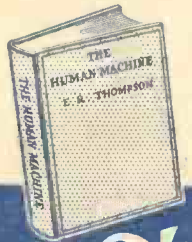
BUILDING OUR £20 CAR!

NEWNES

PRACTICAL MECHANICS

6D.

APRIL



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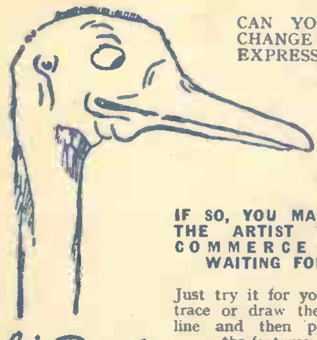

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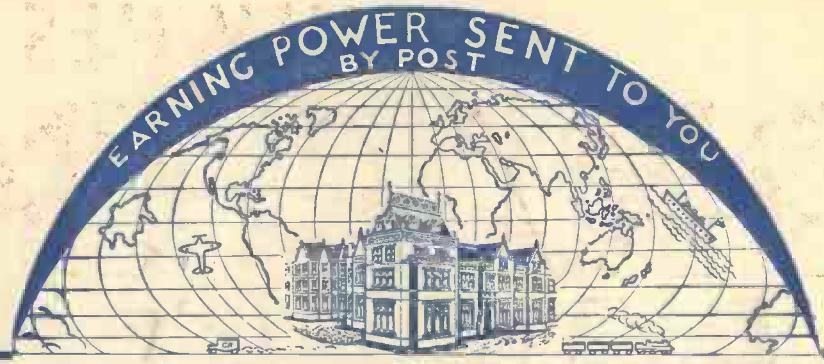
Jim Duck **Art Dept. 76.**



STUDY AT HOME IN YOUR SPARE TIME

OPEN LETTER TO PARENTS

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

J. H. Bennett

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Structural Engineering
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Teachers of Handicrafts
Telephony and Telegraphy
Transport Inst. Exams.
Weights and Measures Inspector
Welding
Wireless Telegraphy and Telephony
Works Managers

If you do not see your own requirements above, write to us on any subject.

HOW TO STUDY

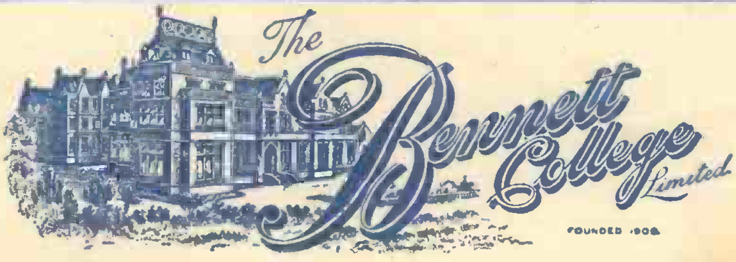
In your spare time when it suits YOU. You fix your own time, you do not GO to your studies—the postman brings THEM TO YOU. There is nothing that a class-room teacher can show on a blackboard that we cannot show on a white paper. The lesson on a blackboard will be cleaned off, but our lessons are PERMANENT. A class-room teacher cannot give you a private word of encouragement, but a Correspondence Tutor can do so whenever your work deserves it. On the other hand he can, where necessary, point out your mistakes PRIVATELY.

TO STUDENTS LIVING ABROAD

or on the high seas, a good supply of lessons is given, so that they may be done in their order, and despatched to us for examination and correction. They are then sent back with more work, and in this way a *continuous stream of work* is always in transit from the Student to us and from us to the Student, therefore distance makes no difference.

IT IS THE PERSONAL TOUCH WHICH COUNTS IN POSTAL TUITION

EVERY DEPARTMENT IS A COMPLETE COLLEGE EVERY STUDENT IS A CLASS TO HIMSELF



Dept. 76, THE BENNETT COLLEGE, SHEFFIELD.

Practical Mechanics

Edited by F. J. CAMM

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Notes, News, and Views

South Atlantic Flown

A YOUNG Cuban airman, Señor Menendly, has flown the South Atlantic from Natal, Brazil, to Bathurst, British Gambia.

New Propellers for the S.S. "Normandie"

THE great liner *Normandie* is shortly to be fitted with new propellers, which have just been made in the South of France.

A "Flying" Tank

AN aeroplane called "The Flying Tank" is the United States latest air weapon. Carried between the retractable undercarriage is a tank. Before landing, the wheels, tucked into the wings, are lowered. Quick-release mechanism allows the tank to make a quick getaway.

Guiding Aircraft

WORK was recently begun on a new wireless direction-finding station for Southampton airport. The station will enable pilots to receive information as to bearings, weather conditions and visibility the moment they come within a 30 or 40 mile radius.

94,000,000 m.p.h.

A SPIRAL nebula travelling fast enough to circle the earth in a second has been discovered in space by Dr. Milton L. Humason, the astronomer, of Mount Wilson, California. It is travelling at 94,000,000 miles an hour—fortunately, away from the earth. No solid object had been thought to travel so fast.

