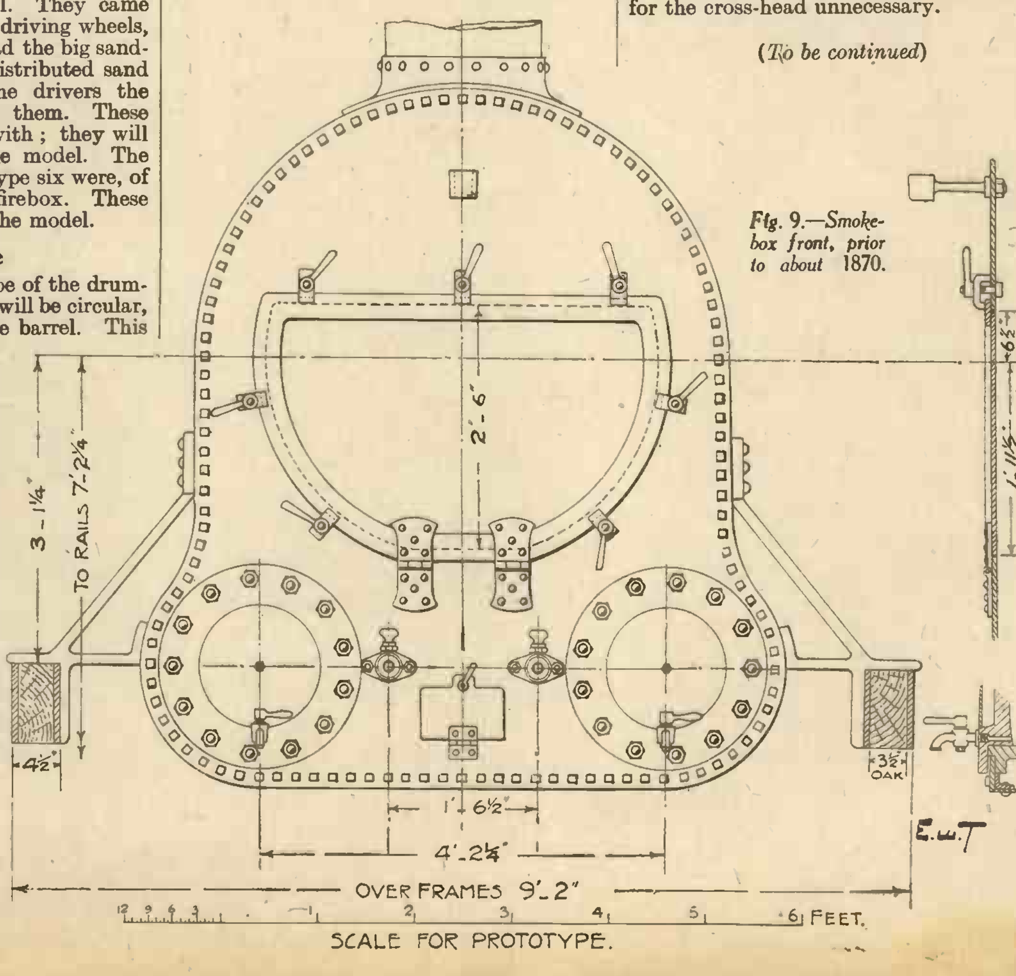


Fig. 9.—Smoke-box front, prior to about 1870.

INTERESTING MODELS OF MECHANICAL MOVEMENTS

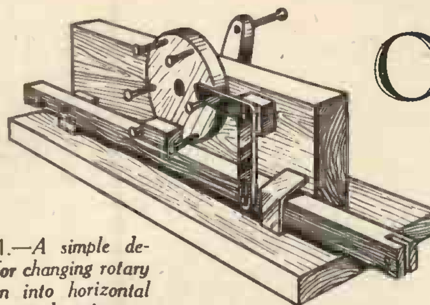


Fig. 1.—A simple device for changing rotary motion into horizontal or vertical motion.

By Fredk. Jace

IT is often possible to devise from wood and nails and pieces of tin little mechanisms of an interesting and instructive nature. These mechanisms, three of which are shown here, may be applied in a variety of ways to other models. They are not new, for you will find them used in spinning machinery, steam engines, pumps, etc., and they were invented so long ago that their origin is lost. In the South Kensington Museum a room is specially devoted to models of mechanical movements, and very fascinating they are.

Merely a Device

A machine is merely a device for altering the magnitude, point of application, or direction of a force, and it is by means of these typical devices that a machine is enabled to carry out its object. For example, if we wished to change rotary motion such as that described by a crank into horizontal motion, we may do it in a variety of ways, one of which is indicated in a simple manner in Figs. 1 and 2. A wooden disc has nails knocked in it at right-angles to the circumference and at equal distances. It will be seen that when the handle is turned these nails will catch upon the crank, and so push the square rod to the right. When the crank is moved down half the distance between two of the nails the nail runs over its end, and the next nail hits the small block on the right and pushes it back. This nail then slides off the top of the block, and at this moment the crank pushes it back to the right, so that as long as the wheel with the nails in it rotates, the square rod will be pushed backwards and forwards. You will easily be able to make this by following the details given in Fig. 2.

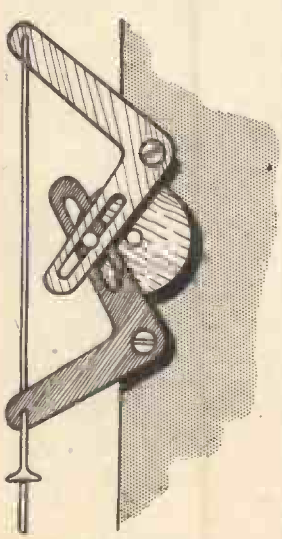


Fig. 4.—A device for giving up-and-down motion to two rods.

A Simpler Method

Fig. 3 shows a simpler method of achieving the same result. In this diagram the rod with the rectangular hole in it moves back and forth three times for one revolution of the cam-shaped wheel. This wheel has sides which are part of a circle drawn from the point of the opposite side, the three points themselves making an equilateral triangle; the spindle must, of course, be secured exactly in the centre. The height of the rectangular slot must be $\frac{1}{8}$ in. greater than the distance from one point of the cam to the centre of the opposite curve, and the slot must be somewhat wider than it is high. Fig. 4 consists of two right-angle cranks, which are slotted to allow a pin secured to a revolving disc easily to pass through. To each crank is attached a rod so that when one crank is up the other one will be down. This movement transmitted to the two rods will provide a mechanism giving alternate up-and-down motion.

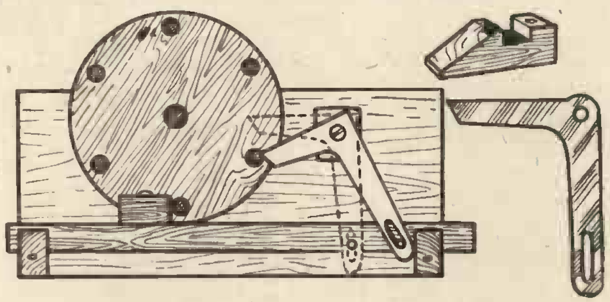


Fig. 2.—Elevation of Fig. 1, and details of the crank and guides.

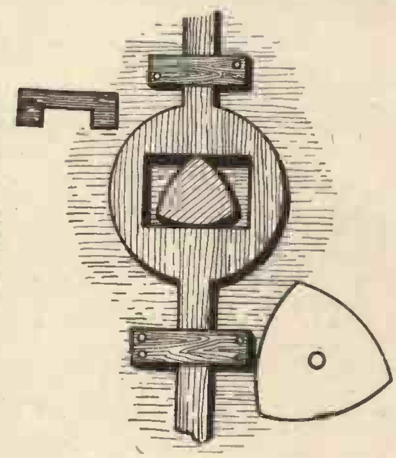
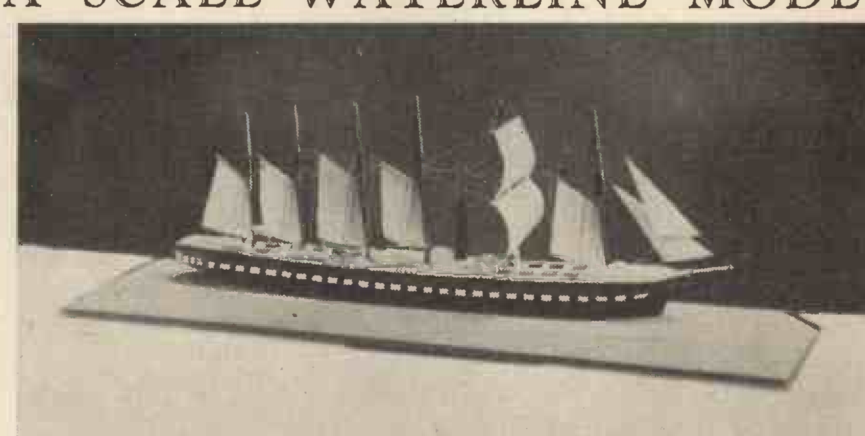


Fig. 3.—Another mechanism for changing rotary motion into horizontal or vertical motion.

A SCALE WATERLINE MODEL



THE above illustration is of a 50-ft.-to-the-inch waterline model of the famous ship *Great Britain*, which was the first screw steamer to cross the Atlantic. The model is supplied by Messrs. Bassett-Lowke Ltd., Northampton.

A Correction

We should also like to point out an error that occurred in Messrs. Bassett-Lowke's advertisement on page 228 of our last month's issue.

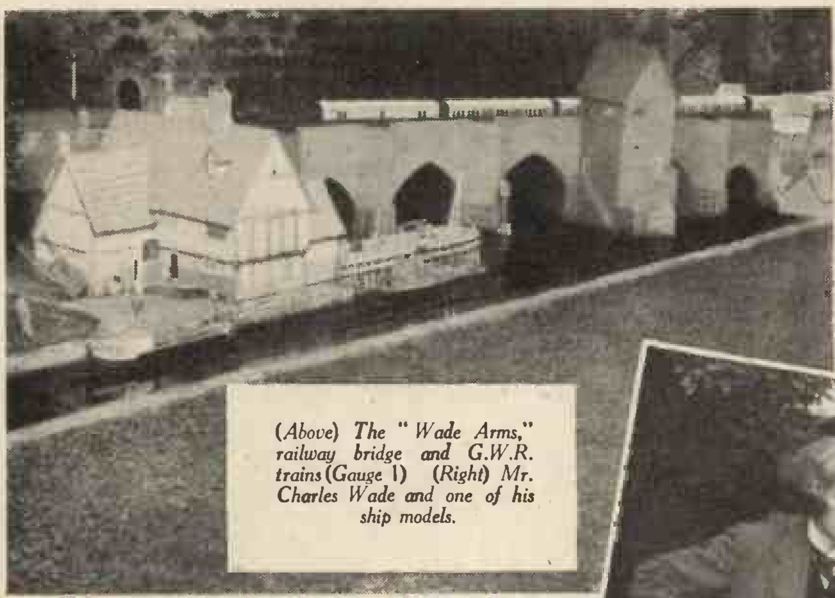
Under the illustration of the 0-6-0 goods locomotive the price was given as clockwork and electric, D.C., 6-8 volts, 35*s*. This should have been 28*s*. 6*d*. for clockwork and 35*s*. 6*d*. for the electric.