Speed Traps Worked by Photo-cells

YET another terror has been evolved to catch the unwary motorist—a speed trap operated by photo-cells. One can at least watch out for "gongster cars," and for police constables with stop watches, but a photo-cell installation defies detection and the only safe plan is to drive at less than 30 m.p.h.

World's Largest Theatre Organ

THE B.B.C. is installing in its studio in St. George's Hall, what is considered to be the world's largest theatre organ.

A New Liner

WE learn that the Cunard-White Star Company are thinking of building a sister ship to the *Queen Mary*. It is regarded as a foregone conclusion that the second ship will be named *King George*, or possibly *King George V*.

A 700 m.p.h. Rocket

DR. R. H. GODDARD, the rocket pioneer, is working on a projectile that has already exceeded all speed records of any vehicle, or missile, under its own power. The projectile, which is actually a 24-ft. rocket weighing 80 lb. and loaded with 60 lb. of liquid oxygen and petrol, has already attained a speed of 700 m.p.h.

For Pumping Concrete

A PUMP has now been designed for handling concrete mixture in vast quantities, as for dams, etc. The almost liquid mixture can be impelled at the rate of a cubic yard a minute, to a distance of as much as 1,500 ft., or to a height of 100 ft. The mixture, thus handled, has no tendency to separate.

A New Type of Aircraft

A NEW type of aeroplane has been designed, the wings of which act on the windmill principle. In order to obtain lift, it is necessary to change the angles of the blades, so that they will present their flat surfaces coming down, and their leading edges going up. This is obtained, in the proposed design, by bevel gears turning the blades on their axes as they rotate in their bearings.

Papermaking Machine

THE largest and fastest papermaking machine in the world has recently been installed at Sittingbourne in Kent. It is over 500 ft. in length, and is capable of reproducing 2,500 miles of newsprint paper per week.

Wool from Milk

ITALY is now converting the casein in her surplus milk into a substitute for wool. Casein is the nitrogenous part of the milk which curdles and forms the solid part of junket.

It is stated that the production of the new wool will soon equal half her total wool consumption, but it is doubtful whether the substitute will have such good wearing properties.

A World Record

A WORLD record has been set up by a new type of German Diesel-electric train, which reached a speed of 127.36 m.p.h. on a trial run from Hamburg to Berlin.

Television in France

TELEVISION programmes are broadcast daily from Paris between 4 p.m. and 4.30 p.m.

A New Submarine

A NEW British submarine to be built by Messrs. Vickers-Armstrongs, Ltd., of Barrow-in-Furness, is to be called the *Triton*.

A Large Magnet

THE largest electro-magnet ever made in this country has recently been completed by the Igranic Electric Company. Measuring over 65 in. in diameter and weighing over four tons, it is capable of lifting about 25 tons of steel or iron ore.

An Economical Cable

A NEW cable has just been laid between Australia and Tasmania, a distance of 160 miles across the Bass Straits. Although the cable contains only a single copper conductor, it has been designed for use with the "Carrier" system, and it will accommodate at least five telephone circuits, a broadcast channel, and no less than seven high-speed telegraph channels.

A New Non-Magnetic Ship

INVESTIGATION of the problems of the variation of the earth's magnetic field can only be conducted on a non-magnetic vessel such as the *Carnegie*, which was destroyed by an explosion in 1929. It is learned that a new vessel will shortly be built by the Admiralty. Named *Research*, the ship will be constructed mainly of wood bolted together with bronze bolts. All the rigging will be of hemp, while even the engines will be built so that practically all iron will be eliminated.