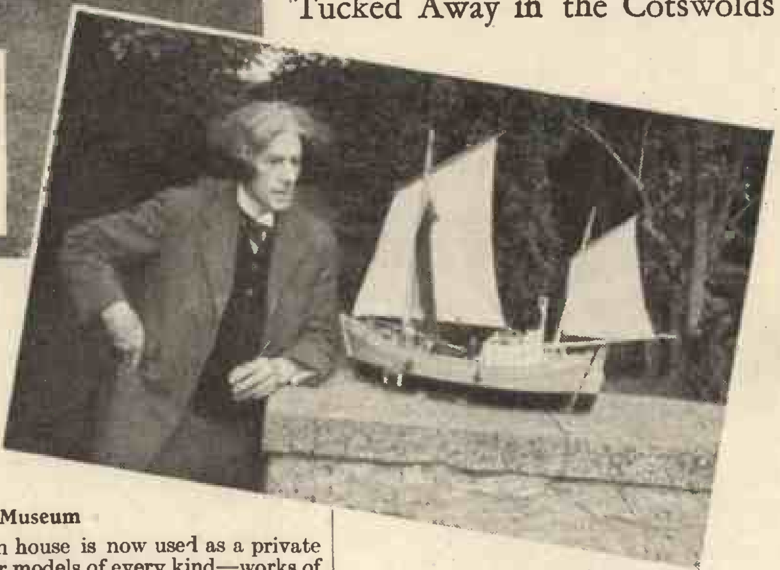
Interested readers should write to this firm for their model-railway catalogue A.12, obtainable for 6d. post free.

A LILLIPUTIAN VILLAGE IN THE COTSWOLDS

By W. J. Bassett-Lowke

Details of a Scale Model Village Tucked Away in the Cotswolds





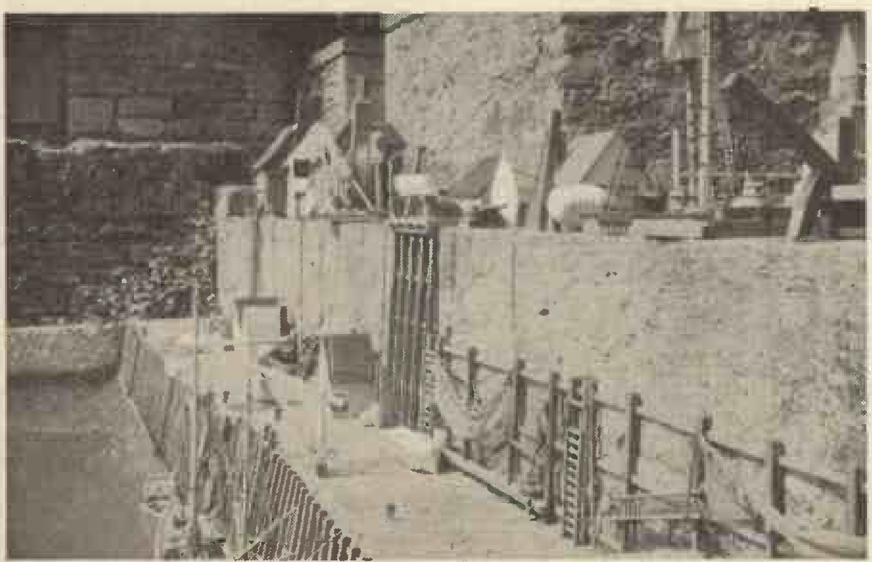
(Above) The "Wade Arms," railway bridge and G.W.R. trains (Gauge 1) (Right) Mr. Charles Wade and one of his ship models.

NOT far from the picturesque village of Broadway in Worcestershire, one of those ideal spots which intrigue our visitors from across the Atlantic, is a quiet manor house called Snowshill Manor, the home of Mr. Charles Wade.

This old house and the manors built on the site before it have a fascinating history. In the olden days it is said British kings and queens have passed a sojourn there, and it has among its owners famous—or infamous—noblemen like Edward Seymour, who ended his ambitious life on Tower Hill in the day of Lady Jane Grey. A famous owner of the manor was Katherine Parr, last wife of Henry VIII, who bestowed it upon her. In those days the Manor must have been the scene of many a gay reception, but now it is a peaceful retreat. The garden is tenanted by beautiful fantail doves, whose melancholy cries merge harmoniously with the weathered buildings and the rustle of the trees in the terraced gardens.

A Private Museum

The main house is now used as a private museum for models of every kind—works of sculpture, curios from many lands, and relics that have come down to us from history. There is a music room, a room of model ships, ancient Dutch vessels, Spanish galleons, etc., but among the various interesting objects in Mr. Wade's possession his favourite is a wonderful Japanese carving of a man, so lifelike that the very veins stand out on arms and legs, and every muscle is perfectly delineated with a master's skill.



The upper and lower quayside with its numerous models of familiar harbour equipment.

In the garden I found what I had come to see, for not knowing Mr. Wade's work as a collector was equal to his model making, I had made the visit with the especial intention of viewing his famous model village in the garden.

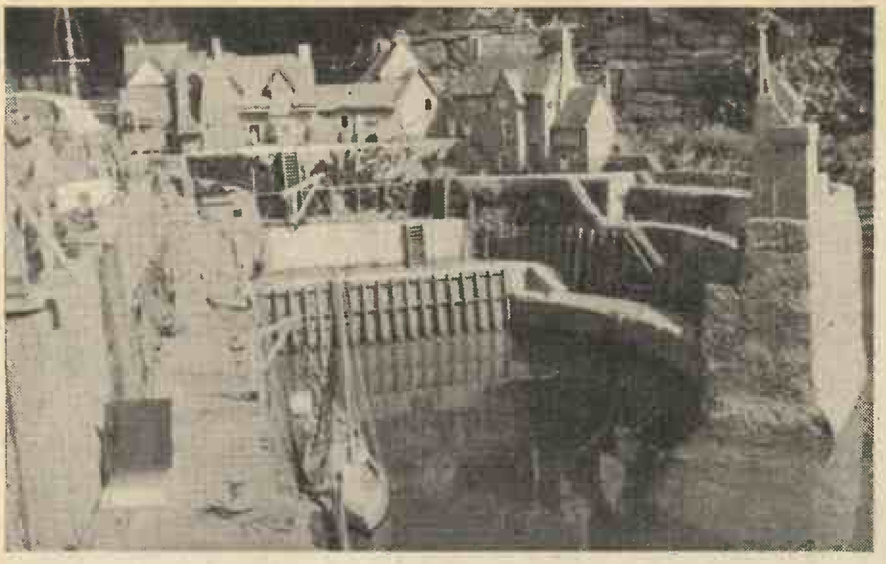
Miniature Fishing Village

We came to a pool lined with concrete with water filtering in by pipe and out on the opposite side, and there, standing on the slope, sheltered by trees, was a miniature fishing village, as it might have been in the seventeenth century.

The photographs which accompany this article will help to show the work which has been put into this wonderful little village, and the lifelike appearance it presents to the onlooker, from the tiny garden gates set in the rock to the large stone breakwater of the miniature harbour, is amazing.

I looked around the harbour with its ship drawn in alongside, with boats and fishing tackle abounding on the quay, nets hung out to dry, mooring chains, signalling lamps, buoys, old capstans, and the interesting old light-house at the head of the breakwater.

Along the quayside is also the popular "Lord Nelson," which might be described as the fisherman's or boatman's inn, frequented by those whose small boats are in dock. It is said that this inn is so realistically made that a friend of Mr. Wade's was asked by a man who had seen a photograph of it, and had travelled much in Cornwall, where this particular inn was on the Cornish coast, because he thought he knew every inn in the shire and was unable to locate it.



An inner view of the harbour and the picturesque houses surrounding it.

The actual figures of the sailors grouped around the inn and on the quay are extremely lifelike, and the whole place made me feel like Gulliver amid the Lilliputians.

"The Wade Arms"

On the canal side is another characteristic inn named, appropriately, "The Wade Arms," where the barges pull up and the bargees call.

Among the groups of houses by the fishing huts is the post-house with its stables, and not far off the cyder mill. Leaving the quay a large, important-looking manor house comes into view, with its spacious garden of small plants, its clipped bushes, and close by is the village church. High up the hill at the back of the village is an old farm house with its buildings and outhouses, sheds and stables, and its wagon drawn by horses in the yard.

The little houses, all of dun-coloured weathering stone, are set among small tree-like bushes of French lavender, and farther up the slope I found the wheelwright's shed with all his tools displayed, and the shipwright's, who from the look of things was at work on a dinghy, with coils of rope and other nautical gear stacked around.

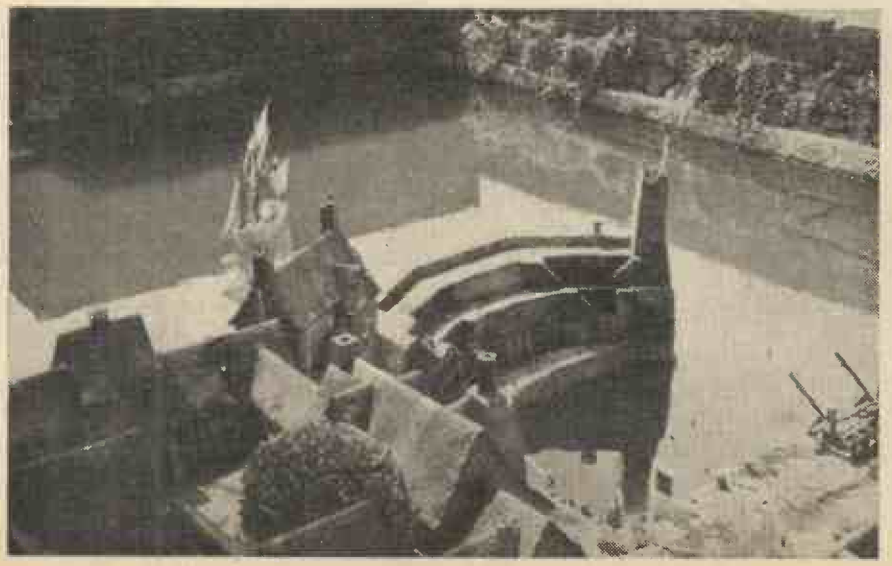
Harbour Station

Twenty years ago this lifelike village began to come into being from one small house, which Mr. Wade made for a small girl convalescing at the Manor from an illness. It is amazing to think how many hours of patient work must have gone to the building of it. Nothing seems to have been forgotten. The houses are all of wood, coloured to represent stone, and covered with a thatch made of Chinese matting. They stand the weather well, but every winter the village is taken indoors and reconditioned and returns to the garden with the first flowers of spring.

Let it not be thought that Mr. Wade was not alive to the progress of time. He has now added a small picturesque terminus station at the upper end of the village called the "Harbour Station," and although smart modern G.W.R. trains and coaches, made by Messrs. Bassett-Lowke, Ltd., run into the terminus, this does not detract from the old-world charm of the village, but makes a striking contrast.

Apart from the fact that the village is accurately built to a scale of ½in. to the foot, which gives marvellous realism, the unique feature of it is that it is so full of small details, which are treated in an artistic manner by one who is a student of detail and an architect by profession.

A village at the back of the harbour.



The harbour and old lighthouse at the end of the breakwater.

SCIENTIFIC OBSERVATIONS

MANY years ago a young biologist noticed that certain types of snails which live in the Potomac river are never found in the tributaries, and some that live in the tributaries cannot live in the main river. He found that the reason was that the river water is slightly alkaline, while that of the brooks was slightly acid and that some snails can live only in acid water and some only in alkaline.

This observation might have had little practical use, but for the recent discovery that a terrible oriental disease, schistosomiasis, is caused by a tiny worm which lives its early life in a certain snail of the "acid" type. Countless thousands have died annually throughout China and Japan from this scourge, but now these two chance discoveries have shown how the disease can be eliminated. By dumping quantities of crushed limestone along the banks of the rivers, the water is made alkaline, the snails die, and so does the disease.

STARGAZING FOR AMATEURS

A NEW SERIES

By N. de Nully

A GUIDE FOR FEBRUARY

SUNSPOTS are increasing in size and frequency. Several of naked eye visibility have appeared during the last couple of months. Giant specimens, either isolated or in pairs, may show themselves any day. The solar disc should therefore be scrutinised at every favourable opportunity, care being taken to use a safety eyepiece or a heavily smoked glass as a screen. A fine photograph of a huge spot accompanied by a lesser one is here reproduced; they are about to disappear over the " limb " or edge of the sun. That they are yawning cavities and not merely surface markings, is very evident.

The moon will be at first quarter on the 18th. Numerous magnificent formations will come into sight shortly before, during and after that phase. Among the most Earth-like are those massive mountain ranges of the northern hemisphere, the lunar Apennines, Caucasus Mountains and Alps. These lofty piles border the western " shores " of the vast Mare Imbrium, one. of the most extensive of the so-called seas Rising in sloping foot-hills on one side and dropping abruptly in precipitous cliffs on the other, their summits bristle with hundreds of peaks some of which tower to a height of 18,000 ft. In the " aerial " view on this page, the Apennines form the upper, the Caucasus Mountains the middle and the Alps the lower sections of the curving chain. A remarkable feature of the last mentioned is the Great Alpine Valley, a straight, wedge-shaped gorge 80 miles long and four to six miles in breadth; it can be distinctly seen in the illustration.

Ring-Mountains

On the level plain within the arms of these encircling buttresses lie several conspicuous ring-mountains. The largest, Archimedes, is half in shade, its terraced borders (of an average height of 4,000 ft.) catching the rays of the rising sun. It is 50 miles in diameter and the otherwise smooth floor is pitted with crater cones. A 3-in. refractor or 6-in. reflector will show these and many other details of the entire moonscape with astonishing clearness.

Of the planets, Mercury and Jupiter rise too near daybreak to be perceptible, and Mars is as yet too much a morning star to be conveniently observed. Saturn, though still an " evening star " in the western sky for a couple of hours, will soon be lost in the glare of sunset. After passing beind the sun in " inferior conjunction," it will reappear in the dawn in early summer. Venus grows brighter and sets continuously later. It is a dazzling object fairly high up in the evening twilight and its phase is now a " half moon." It is not yet at its greatest brilliancy.

The Winter Pageant

The usual winter pageant of the stellar host will irresistably attract attention in the south—especially during the moonless nights of the second week of this month. Most conspicuous is, of course, the constellation Orion with its well-known " Belt " of three stars. These seemingly small bluish-white points of light are actually colossal suns and among the hottest known. They consist of globes of incandescent helium gas, each emitting four times as much light as our own sun. Long-exposed photographs reveal that the whole of the constellation is enveloped in a thin nebuous haze, which is believed to be due to vast clouds of cosmic dust dimly illuminated by the stars immersed in it. This celestial fog is thickest where it surrounds the six suns forming the multiple star Orionis, not far below the left hand component of the Belt. The glow of their radiance through the translucent medium is perceptible to unaided vision as a misty patch. Even a binocular will indicate its nebulous character; and a small telescope will show it as a ragged-edged luminous cloud suggesting a ghostly bird with outstretched wings. Photographs taken at the big observatories disclose a complicated structure with far extending wisps and streamers.

A pair of large sunspots about to disappear over the edge of the sun's disc.

A Solar Giant

A little distance above and to the left of the Belt is Betelgeuse, a rather dull reddish solar giant, having a diameter 300 times that of the sun. It is a remarkable instance of a " pulsating " star which, at irregular intervals, alternately shrinks in width from 260,000,000 miles down to 180,000,000 miles. This abnormal behaviour implies a comparatively small solid core, enclosed in a contracting and expanding gaseous shell of enormous thickness, and in a state of violent commotion. To the right of Betelgeuse is Bellatrix; while below, and to the left of the Belt, is K. Orionis. Both are colossal suns at a white heat. To the right of K. Orionis shines Rigel. This superb intensely brilliant star sheds about 15,000 times the light of our luminary. It has a relatively diminutive " companion " of material similar to itself; but so close as to almost touch. The average distance of the Orion family of suns (except Betelgeuse which does not properly belong to the group) is about 600 " light years."

The Great Dog

To the left of Orion and slightly lower, is the little constellation Canis Major (the Great Dog). It contains Sirius, popularly known as the Dog Star, and the brightest in all the heavens. Sirius is also the nearest star to us that is visible from these latitudes. It is however, neither the largest nor the closest to the solar system; being barely twice the diameter of the sun and nearly nine light years away. Sirius has a unique companion of such unusual density that a single cubic inch of it weighs a ton! Farther still to the east and higher up, flashes Procyon in Canis Minor (the Little Dog). Pale yellow in colour, it likewise has a companion, which is perceptible only in very large telescopes. Above Procyon will be noticed the striking pair Castor and Pollux. They are the chief stars of Gemini (the Twins). Castor consists of two components of equal brightness and a small instrument will easily separate them. Each of the pair is a spectroscopic double. In the zenith shines Capella in Auriga (the Charioteer), ranking third in brilliance among the stars of the northern hemisphere.

The Milky Way

Finally, as if to add to the magnificence of this richly jewelled quarter, the white powdery track of the Milky Way passes diagonally across it. This wondrous arch of infinitely remote suns is thickly strewn with multitudes of glittering points of light. The crowding is noticeable where it traverses the constellation Monoceros (the Unicorn), lying between Sirius and Procyon.

The lunar Apennines, Caucasus Mountains and Alps. Note the Great Alpine Valley and the spire-like shadows cast by the higher peaks.

NEW INVENTIONS

The following information is specially supplied to "Practical Mechanics," by Messrs. Hughes & Young (Est. 1829), Patent Agents, of 9 Warwick Court, High Holborn, London, W.C.1., who will be pleased to send readers, mentioning this paper, a copy of their handbook, "How to Patent an Invention," free of charge.

The Sex of Eggs

CHANTICLEER with his fine feathers is a handsome fellow, but, commercially, his less showy spouse is the better half. In other words, the hen is more profitable than the cock. Now, the poultry farmer cannot count his chickens before they are hatched, but I am informed that he is, at least, able to determine the sex of his eggs. An inventor has just patented an improved device for this purpose.

The eggs are placed in a box in a vertical position with the pointed ends upwards. They are illuminated from below with a light of from 40 to 60 candle power, and the embryonic rooster can be recognised by the fact that a dark and a bright part are visible in the egg. With the female sex, there is either a dark or a bright spot, but not a double effect. The eggs which have not been fertilised do not give any effect when the light shines through them. They can, therefore, be withdrawn as unsuitable for hatching.

From an economical point of view, it is important to be able to determine with certainty the sex of the bird before the incubating process. As a consequence, the breeder can, from the beginning, avoid the unproductive rearing of the less valuable male bird. By the way, it is asserted that one cannot tell the gender of a hatched chick until after about four weeks.

The detection of the sex of eggs is not limited to those laid by farmyard hens. It is, for instance, useful in the case of the family of birds, of which the most eminent representative is Donald Duck.

Walker Under Water

THE equipment of a diver is generally somewhat expensive and cumbersome. An inventor has recently aimed at producing a simple, cheap and effective apparatus making it possible for a person to walk under water.

The device comprises a mask similar in shape and size to a gas mask. This mask is connected, by means of a length of flexible tubing, to a float. The latter is provided with a valve so constructed that, should the float be submerged, the valve automatically closes, thus preventing water from entering the tube. On the other hand, when on the surface, the valve opens with equal facility. It is obvious that the diver must carry sufficient weight to keep him submerged.

In these times of war and rumours of war, it is interesting to note that the inventor suggests that this device might be used as a protection against mustard gas or other noxious fumes. He states that the wearer could immerse himself in a pond. In such a contingency, an anti-gas substance would be incorporated with the mask. It is possible, therefore, that beneath the surface of our bathing pools there will one day be found a crowd of temporary water-sprites.

A Stirring Idea

WHEN "everything stops for tea," it is a familiar sight to see the housewife stir the contents of the teapot with a spoon. There has recently appeared on the scene a teapot with a gadget in the lid which enables one from the outside to stir the tea within the pot. This rotatable stirrer is shaped like a spoon.