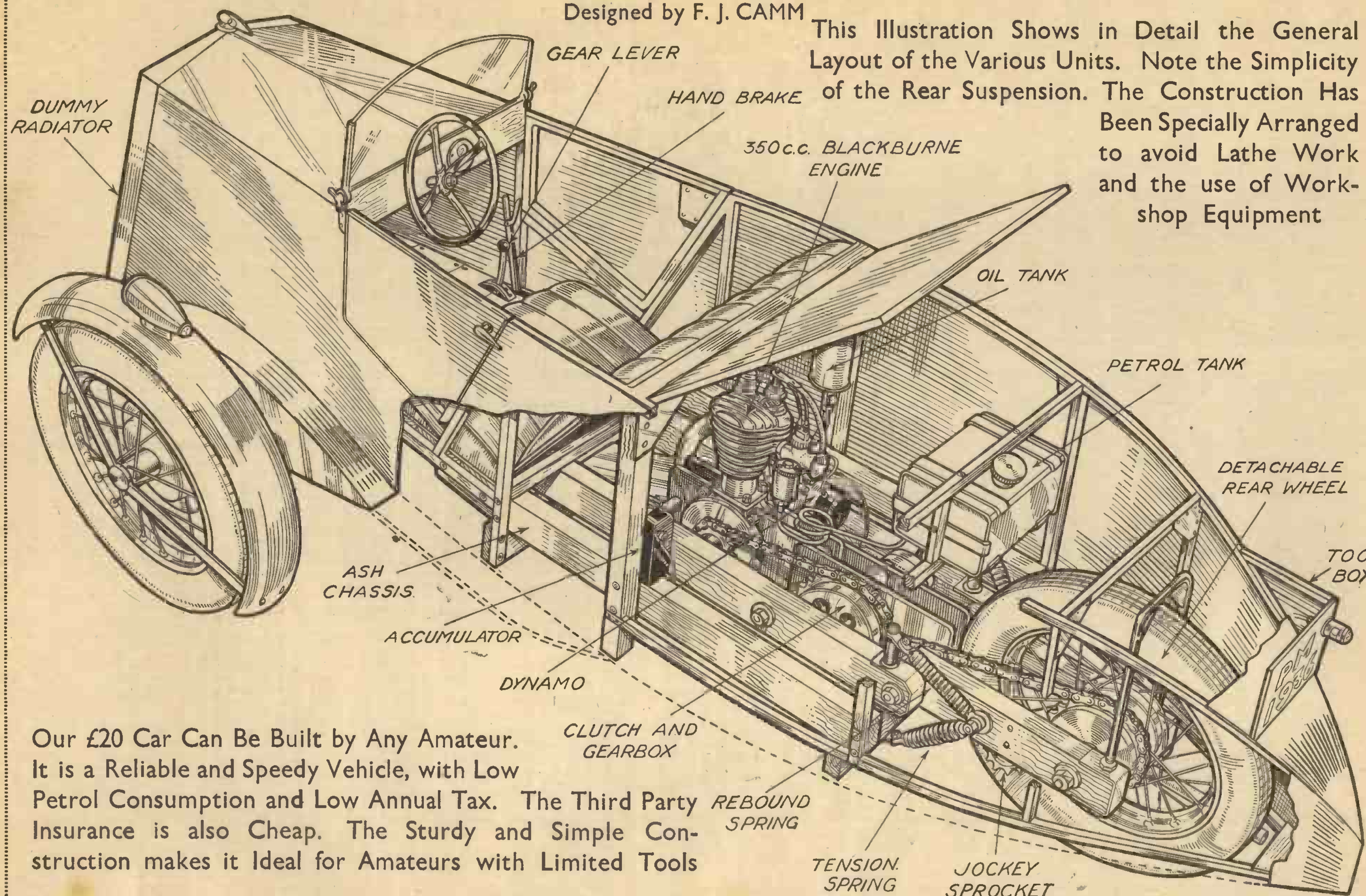
Electric Motor Driven by Sunshine

A SMALL electric motor has been invented in America which can be driven by the electricity provided by a bank of barrier-plane photo-cells. Sufficient energy is generated to run the motor by ordinary daylight.

CUT-AWAY VIEW OF OUR £20 CAR

Designed by F. J. CAMM

This Illustration Shows in Detail the General Layout of the Various Units. Note the Simplicity of the Rear Suspension. The Construction Has Been Specially Arranged to avoid Lathe Work and the use of Workshop Equipment



Our £20 Car Can Be Built by Any Amateur. It is a Reliable and Speedy Vehicle, with Low Petrol Consumption and Low Annual Tax. The Third Party Insurance is also Cheap. The Sturdy and Simple Construction makes it Ideal for Amateurs with Limited Tools

BUILDING OUR £20 CAR

The First Article on the construction of this ingenious three-wheeler appeared last month. Many hundreds of readers have already commenced construction and we have received an enormous amount of correspondence. As stated last month this car can be built for even less than £20, its annual tax is only £4, and it is capable of 50 miles an hour. It may be driven by any reader over 16 years of age, and its petrol consumption is over 65 miles per gallon. Best of all, it may be built by any amateur, for the construction has been simplified to avoid skilled fitting, turning, and brazing. A further article will appear next month.

By F. J. Camm

I COMMENCE this month by disposing of some queries I have received. As these queries are of a general character, I shall thus arrest the pen of other correspondents who may wish to ask similar queries.

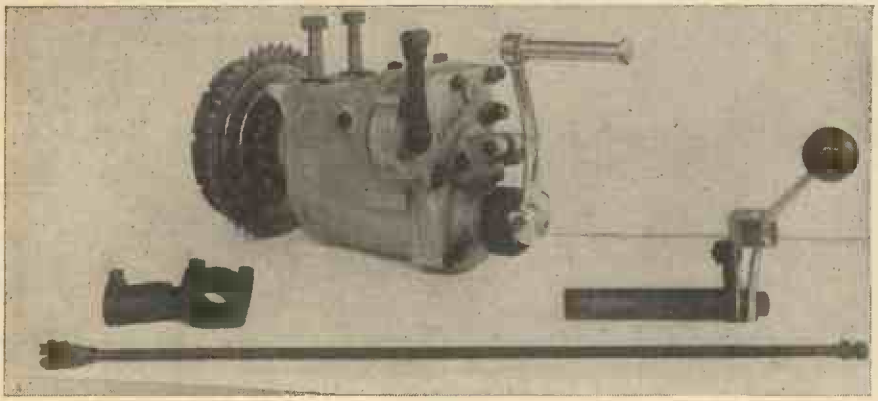
Firstly, regarding the blue prints. These will be ready in a fortnight's time and will cost 10*s.* 6*d.* the set of four sheets. This may seem rather a lot of money, but they are being produced for the convenience of readers and the work entailed in their preparation is heavy. It will also be appreciated that the demand for them will be comparatively small, and it is impossible therefore to produce them cheaper.