Antidote to Paw Prints

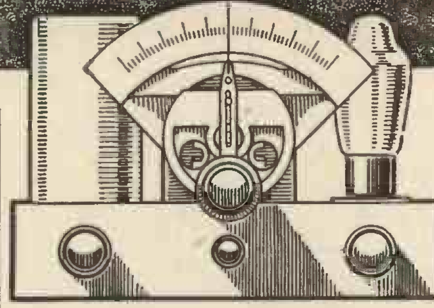
FOOTWEAR for dogs has not been unknown in the past, but an improved boot or golosh for these faithful pets has been introduced. This is made of waterproof material and has a sole attached. If it does not prevent the canine species from contracting the prevailing epidemic, the removal of the dog's boots after a walk will prevent him from leaving behind him footprints upon the linoleum.

A Crooked Tube for Drinking

SCHOOL children and others imbibe many gallons of milk and soft drinks through a straw. An American has now devised, for this purpose, a glass drinking tube with a bent portion somewhat like the crook which a cornet player fixes to his instrument to change the key. The idea seems to be to lure the young to take nourishment by exciting their curiosity. The liquid, the movement of which can be watched through the transparent glass, naturally follows a circuitous route. In short, as Mr. Micawber would have said (I almost wrote "would have condensed it"), the milk "goes round and around."

DYNAMO.

The PRACTICAL MECHANICS WIRELESS EXPERIMENTER



USING THE TELEVISION TWO

Further Operating Notes and Suggestions for Making a Wider use of this Interesting Ultra-short Wave Two-valve Receiver

AS was mentioned last month, the aerial is a critical part of the ultra-short wave receiver. A large aerial will not give increased volume, as might be expected, but will so damp the receiver that it will fail to act. In view of this, therefore, it may be found worth while to experiment with various forms of coupling the aerial to the tuning coil. It was suggested last week that the aerial lead could be twisted two or three times round a short thick wire attached to the aerial terminal, but it may be found worth while to make a single turn of thick wire and place this near to the aerial coil, connecting the aerial and earth to the ends of the single turn of wire.

The Aerial Coil

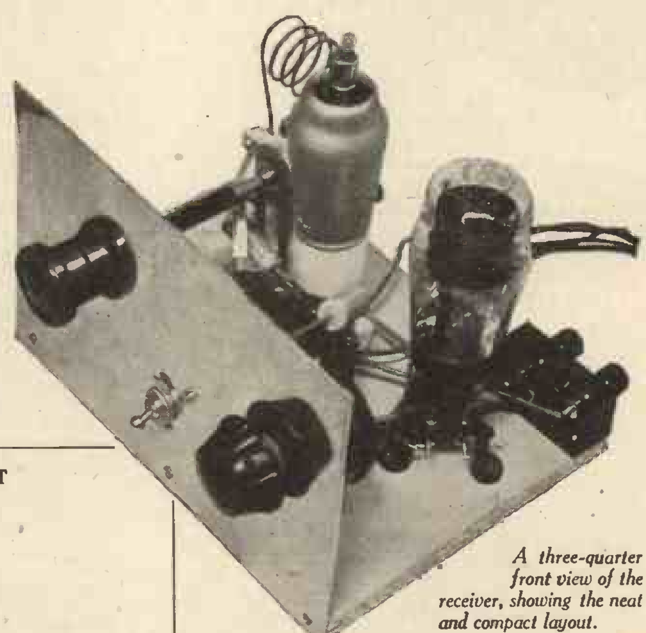
Its position also can be varied with a view to obtaining the most efficient working point. No signals will be heard until the potentiometer has been set so as to cause oscillation, and this will be indicated by a rushing noise. Remember that this noise ceases when a signal is tuned in, and if you rotate the tuning condenser and no signals are heard, the potentiometer should be adjusted still further. If correctly wired, and ample H.T. is used, this control should be capable of being set to a certain position where no further adjustment is required, and the receiver will "quench" throughout the entire range covered by the coil which is specified.

Other Ranges

Although it may be possible to hear one or two amateurs on the very lowest range covered by the set, that is, with the condenser at zero, it may be thought desirable to use the receiver for lower wavelengths in order to hear transmitters on the 5 metres band and below. For this purpose one turn may be cut out of the coil, simply by untwisting it and cutting off at such a position that the end may be connected to the fixed vanes of the tuning condenser, and a single turn of wire as already mentioned soldered to the aerial and earth terminals for aerial-coupling purposes. To many listeners the amateur band will probably offer the most interesting entertainment as there are not only many two-way communications which may be picked up, but the various technical subjects which can often be heard under discussion will afford valuable information to the beginner.

Sharp Tuning

It should be remembered, however, that in view of the extreme sharpness of tuning, it is imperative that the control knob be operated slowly, and when it is desired to hear one transmitter answering another the adjustment which may have to be made in the tuning may easily occupy so much time (until the operation has become familiar) that it may be found impossible to make the change over in time to hear the reply. However, after the receiver has been in use for some time the tuning will become familiar and will be found very little different



A three-quarter front view of the receiver, showing the neat and compact layout.

from ordinary broadcast tuning except for the small movement which has to be made to cover quite a large number of stations.

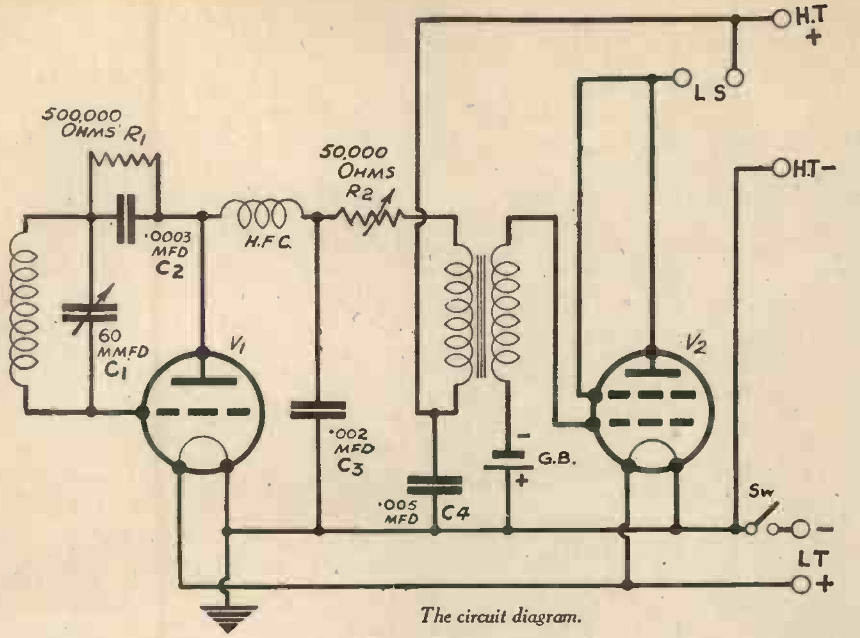
The "Q" Code

When making your first acquaintance with the amateurs you may be confused by the apparently unintelligible terms used by them. There is a standard code employed in which groups of three letters of which the first is "Q," are continually used. Consequently, this is known as the "Q" code and includes many phrases which are in common use. Thus the address of a transmitter is referred to as QRA, and QRM is used for interference. These groups of letters are used in the form of both question and answer. Thus "What is the address of your station?" would be translated as "What is your QRA?" or if the operator is using the Morse code he might even abbre-

THE "TELEVISION TWO" COMPONENT LIST

One U.S.W. Tuning Condenser (S.W. 106) (Bulgin).
One L.F. Transformer (3/1) (B.T.S.).
One Extension Rod (4 in.) (Bulgin).
One 4-pin S.W. Baseboard-mounting Valveholder (Clix).
One 5-pin S.W. Baseboard-mounting Valveholder (Clix).
One On-off Switch (type S. 80) (Bulgin).
One U.S.W. Choke (type H.F. 21) (Bulgin).
One 50,000 ohms Potentiometer (VC 36) (Bulgin).
One 500,000 ohms Resistance (1 watt) (Dubilier).
One ·005 mfd. Fixed Condenser (tubular) (Dubilier).
One ·002 mfd. Fixed Condenser (tubular) (Dubilier).
One ·0003 mfd. Fixed Condenser (tubular) (Dubilier).

Wooden baseboard, size 8 in. × 6 in. (Peto Scott).
Aluminium panel, size 8 in. × 7 in. (Peto Scott).
Two valves (types D210/SW, Y/220) (Hivac).
Quantity No. 16 S.W.G. bare copper for coil (Bulgin).
Quantity No. 18 tinned copper for wiring (Bulgin).
Flex leads for battery connection (Peto Scott).
Two lengths of sleeving (Peto Scott).
Two terminal blocks with A, E and L.S. terminals (Belling Lee).
Four plugs, GB +, GB −, HT −, HT + (Belling Lee).
Two spades, LT −, LT + (Belling Lee).
One component bracket (Peto Scott).
Telephones (Ericsson).
Loud speaker—37 J (W.B.).
Accumulator—2-volt (Exide).
Batteries, H.T. 120 volts, G.B. 9 volts (Drydex).



The circuit diagram.

viate it to " QRA ? " As many amateurs do employ the Morse code it is necessary to learn this if you wish to increase the entertainment value of the receiver. From His Majesty's Stationery Office, Kingsway, London, W.C.2, you can obtain a publication giving the " Q " Code in full, and there are also several publications in which the Morse Code is given.

Component Values

If it is desired to use this receiver as the basis for experimental work it may be found that considerable experience may be gained by experimenting with different values of condenser and resistance in certain parts of the circuit. For instance, the value of the grid leak specified, R1, is 500,000 ohms, and the grid condenser ·0003 mfd. Changes in these are permissible, and it may be found that with the particular valve in use, and the setting of the potentiometer R2, a combination may be found which will give an increase in the volume which is obtainable, or in the range covered by the receiver. Similarly, the value of the condenser C3, specified as ·002 mfd. may be increased up to ·006 mfd. in some cases with advantage. A great deal depends upon local conditions and the particular characteristics of the valve which is employed.

Above 9 Metres

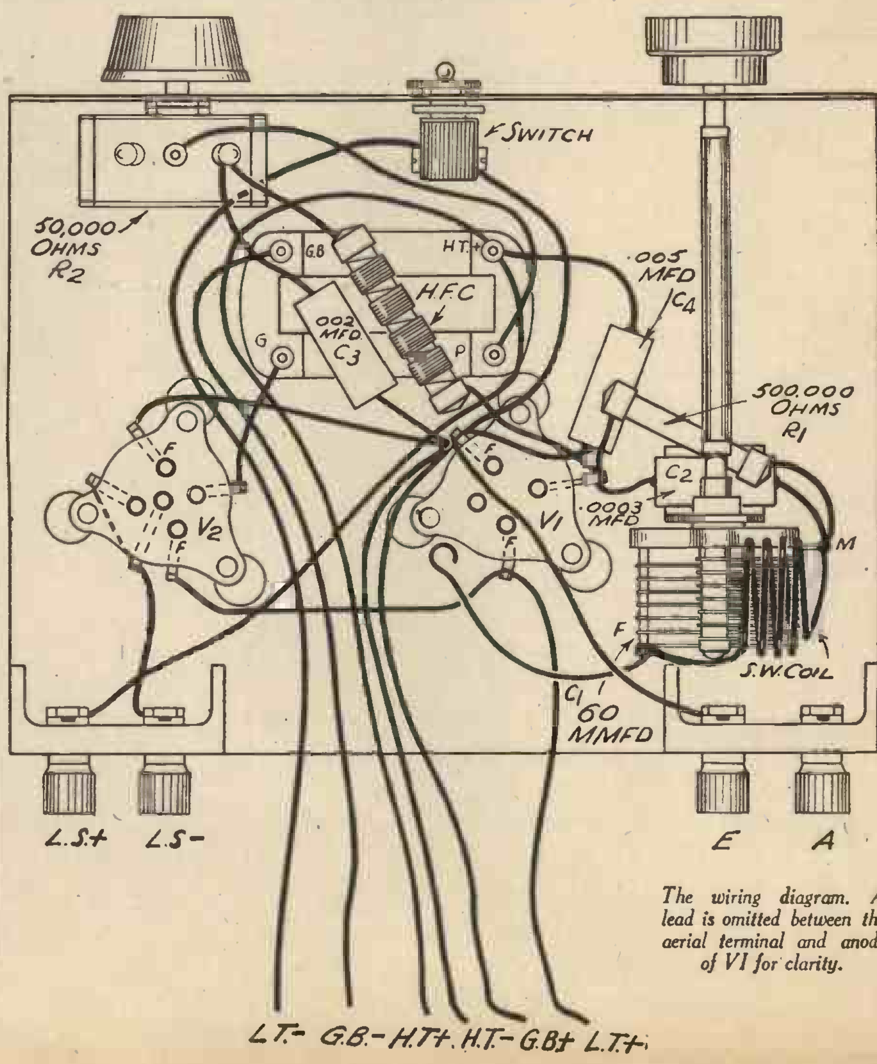
If it is desired to use this receiver on higher wavelengths than 9 metres, it should be borne in mind that the circuit arrangement is not recommended for use above 100 metres. On the 9-metre band, which may be covered by using a coil having two turns more than specified in the original design, the American Police broadcasts may be heard under favourable conditions. The familiar " Calling All Cars " comes through quite strongly under good conditions and it may even be found that the signal will be as loud as your local, in spite of the small power which is employed.

To hear the weaker stations, and to assist n searching, a sensitive pair of headphones should be used. The 'phones specified in this case are those manufactured by Ericcson Telephones Ltd. and the resistance which should be chosen is 4,000 ohms. These will be found very sensitive and will enable you to tune in dozens of very weak stations which would otherwise be unheard. A change-over switch may be fitted if desired, so that when a station has been located on the 'phones the switch may be operated and the speaker brought into use.

Undisturbed Listening

Alternatively, it may sometimes be found desirable to listen on headphones in order to prevent other people from being disturbed by the signals. This is especially the case if you intend to listen into the early hours of the morning in order to pick up the American stations and amateurs. In this case the headphones may then be connected in place of the primary of the L.F. transformer, and again a change-over switch may be fitted if desired in order to avoid the necessity of changing from one to the other. It is not necessary to arrange filament switching to cut out the second valve in this case as it may give rise to troubles due to the additional wiring which would be required.

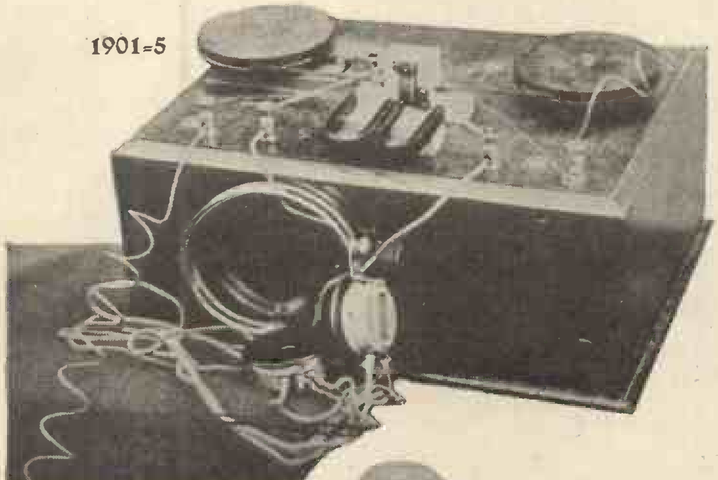
Many problems of short-wave transmission, such as the apparent proof of the fallacy of the optical range of ultra-short waves. may be investigated, and to conclude we may mention that using a circuit of this type, the present Alexandra Palace television transmissions have been picked up in South Africa, in spite of the fact that it is stated that the signals are only effective over a radius of about 25 miles from the transmitter.



The wiring diagram. A lead is omitted between the aerial terminal and anode of VI for clarity.

THE BIRTH OF THE WIRELESS RECEIVER

1901-5



1910-14

(Above) An early Marconi magnetic detector, period 1901, the predecessor of the crystal detector.

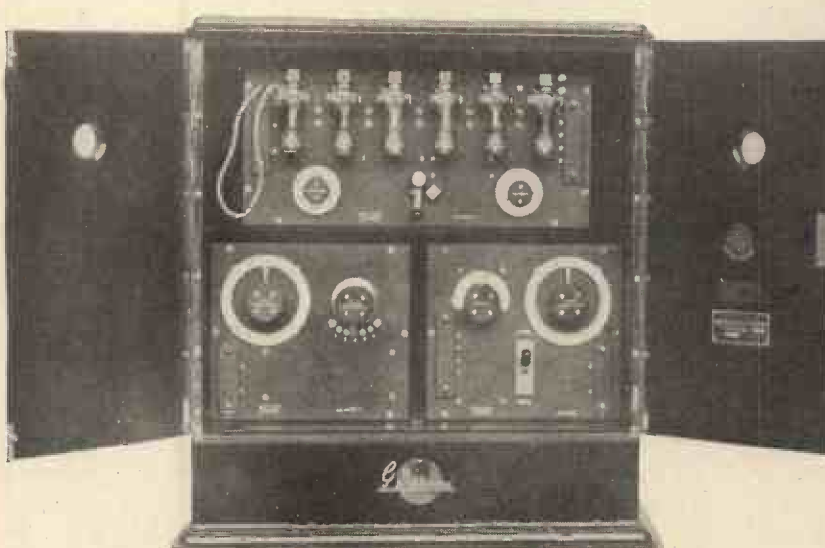
A Marconi crystal receiver, period 1910–14, as used in many ships' installations.

(Right) An early Marconi valve-crystal receiver employing two of the V24 "test-tube" low-capacity valves, period 1919–20.

1919-20

1937

The H.M.V. radiogram, which is a typical example of a modern receiver.



1923

A Marconiphone 6-valve battery receiver, period 1923, which cost £83 yet was for headphone reception only.

The Peculiarities of Pressure

Many Surprising and Fascinating Phenomena are to be Observed in the Most Commonplace Processes and Materials when Conditions of Atmospheric Pressure are Rendered Subnormal

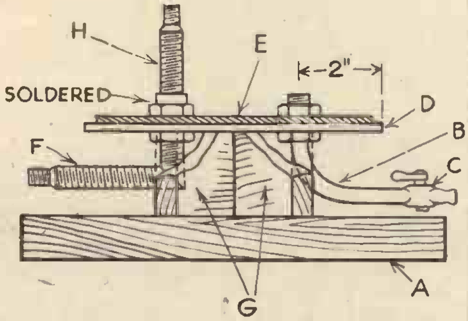
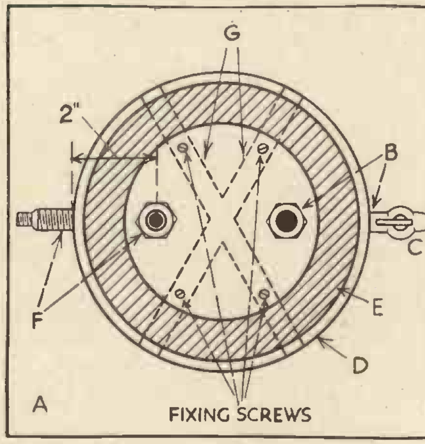


Fig. 1.—A simple yet efficient air-pump. The exhausting platform. A. Baseboard 10 in. × 10 in. × 1 in.; B. Bent gas-pipe; C. Gas-tap fitted to B; D. Metal plate 7 in. diameter, about ⅛ in. thick; E. Rubber gasket ring, 6½ in. overall diameter; F. Right-angled Schrader tyre valve without " inside"; G. Platform support, 2 pieces of ½-in. wood, each 7 in. × 2 in.; H. Ordinary short tyre valve with " inside."



THE necessity for man to, as it were, carry his own atmosphere with him if he were to venture into the realms of space, or even into the rarefied upper reaches of the troposphere, brings to our minds very forcibly the fact that we carry an average atmospheric pressure of fifteen pounds to the square inch of surface, and that, quite apart from our physical well-being, all our conceptions of scientific and natural conditions are based on atmospheric conditions being maintained.

Unfortunately an efficient air-pump is not within the range of every hobbyist's purse, for the commercial instrument is an expensive item. We are glad, therefore, to be able to give readers details of a practical and thoroughly efficient apparatus which will function perfectly, yet may be built with the minimum of labour, skill and cost.

A glance at the lists of components attached to the diagrams will show that practically all the material required can be found in the average handyman's junk box; the only item which need be purchased new being an ordinary motor-tyre valve of the "short-barrel" variety, such as is used on the modern "balloon" type of inner tube. This can be got very cheaply at any garage, and its purchase is strongly recommended, as the efficient working of the whole apparatus is dependent on the efficient working of this item in particular. As regards the actual pump, any old, second-hand one will do quite well, as all that is likely to be required will be a new leather cup-washer if the original be worn or leaky.

The general idea of the apparatus will be perfectly obvious from the diagrams, and the changing of the tyre pump from an air compressor to an air exhauster is childishly simple, consisting as it does of the reversal of the cup-washer as shown at C in Fig. 2. Under usual conditions, this washer expands on the down stroke, filling the pump-barrel and forcing the imprisoned air column to depress the plunger of the valve, thus filling the tyre with air. With the cup-washer *reversed* the pump barrel is filled on the *up* stroke, and the resultant suction on the right-angled valve F is communicated to the plunger of the upright valve H, which, as will be readily seen, is soldered to F in such a way that the plunger is sucked downwards, thus drawing air from the vessel or bell on the plate D. The bent valve F has, of course, no plunger of its own.