Those readers who wish to proceed with the construction in advance of the publication of further details will, if they purchase a set of blue prints, be enabled to do so. Which brings me to another question which I have received from many readers. I cannot send drawings and details through the post in advance of publication. The preparation of separate drawings and sketches and descriptions involves, unfortunately, more time than I have to spare, and queries should be confined to materials, choice of engine's, gearboxes, etc.

Conversion to a Two-seater

As I anticipated, I have received shoals of letters from those who wish to convert the design into a two-seater. This I do not advise, nor do I think that anyone can reasonably expect to build a passenger-carrying vehicle for £20. This car has been designed as a monocar, and one must draw the line somewhere. Suppose, for example, I altered the design so that it could be used as a passenger-carrying vehicle ; this would mean that the whole structure would need to be strengthened, would be considerably heavier, require a more powerful engine, involve a higher insurance premium, need a heavier gearbox, and so on. Moreover, it would invite queries as to how the design could be amended to carry a third passenger, and even a fourth. Those readers who are minded to do so, can easily adapt the designs here given. I had in mind when producing the designs for this car a vehicle as speedy as a motor cycle, but with the added advantages of weather protection. I also had in mind economy of construction and low running costs, and set myself the limit of £20. Deviation from this along the lines which so many readers have been kind enough to suggest would bring the cost of materials alone up to £30 or £40, and for this figure you can pur-

The £20 Car !



The Albion gearbox.

chase an excellent second-hand three- or four-wheeled car.

The Engine

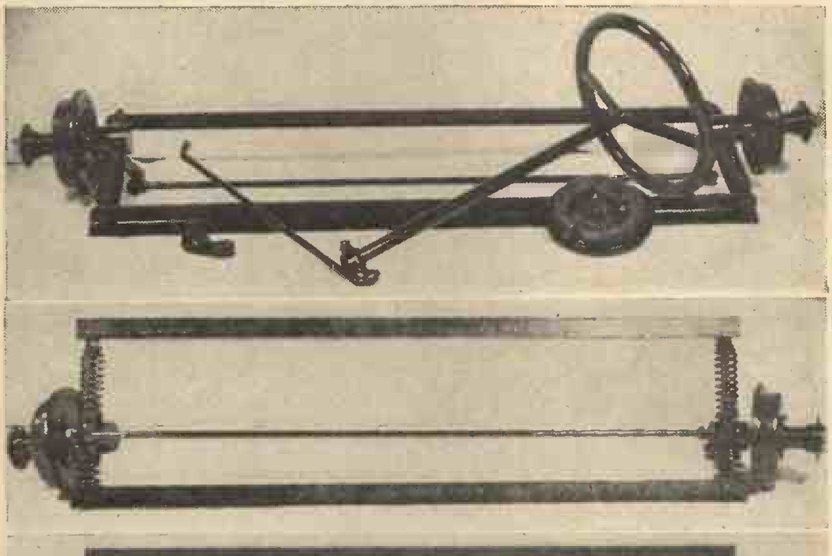
And now regarding engines. Readers apparently have experienced no difficulty in obtaining offers of second-hand motor-cycle engines and gearboxes at prices varying from 20*s*. to 30*s*. The engine which I have selected is the 350-c.c. side-valve Blackburne, and I am using the well-known Albion gearbox, to the manufacturers of both of which I desire to tender my thanks for their co-operation in placing units at my disposal. An engine which is eminently suitable for this car is the unit-constructed New Imperial engine which also has the gearbox incorporated. Thus, in the one-unit you save yourselves the trouble of having to make two mounting plates—if you can call simple metal-work a troublesome operation. It isn't really.

Another question which has produced a volume of correspondence is that concerning the steering system. I show herewith photographs of the type of steering which I have used. This is similar to that which was fitted on the Carden car, a popular light car which was on the market a few years ago. The great advantage of this system is that it dispenses with leaf-springs, which are somewhat expensive. It will be seen that the steering heads are mounted between the springs, which in themselves absorb the road shocks; no other form of additional front suspension is necessary.