On the cessation of the suction stroke the plunger of H returns to the closed position by virtue of its spring seating, and remains closed during the down stroke of the pump, opening only on each successive up stroke. Thus air may be drawn from the vessel, but none can be driven into it.

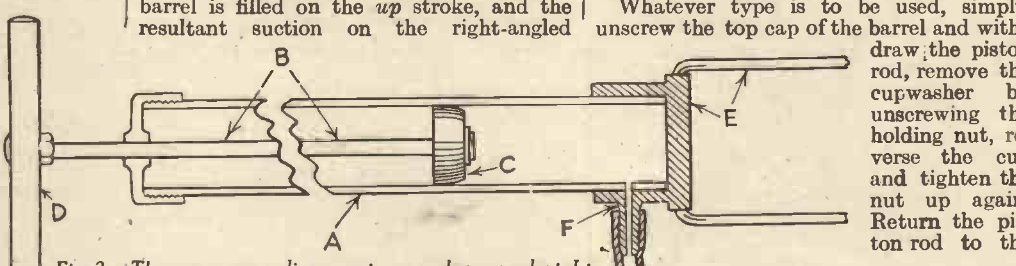


Fig. 2.—The pump—an ordinary motor or cycle pump adapted to exhaust instead of compressing. A. Barrel of pump; B. Piston rod; C. Piston cup-washer reversed: *D. Handle; E. Foot-rest; F. Outlet (now becomes* Inlet*); G. Hose connection; H. Standard adapter for tyre valve.*

The Pump Proper

This may be of practically any type, so long as the rubber hose connection is equipped with an adapter of standard pattern to fit motor-tyre valves. If the hand-pump type is used it may be clamped to the bench or table to facilitate working, while if the foot-type is used it will, naturally, rest on the floor, but care must be taken that the connection is long enough to reach to the valve without any risk of jerking the whole thing off the table.

Whatever type is to be used, simply unscrew the top cap of the barrel and withdraw the piston rod, remove the cupwasher by unscrewing the holding nut, reverse the cup and tighten the nut up again. Return the piston rod to the barrel and put the cap back in place as before.

There is nothing more to do to this part and the pump may be laid on one side or clamped to the bench ready for use later on.

The Platform and its Fittings

This is quite a simple and straightforward job, consisting of a block of wood, 10 in. square by 1 in. thick, surmounted by a cross-shaped support for the metal plate D. This support consists of two pieces of wood, each 7 in. by 2 in., and half an inch thick. These should be crossed as shown at G, with a simple joint where they cross, and screwed to the wood block A in the manner shown in Fig. 1.

The metal plate D may be of iron, steel, brass or any other metal and should be dead level on the surface. Wood, bakelite or even slate may be used if more convenient, only the upper surface *must* be level and perfectly smooth. Metal is undoubtedly best. Lay the plate on the cross-shaped support G, and mark out suitable holes for screwing down as indicated in the diagram. Drill the four screwholes and another two of a size suitable for the valve F, and the threaded end of the gas-pipe B. These last two holes have centres 2 in. from rim of the plate D.

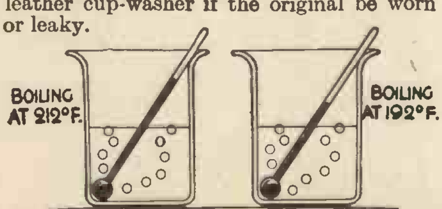


Fig. 3.— Boiling with no heat—Water boils at 212° F. under ordinary pressure (30 in. of mercury), but at 192° F. when mercury falls to 20 in.

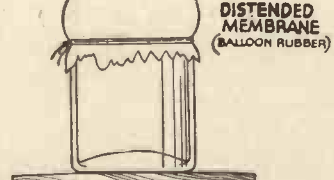


Fig. 4.—The expansion of ordinary air in space. The jam-jar contains air at ordinary pressure, which bursts the membrane as it expands.

Fix F and B to the plate by nuts as shown, making sure they are drawn up good and tight, then screw the whole thing down to G with four screws, as previously explained. Now take your short, straight tyre valve H (this is the one with the "inside"; don't forget) and solder it to the end of F, where the latter protrudes through the top of the plate as shown. The two valves F and H are one now, so that suction on F will draw down the plunger of H.

Lastly, cut the rubber ring, or gasket, out of fairly stout sheeting (an old rubber hot-water bottle will provide the rubber),

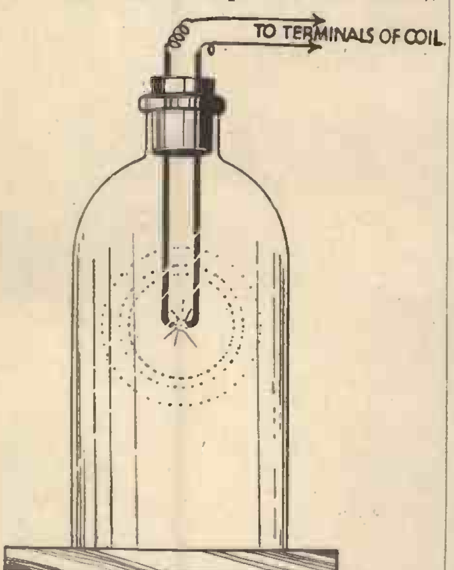


Fig. 5.—Luminous effect of electric spark in partial vacuum. The spark does not "jump" as usual, but sets up a luminous glow as pressure decreases.

making the ring $6\frac{1}{2}$ in. overall diameter and $4\frac{1}{2}$ in. inside.

For general experimental work a glass bell (such as may be found over wax-fruit horrors, ormolu clocks and the like) will be required, with a diameter, across the open end, of from 5 to 6 in. Certain experiments will call for a bell with an opening at the top, and this may be got from a large, clear-glass bottle of suitable size and shape, such as chemicals, cod-liver oil, etc., come in when bought in bulk. Any good glazier will cut the bottom of the bottle off for a copper or two, but be certain that the edge is ground down so that it will sit dead level on the rubber gasket.

Preparations for Use

Having completed the platform and got your glass bell ready as above described, connect the adapter of the pump connection to the valve F, having first made sure that the pump itself is fixed so that the action of the handle will not tug the apparatus off the bench. Place the glass bell or bottle (if the latter, see the cork or stopper is tight) on the rubber ring, make certain that the tap of the gas-pipe B is closed, and give a dozen or so good strokes of the pump.

Should there be any leakage of air round the bottom edge of the glass bell you will hear the hissing of the inrushing air. Should this happen, smear the edge of the glass where it joins the rubber with a good coat of vaseline or grease and test again. If all is well, turn the gas-tap slowly, when the air should rush into the bell quite audibly.

We are now quite ready to proceed with practical experiments.

Having tested the air-pump, and satisfied yourself that it is functioning satisfactorily, a few elementary experiments may be embarked upon with very little trouble or outlay.

For the first, we may well try to reproduce the phenomenon of the reduction in the boiling-point of liquids at low atmospheric pressures. It is an established fact that water, for instance, boils much quicker on a mountain top than at sea-level.

Take a beaker, or very small saucepan if you have no laboratory glassware, and boil some water in it on the gas in the ordinary manner. A thermometer placed in the water will register approximately 212° Fahrenheit (see Fig. 3). Now take the vessel away from the gas and allow the water to cool till it has dropped about 15°. Put the vessel on the exhausting platform and, covering it with the bell, operate the pump. When a certain amount of air has been exhausted the water will commence to boil again, though no heat has been applied and the thermometer is showing a temperature very much below the original 212°. Should you be the fortunate possessor of a small barometer, this instrument, if placed under the bell, will enable you to check the pressure conditions produced. The average barometric pressure is usually expressed as 30 in. of mercury, and when this is reduced to 20 in. the water will be found to boil at 192° instead of 212°.

Expansion of Air

You will have noticed, when testing the pump, that the air at normal pressure rushes violently into the bell which has had its internal pressure reduced; in fact, it is a confirmation of the saying that "Nature abhors a vacuum." This expansion of the ordinary atmosphere, in an attempt to fill the semi-vacuum formed by pumping, may be very interestingly demonstrated as shown in Fig. 4.

Here we have an ordinary small jam-jar with a piece of rubber membrane (from a toy balloon) stretched over the mouth and tied tightly round the groove at the neck of the jar. Normally the membrane remains taut like the head of a drum, but if the jar is placed in the pump chamber and the pressure reduced, the membrane will begin to rise in a bulge, owing to the difference in pressures on its two faces. By continuing the exhaustion the membrane may be made to swell up tremendously and eventually burst, just as the original balloon would have done when distended by *compressed* air being forced into it.

Many simple phenomena of this nature may be produced and, though space does not permit of our illustrating each of them, a few may be briefly described.

Those readers who are keen egg-collectors may be interested to know that an egg which has a hole punctured in one end and is inverted over an eggcup or, in the case of a very small egg, a thimble, may be completely emptied of its contents in the air-pump chamber. The egg contents here rush out into the partial vacuum just as the air tried to do in Fig. 4. Lemonade, ginger beer, or ale will foam over in a very fierce manner if placed in the bell. In this case the carbon dioxide gas which is dissolved in the liquid, rushes back into gaseous form and out of solution in an attempt to fill the void created by exhaustion of the surrounding atmosphere.

Sound and Electricity in "Vacuum."

Sound does not travel well in low-pressure atmosphere, and this may be convincingly demonstrated.

Take a small electric bell (they may be purchased for as little as sixpence nowadays) and suspend it in the corked-top bell so that the wires, which should be very thin, pass through or alongside the cork in such a way as to allow no leakage of air. If the battery is connected the sound will be clearly heard through the glass, but as the pump is operated the sound will become gradually fainter as the degree of exhaustion increases until it disappears atogether, though the hammer of the bell can be seen vibrating just as before.

Most of us have, at one time or another, seen the glow of luminous discharge produced in a Geissler tube when a high-frequency spark is passed through it. Even a $\frac{1}{4}$-in. spark will illuminate quite a big tube, and this effect may be easily reproduced in the air-pump exhausting bell. Fig. 5 shows the arrangement.

Pass two stout wire electrodes through the cork in the bell neck, making sure they are tight, and connect the outside ends or terminals to an ordinary spark coil secondary. If the electrode ends (inside the bell) are, say, 1 in. apart, there will be no spark with a small coil under ordinary pressure of atmosphere. As the air is exhausted, however, the two electrodes will commence to glow, then, as the degree of exhaustion increases, a distinct and steady flow of light passes between them. If viewed in a darkened room the effect is very fascinating, and with a fair-power coil and electrodes wider apart the whole bell may be got to glow with an eerie brilliance.

Recoil in Space

Recently much has been written about the possibilities of travel in the upper stratosphere or even in space itself by rocket-propelled vehicles, and a question which is constantly asked is: "Will not the driving force or recoil of the rocket be annulled by the lack of an atmosphere?" The fallacy of this idea may be very easily proven.

Fig. 6 shows the necessary arrangement. A hook cemented to the top of the bell (or stuck into the cork) carries, suspended by a thread or string, a *small* squib of the

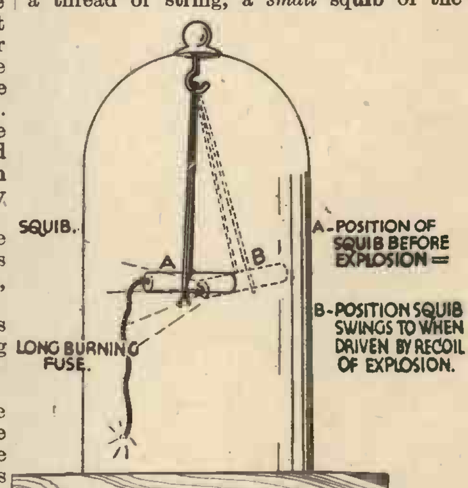


Fig. 6.—To prove that the recoil of a rocket would be effective in the "vacuum" of space.

"cracker" type. The squib should be fairly evenly balanced and have a long fuse, to allow time for operating the pump. Naturally the exhaustion must not proceed too far or there will be insufficient oxygen to support the combustion of the fuse. When the squib explodes it will be seen to swing violently over to B just as though normal atmospheric conditions were present.

In the original experiment a cartridge was fired electrically and the vacuum was almost complete, but such an arrangement is not practicable for home experiment.

THE SPRAY METHOD OF COATING SURFACES WITH METAL

By Frank W. Britton, D.Sc.

(Concluded from page 240 of last month's issue)

THE thickness of tin deposits is about $\frac{1}{64}$ of an inch, which is quite considerable and just shows what may be achieved with the metal-spray. Deposits of $\frac{1}{100}$ of an inch of the tin coating are also usual and are very protective. It should be remembered that tin is a really beautiful metal and it is almost remarkable that more use is not made of it for ornamental purposes and motor-car fittings, etc. Its price is fairly high of course, around £230 per ton as compared with copper at £44 per ton.

Lead, principally associated with the definite protection of metals against acid fumes owing to its great acid resistance, requires a limit of deposit thickness for this purpose of $\frac{1}{16}$ of an inch.

Nickel and Silver Spraying

The chief advantage in the spraying of nickel lies in the fact that great areas may be covered, which would be impossible in the electro-plating of the metal. In this manner huge rolls of sheet iron, the size of which would absolutely preclude them from entering the largest plating vat made, are easily treated. The use of the nickel-spray, however, is decidedly limited, far better results being obtained by the electro-method on account of the brilliance of the resulting deposit. Thus far, therefore, such spraying appeals only to the commercial and bulk handling of large and unwieldy articles and machinery.

In the case of silver, I cannot see that any particular advantage can be claimed over the electro-deposition method since any thickness may be obtained by the latter process coupled with many pleasing variations from a matt to a bright finish. Some intricate filigree work may, perhaps be more effectively treated with the molten-spray method than by electro-depositing, but it is doubtful. Generally speaking, the size and nature of articles for silvering adapts them to the plating-vat rather than the spray. One advantage perhaps of the latter might be in the direct application of silver to iron and steel which do not require to be coppered beforehand as in the case of electro-silvering.

Copper, Brass and Zinc Spraying

The remarks which apply to copper apply to brass and bronze, etc. As a protective coat, brass is often applied to iron as it also is for ornamental purposes, but a certain thickness is essential. Since steel and iron are by far the commonest bases to which copper and brass are applied the porosity of copper and brass is important to consider, this is partly due to the largeness of the particles of molten metal—repeated layers of brass and copper are needed to give a perfectly homogeneous and close skin. What happens if this is not provided is this. When brought into an acid atmosphere, or alkaline for that matter, and even damp, the under-surface of steel or iron becomes corroded and gradually oxidised, so that the otherwise protective coating of copper or brass peels off. Thickness of deposit alone is not all that must be considered, for the same peeling effect is liable to occur if the article is damaged in any way so that the coat is scratched. Indeed, this is the most important thing to guard against in all coated metals.

Zinc is chiefly used as a coating to iron and the incorrectly termed "galvanizing" usually consists in dipping the iron articles in molten zinc. Electro-galvanizing *is* done, as well, of course, but on a large scale dipping is the general rule. As a protection, zinc must be pure, and this purity is ensured by using the spray method of application. It particularly commends itself to the treatment of small articles and is an extremely economical process since the thickness of zinc sufficient to prevent rusting and corrosion need not exceed $\frac{1}{500}$ of an inch. The thickness of deposit naturally depends upon the use to which the articles are to be put, for most purposes twice the above thickness being usual for the prevention of atmospheric corrosion. Zinc, it has already been mentioned, is often sprayed in conjunction with aluminium, the effect being an ideal, tenacious deposit.

Gold Spraying

Porosity again, is the chief deterrent in the spraying of gold and, since additional thickness would be prohibitive in most cases, the porous nature can only be checked by using suitable varnishes. However, the same remarks here apply as to silver, for both metals are what may be termed "luxury metals" principally being used for ornamental and artistic effect. Sometimes it is necessary to have appliances covered with gold—as in some laboratory apparatus. I remember it was necessary for me to use a metal stirrer made of a non-reactive metal for agitating a particular solution, the matter being solved by using a heavily plated steel rod. The gold was deposited on the rod in the familiar "gilding vessel" and electro-deposited. It answered its purpose for one or two experiments but, the under-surface of steel soon became corroded, the stirrer being then discarded and a glass one used in its stead. On steel, the metals gold, silver, copper and brass appear to be best deposited electrolytically, very little dissatisfaction arising therefrom.

The factor to be taken into consideration in the spraying of metals is the convenience and facility of adhering to the ground-surface. As has been indicated, this is of decided advantage in the case of a metal like aluminium, the electro-deposition of which is a difficult process—such a difficulty being removed by spraying. We have chiefly dealt with the spraying of metal upon metal, but it is equally important to understand that certain bodies—wood, plaster, unglazed porcelain, etc., are quite easily treated by spraying. In their case the process seems to be far more convenient than the usually messy pre-electrolytic preparation—treating carbon-disulphide and phosphorus or brushing with graphite—to obtain a good conducting surface. Certainly, metal-spraying holds out great possibilities and is an attractive and fascinating subject.

"How the Locomotive Works and Why," 3/6 net. 94 pages, published by the Locomotive Publishing Co., Ltd., 3 Amen Corner, London, E.C.4.

THIS handy volume, by M. P. Sells, O.B.E., was originally written for the locomotive drivers, firemen and drivers-in-training of the Nigerian Government Railway, but, following up a suggestion that it would be of benefit to the running staff of other railways, it has been revised and made available in its present form. Not only engine crews and members of the running-shed staff, but also the layman who takes an intelligent interest in the modern railway locomotive will find this book helpful. It explains how steam is generated in the boiler, how the steam actuates the cylinder mechanism, which in turn causes the wheels to revolve; and how the engine is brought to rest. The important subject of lubrication has a chapter to itself. The book is well printed on stout paper, and is illustrated with numerous line drawings and two coloured plate diagrams.

"Press Tool Making," 3/6 net. 92 pages, published by The Technical Press, Ltd., Ludgate Hill, London, E.C.4.

In presenting this useful manual, the author, Ernest Perry, had in mind a desire to help fitters and others who wish to become toolmakers. The various methods of obtaining that degree of accuracy, which is necessary when working to fine limits with jigs or press tools, are carefully explained. All the methods dealt with in the manual have been tried out in actual practice. Among the subjects covered are: Micrometers; Drilling Jigs; Press Tools for Motor-body Work; Bakelite Moulds; Tempering and Case Hardening; Blanking Tools; and Stops. The manual is well illustrated with line drawings and half-tones.

Silence No Longer Golden

IN these days it is the man or woman who knows how to speak that wins life's rewards. One has only to consider the successful people in life to see the truth of this. The gift of speech is a tremendous asset. A remarkably successful course in "Effective Speech" is now being conducted by Professor D. E. Watkins, M.A., Ph.D., and many hundreds of students have already reported remarkable benefits from its teaching; shyness, timidity, stage-fright and nervousness have soon been conquered and replaced by assurance, confidence and prestige leading to happiness, promotion and success.

Full details of this remarkable course are given in a little booklet "How to Work Wonders with Words," which is sent entirely free to all who write a post card to The Psychology Publishing Co., Ltd., 3, 5 & 12 Queen Street, Manchester 2.

MODEL AERO CLUB FOR SHEFFIELD

MR. C. F. W. Cudworth wishes to start a Model Aeroplane Club in his district for juvenile enthusiasts. Those interested should get into touch with him at—"Daisy Cottage," 18, Derbyshire Lane, Meersbrook, Sheffield, 8.

PRACTICAL MECHANICS Replies to Queries and 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 303. Send your queries to the Editor, PRACTICAL MECHANICS, Geo. Newnes Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

PHOTOGRAPHY

"(a) HOW can ultra-violet and infra-red rays be easily produced separately and without visible light from 200 volt A.C. mains?

"(b) Are ultra-violet and infra-red plates bought separately or by the dozen? Are the rays in sunlight strong enough to instantly affect a plate through a filter? What light may be used during development?

"(c) What is the formula of a developer containing Amidol? I bought some the other day and it contained a grey powder, which, I believe, is Amidol, and about three times as much white powder. Can this developer be used for X-ray, ultra violet and infra-red plates.

"(d) How long should a plate be exposed to daylight or a 60-watt pearl bulb 1 ft. away, during contact printing?

"(e) Assuming that plates and filters could be obtained to fit it, can a midget camera be used for infra-red and ultra-violet plates?

"Are the midget films for this camera orthochromatic or panchromatic?

"(f) I wish to construct an enlarger, giving a plate about five times the size of the negative, what would be the approximate distances? The distance from the plate to the lens in the camera I wish to use, is about 5 in. I should employ a 60- or 100-watt pearl bulb.

"(g) What is the simplest formula for a developer?" (P. H. H., Sheffield.)

(*a*) ULTRA-VIOLET rays are generated by an electric arc lamp or a mercury vapour lamp. A specially constructed filter of surface-silvered glass or, preferably, quartz will pass ultra-violet rays without visible light. Such filters are obtainable from Kodak, Ltd., Kingsway, London, W.C.2. They are expensive. Any electric bulb generates infra-red rays. A simple way of obtaining such rays unmixed with visible light is to screen the electric bulb with a very thin sheet of ebonite or a very strong solution of iodine in alcohol.