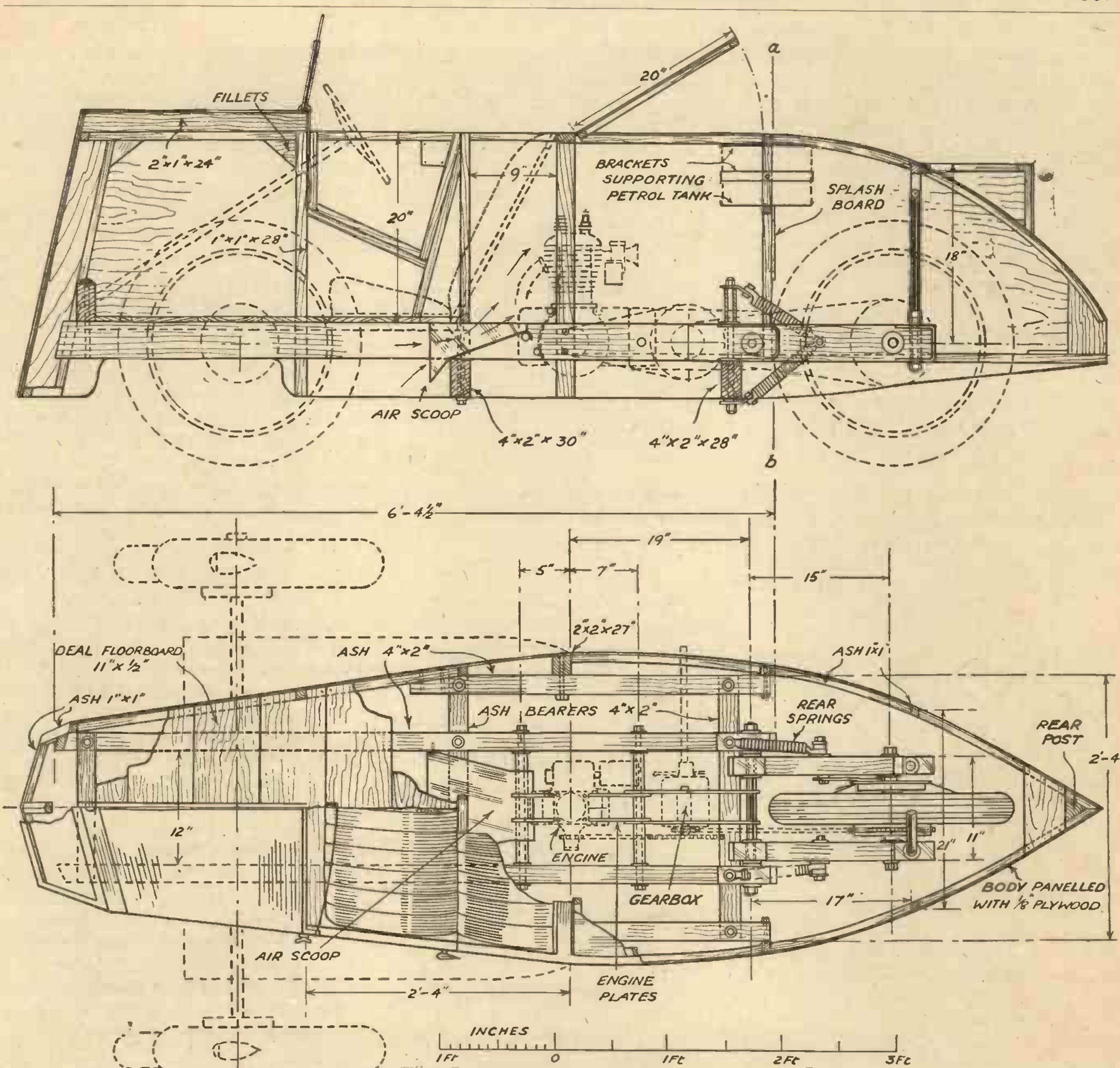
Type of Steering

A further advantage of this type of steering is that it eliminates the need for a geared steering box such as would be necessary on a heavier car, but quite unnecessary on a light vehicle of this description. Thus, it will be appreciated that direct steering is employed. It is easy to make, and satisfactory in every way. The front axle merely consists of two pieces of angle iron which can be purchased locally, and which are bolted direct to the chassis members. Nothing could be much simpler than that. I shall give detailed drawings, of course, so that the reader can make up the steering system himself, although he will need to purchase the hubs and rims. Complete wheels will be supplied by the British Hub Company, whose address readers may have on application. It will be seen that the internal expanding brakes are incorporated in the hubs. If you are skilled at wheel building (I shall give instructions on how to assemble and true the wheels) the cost is very low. I have made arrangements with a manufacturer to supply the steering heads to our readers for a nominal sum, although, of course, they can be cut from the solid if it is desired to save even that expense.

But it is not essential that the type of steering illustrated should be used; you may use, for example, the front axle assembly of an Austin "7," provided that you are able to purchase also the steering box, and the semi-elliptic front springs. These are quite easily mounted by



Four views of the front axle, hubs, track rod, rims, spokes, and nipples.



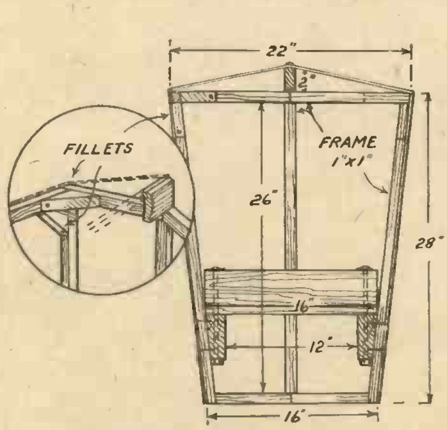
Side and plan views of our £20 car.

means of the shackles, as on the Austin "7." It is possible to pick up a complete front axle and assembly quite cheaply from the car breakers.

The Rear Wheel

For the rear wheel I have selected one of the quickly detachable wheels with knock-through spindle as fitted to the Norton and Rudge-Whitworth motor cycles; thus, in the case of a puncture in the rear tyre, the rear wheel can easily be removed by uncoupling the rear chain and knocking out the spindle. The rear members which carry the front wheel are made of wood; if you are a skilled metal-worker you will, of course, braze up a pair of rear forks. But wood is quite satisfactory, and easy to work. I am aware that some of the methods employed in this car are not those used by car manufacturers, but I have had in mind all the time the amateur who has only a few tools. The methods I have employed I have found from experience to be quite satisfactory.

For the rear suspension I have used tension springs. These can be purchased locally, and springs of the type used in the front forks of motor cycles will suit. It will be noted that as the rear members are not pivoted on a centre coinciding with the centre of the gearbox sprocket, a jockey sprocket must be fitted to compensate for the varying chain tensions.

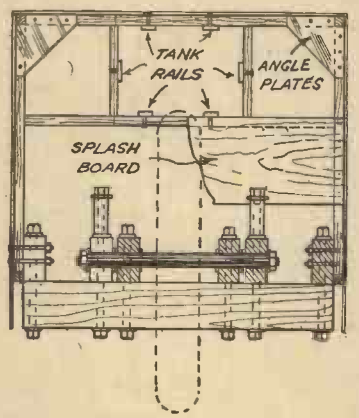


The frame of the dummy radiator viewed from the rear.

List of Materials

Several readers have asked for a list of materials, but it is obviously not possible to give this in complete form because each reader will be using a different make of engine and gearbox. The drawings given this month, however, will enable each reader to get together the necessary components. If you have not yet commenced construction, the first thing to do is to get together an engine, gearbox, three wheels, and the front axle. From these components you can erect the chassis, leaving the superstructure until last. The chassis consists of 4 in. × 2 in. ash bearers, and the cross-members are of similar material.

Many readers have asked about the cooling system. An opening is left behind the driving seat, as will be seen from the side elevation, so that an air scoop can direct a current of air straight on to the cylinders. This is simple and certainly efficient, for the engine keeps just as cool as it would do if mounted in the frame of a motor cycle. Observe that the engine and gearbox are carried on engine plates, bolted between the two main members by means of long bolts with suitable distance tubes for location purposes. In order to brace the two rear members and keep them in alignment a long U bolt with angle pieces brazed at each corner are used, and the rocking members which carry the rear wheel are covered with a washer plate at the rear extremities ; bushes are placed through to suit the rear-wheel spindles. A detail of this is shown. The petrol tank can conveniently consist of a standard petrol tin.

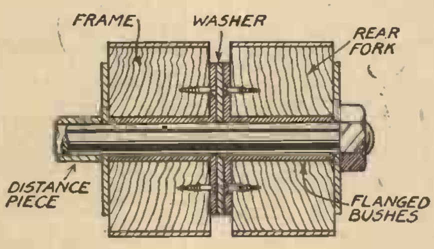


End view across line AB.

Lubrication

Lubrication is by means of the pump incorporated with the engine and which merely needs to be coupled up with a small oil tank with a tap soldered into the bottom. This is conveniently mounted through one of the bearers as shown. Mild steel angle brackets could be used to connect the various wooden members together.

I have shown the position of the steering and the wheels dotted, but it will be appreciated that the position of the front wheels is provisional only, and will depend upon the type of front axle which is employed. Scale drawings of the axle will be given next month, together with details of the body, seating, and finishing. The screen, as I mentioned last month, is the Auster type, and steering wheels can be purchased from Bluemels. I shall also include next month actual photographs of the completed car.



The rear frame members are bushed to take the rear fork pivot.

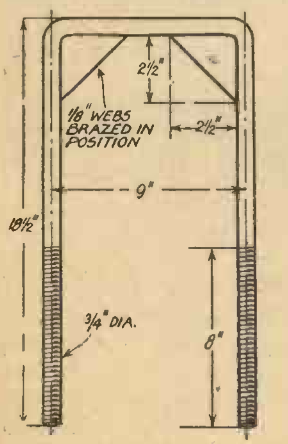
The whole of the wooden structure forming the chassis will be apparent from the side and plan views. In selecting the wood, insist upon straight-grained material free from knots and shakes. Ash must be used—no other wood is suitable to resist the stresses imposed by the engine. You will save yourself a lot of disappointment by adhering to the specification, and using ash. Most coach-builders will supply it or get it for you.

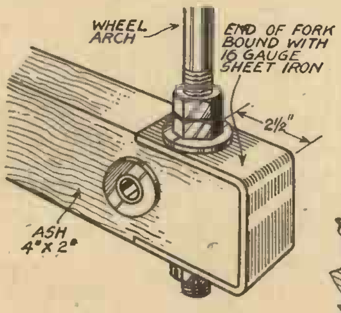
Wherever possible use bolts. Where wood screws are essential use a small drill to give a leading hole, and dip the point of the screws in vaseline before inserting them. This will prevent rust and make it easy for the screws to be removed. Ash is a hard wood, and any attempt to force a screw home will result in a mutilated head and a screw which cannot be removed. Where two parts are to be screwed together the top part should have a clearing hole so that the head of the screw can draw the two parts together.