(*b*) Any photographic plate is sensitive to ultra-violet rays and such plates need not be especially prepared. Specially prepared infra-red sensitive plates may be obtained fairly cheaply from Ilford, Ltd., Ilford, London. They are sold in dozen lots. The infra-red rays in sunlight will affect such plates, the necessary exposure being a few seconds. Infra-red plates must be developed in total darkness. Alternatively, they may be de-sensitised before development by immersion in a bath of Pinacryptol Green (also obtainable from Ilford, Ltd.), and subsequently developed in bright green light.

(*c*) A good amidol developer is made up according to the following formula:

Amidol	3 grains
Sodium sulphite .	25 grains
Water	1 ounce

This developer will not keep in good condition for more than a week. It is the best of all developers for bromide papers, but, like all amidol developers, is of little use for developing plates and films. For the latter purposes any ordinary metol-hydroquinone or pyro-soda developer should be used.

(*d*) We suppose that by the term "plate" you really mean paper, since you refer to contact printing. We cannot give you the times of exposure, since you do not state the type of paper to be used. An average bromide paper, however, exposed 1 ft. away from a 60-watt electric bulb under a normal negative, requires about 1 to 2 seconds to make a good print.

(*e*) Yes, any type of camera may be used for ultra-violet and infra-red photography, provided that the necesasry plates or films and filters are obtainable. The smaller sizes of films are usually orthochromatic, but they are also obtainable with panchromatic emulsions.

(*f*) We cannot give you very accurate figures, since you do not state the focal length of the lens you propose to use for your enlarger and since all enlarger calculations are governed by the focal length of the lens. We note, however, that you propose to place the lens about 5 in. away from the plate. This, however, gives us little information concerning the lens' focal length or the size of the negative you propose to enlarge from. Assuming that your lens has a focal length of 4 in. an approximately five times enlargement would be given when the distance from the negative to the lens is 6¼ in. and the distance from the lens to the bromide paper 25 in. If the lens employed has a focal length of 5 in., then the above distances would be 6 and 10 in. respectively. Such figures must be taken as approximate ones only, since much depends upon the type of lens employed.

(*g*) A good developer for plates, films and papers is made according to the "Wellington" Universal formula:

Metol	10 grains
Hydroquinone . . .	30 grains
Sodium sulphite crystals .	350 grains
Sodium carbonate crystals .	350 grains
Potassium bromide . .	3 grains
Water	10 ounces

Use full strength for gaslight papers, but dilute with an equal quantity of water for plates, films and bromide papers.

A NEW TYPE OF GRAMOPHONE

"I SHOULD like advice on the practicability of a new type of gramophone which I am at present working on. Briefly the idea I have been experimenting with is to do away with the spring motor and to utilise the falling weight principal to turn the turn-table. The lid of the gramophone as it falls from the vertical to the closed position, driving the turn-table through a train of simple gears. I have done con-

siderable experimenting to get the correct ratio of fall, etc., and am in hopes of getting it perfected shortly.

"Do you think the idea would be worth patenting?" (J. P., Somerset.)

THE idea of utilising the falling movement of a lid of a gramophone cabinet to rotate the turn-table is thought to be novel and forms fit subject matter for protection by Letters Patent. It is not, however, broadly novel to employ a falling weight in place of a spring, and although several ideas have been patented it is not thought that any were ever placed on the market. If you are able to produce a simple arrangement, it is thought that it should have possibilities of being made a commercial proposition. It would probably be worth while making a cursory search amongst prior patent specifications to ascertain the novelty of the invention. We would advise you to protect your invention by filing an application for patent with a provisional specification, which will give you protection for about twelve months during which time you should be able to complete experiments and ascertain the novelty of the invention.

Should you require professional assistance in protecting the invention, a reliable patent agent is Mr. A. Millward Flack, Imperial Buildings, Ludgate Circus, E.C.4.

A NOVEL CIGARETTE PACKET

"I SHOULD be grateful if you would advise me on the practicability of my idea and if it would be worth patenting.

"The idea is a match-box attached to the top of a cigarette packet." (J. D., Torquay.)

THE idea broadly of combining a match-box with a packet of cigarettes is not thought to be a patentable invention. Also, the idea of so constructing a match-box or case so that the match is lit on withdrawal, is no longer novel. There are match-cases already on the market embodying this idea. Apart from want of novelty, the idea is not considered to be a commercial proposition. The match-cases would have to be combined with the cigarette cases by the manufacturer of the cigarettes, and for that reason alone it is not thought to be possible to interest cigarette manufacturers in the idea.

A CURTAIN HANGING DEVICE

"I HAVE designed a curtain hanging device. As you will see from the sketch, the spring (spiral) is merely for a preliminary grip; after which the weight of the hanging curtains or a jerk on the curtain will cause the grip to tighten.

"Will you please answer these questions:

"(1) Is the idea original to your knowledge?

"(2) Should I apply for a patent and where?

"(3) Do you consider it marketable?

"(4) Can you tell me the name of any firm who would consider buying the idea?

"Its advantages are obvious." (S. A., c/o G.P.O. London).

THE improved curtain hanging device is novel, but it is not thought to contain subject matter or invention to support a valid patent. Similar grips are well known for other purposes and it is not considered that any invention is required to use such grips for a novel purpose, i.e. for hanging curtains. Unless invention or ingenuity is required to adapt a known thing for a new purpose, it is not a "manner of new manufacture" as required by the Patents Act.

The answers to the specific questions are as follows:

1. Probably original but not patentable.
2. Should it be possible to obtain a patent it would not be valid or have any commercial value.

3 and 4 are answered on the previous page.

A RACE GAME

"I HAVE designed a novel race game, but before putting it into operation (it is already constructed, and will be worked by myself) I wish to protect the idea from being copied.

"I propose working it on the hunting scene principal, with horses and hounds catching the fox. But what I would like to know is, if I decided to work the hunting scene could a person copy the game (if it was patented) by introducing greyhounds and hare, or should I have to take out an additional patent." (A. J., I.O.W.)

THE improved apparatus for playing a game forms fit subject matter for protection by patent, but as the novelty would appear to be doubtful we would advise you to make a search amongst prior patent specifications dealing with the subject matter of the invention before applying for a Patent.

As any patent that could be obtained for the invention would relate solely to the apparatus employed, and not to the rules for playing a game, anyone using, making or selling the apparatus would infringe the patent, irrespective of the way it was used.

After you have satisfied yourself as to the novelty of the invention you can apply for a patent, either with a provisional specification or a complete specification. In the former case, it will be necessary to file a complete specification within twelve months from the date of application if a patent is desired. The official search for novelty is only made after the complete specification has been filed.

As the drafting of patent specifications is a highly technical matter, we would advise you to employ professional assistance. A reliable patent agent is: Mr. A. Millward Flack, Imperial Buildings, Ludgate Circus, E.C.4.

AN INSECT CATCHER

"WILL you give your opinion of my invention and, what I should particularly value, a list of manufacturers whom you think would be interested?" (S. B., Norfolk.)

THE improved insect catcher forming the subject matter of patent application No. 449721 is thought to have little if any commercial value. It is evident from the preamble in the complete specification to possess small subject matter or invention, in fact, it appears questionable whether any patent to be granted on the invention could be upheld if contested.

You would have been well advised to have consulted a patent agent before incurring expense in proceeding with your patent application. The following firms might possibly be interested in such a device: Messrs. E. J. Salt & Son, 35 Oakley Street, S.E.1; Messrs. W. Shepherd & Sons, 12 Oscar Street, S.E.8.

PERFUMERY

"1. CAN you give me the names of any chemicals that can be used in perfumery besides acetic ether and butyl ether?

"2. Are any of the above poisonous?

"3. What is methyl?

"4. What is ionone obtained from?" (R. F., Sussex.)

1. A VERY large number of chemicals are used in perfumery and it would be impossible for us to list even a tithe of them here. If, however, you will write to Messrs. A. Boake, Roberts & Co., Ltd., Carpenter Road, Stratford, London, E.15, requesting a copy of their perfumery chemical list, you will obtain an ample supply of information on the subject.

2. Most perfumery chemicals and oils are more or less directly poisonous when taken internally in sufficient quantity, but none of them is scheduled officially as a poison. Hence, they may be freely purchased.

3. "Methyl" is the name given by chemists to a "radicle" or group of atoms containing one carbon atom and three hydrogen atoms. It is symbolised by the chemical formula: CH_3.

"Methyl" cannot exist by itself. It must have some other atom or group of atoms added on to it. Thus CH_3-OH is methyl alcohol, CH_3-Cl is methyl chloride, whilst CH_3-CO-CH_3 is di-methyl ketone, or acetone. CH_3-COOH is methyl carboxylic acid, or acetic acid. In all these formulæ you will observe that a group of atoms is attached to the CH_3-group, which remains the same in each case.

4. Irone or ionone, a violet-smelling liquid, can be extracted from iris roots. Commercially, however, it is made synthetically from citral by acting upon the latter with acetone and subsequently treating the product with sulphuric acid. Citral is obtained from lemon grass oil.

A DIFFERENCE IN STRENGTH

"COULD you please let me know the difference in strength and weight of high manganese and chrome molybdenum tubing (also after brazing)?

"Further, what is the effect of radial spokes in a front wheel?" (W.—., Herts.)

MANGANESE steels are hard and they resist pressure well. Hence, they are frequently used for the making of axles, shafts, etc. Chrome-molyodenum steels, on the other hand, are tougher than manganese steels and they possess a greater tensile-strength, this increase in tensile strength being mainly due to the alloying of molybdenum with the steel. Consequently, for the bearing of a given strain or stress, a rod, tube or bar of chrome-molybdenum steel may be made considerably lighter than one of ordinary steel. Hence the increased use of such steels in cycle frame making. There is no change in the properties of such steels after brazing.

Radial spokes, that is to say, spokes running directly from the hub to the rim of a wheel, are designed with the object of carrying a load. They may be in compression or in a state of tension, but they are not calculated to take a very high rotational stress, as are the now universal tangential spokes. A front wheel fitted with direct radial spokes would have plenty of "give" and it would absorb small road shocks well, but it would possess little strength under bad conditions.

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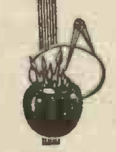

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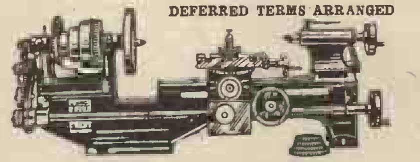

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