Croid or Seccotine are admirable as glues. Where a large surface is to be covered the wood should first be warmed and the glue itself heated in hot water to render it more fluid. After the two parts are glued they should be placed under pressure for several hours until the glue has set. When using a bradawl make sure that you insert the blade with its cutting edge at right angles to the grain. This will avoid splitting. Use coach-maker's panel pins and oval section brads for nailing purposes. Such should be at least ¾ in. long, otherwise they will vibrate loose.

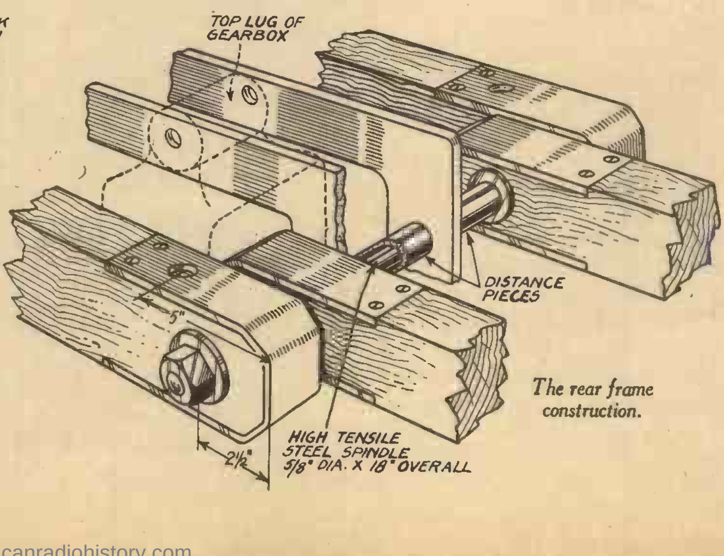
Where possible use Whitworth or B.S.F. bolts. Do not use stove or gutter bolts as the threads are not sufficiently accurately cut and the nuts will vibrate off. Locking washers should be used under the nuts securing the engine and gearbox plates. The bolts should be of the castellated type and split pins must be used to secure the nuts.

Metal straps should be of 16-gauge mild steel plate of the bright rolled variety. Tinned iron is unsuitable ; for the spacing and distance tubes use bright drawn steel tube of 16 gauge ; the ends, of course, must be cut square, and the tubes should be a reasonable fit on the bolts to prevent the latter from bending.





The rear bracing bolt for the rear "fork" member.



The rear frame construction.

The ELECTRON MULTIPLIER

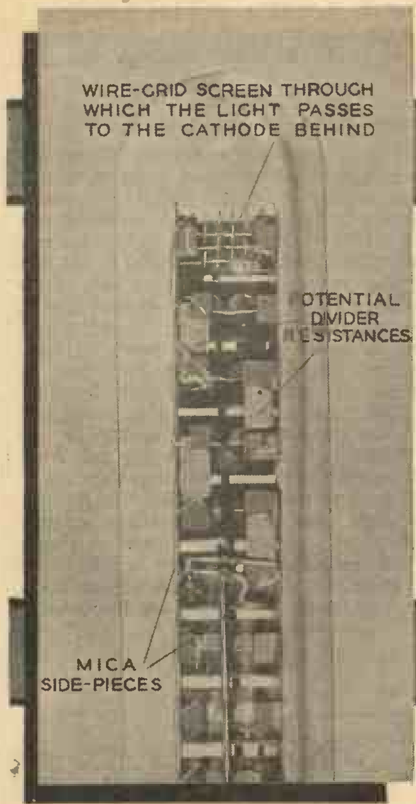


Fig. 1.—An enlarged photograph of the upper end of the multiplier. The cathode is the top element, and some of the potential divider resistances may be seen connecting the screens.

CONTRARY to popular belief, there is a fairly definite limitation to the amount of amplification which can usefully be obtained from the multi-valve amplifier on account of the thermionic noises which are generated in the valves themselves, and when the input signal is so small as to be comparable with the valve noises of the first stage, it is obvious that any amount of amplification will not succeed in making the signal more audible above the noises of the valves.

It will be realised that the behaviour of the first tube of a multi-valve amplifier and its associated couplings must be extremely regular if it is to produce only inappreciable noises at the output. For example, assume an amplifier which multiplies the input voltage by 100,000 ; suppose that the first plate circuit has an impedance of 50,000 ohms, and that a signal of .02 volt is sufficient to give an audible sound from the loud speaker. On this basis, a change in the current passing through the first valve of only 10^{11}, or one hundred-millionth of a milliampere, will produce an audible noise if the change occurs suddenly.

Thermal Effect

If we remember the surface conditions of the hot filament from which the electrons are being " boiled-out," it is not difficult to realise that some irregularity is inevitable. Besides this thermal effect, there are two other causes of noise known as the shot effect and the ionization effect, all of which impose a more or less definite limitation on the practical degree of amplification attainable.

This limitation of the degree of amplification possible with the conventional type of thermonic valve, renders the invention of the Electron Multiplier, by Dr. V. K. Zworykin, of the Radio Corporation of America, a matter of unique interest on account of the fact that the noise level is between 60 and 100 times lower than in an ordinary valve, and a much greater degree of amplification can thus be usefully employed. This feature alone would entitle the electron multiplier to be regarded as a highly important development in high-gain amplifiers, but when it is taken together with the fact that ten or more stages of amplification producing gains of the order of several millions can easily be incorporated in a single tube, it is indeed difficult to foretell the influence which the principle of the electron multiplier may have on the future development of thermionic tubes and radio practice in general.

The Principle of the Electron Multiplier

The actual principle is simplicity itself. It has been known for many years that when an electron collides with a surface, the impact sometimes causes the emission of a number of secondary electrons from the surface, rather like the effect of dropping a golf ball on to a heap of other golf balls at rest on the ground, some of which would be made to jump into the air. These secondary electrons are an unmitigated nuisance in the ordinary valve, and innumerable devices have been invented to avoid their effects. In the electron multiplier, however, their production is encouraged by the use of suitable emitting surfaces which emit eight or ten secondary electrons for every initial one striking the surface. These eight or ten secondaries are then " focused " on to a second emitting " target " where each one liberates a further eight or ten secondaries. This process is repeated many times in successive stages and thus, even allowing for a certain amount of scattering, it is possible to obtain a current amplification of the order of 5,000,000 from a 10-stage multiplier. The whole art of this achievement has been the perfection of the technique by which the electrons are " focused " into their correct paths.

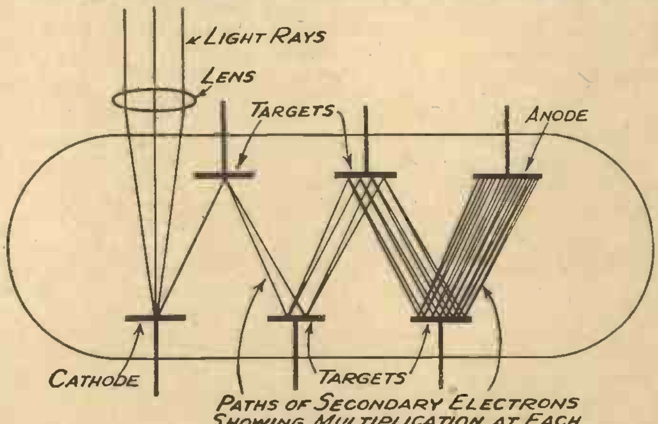


Fig. 2.—A diagram showing how the electrons are " focused " into their correct paths.

The diagram Fig. 2, shows the general principle, and it will be clear that if suitable means were adopted to control the number of electrons passing between the cathode and the first target very great amplification is possible. The electrons from the cathode are attracted to the first target by the application of a positive potential to the target, and a still higher positive potential on the second target attracts the secondaries released at the first. Unfortunately, this simple arrangement would not work in

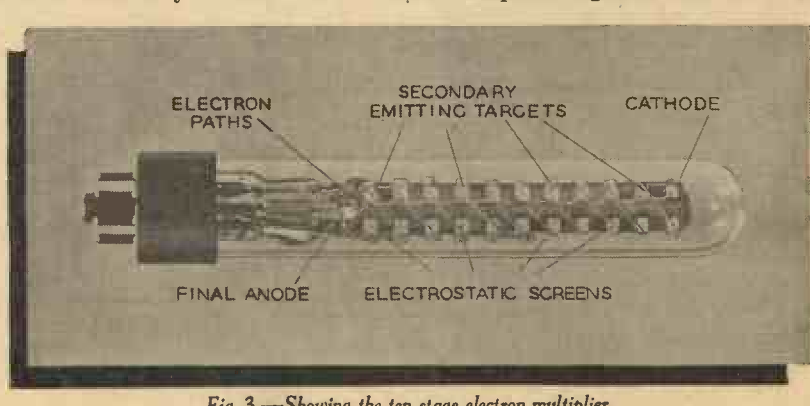


Fig. 3.—Showing the ten-stage electron multiplier.

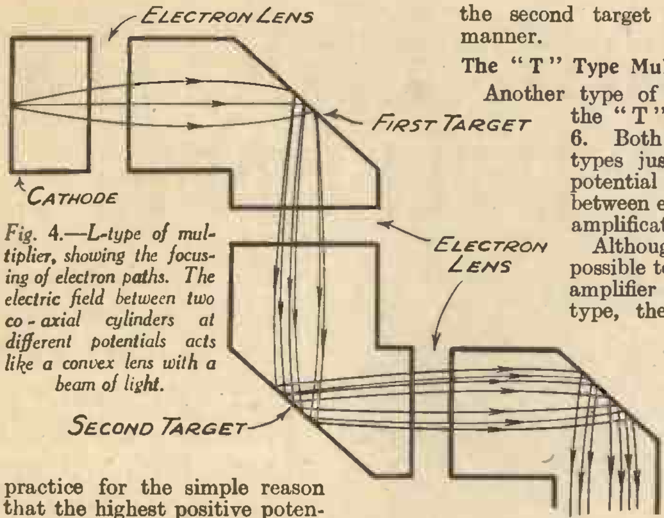


Fig. 4.—L-type of multiplier, showing the focusing of electron paths. The electric field between two co-axial cylinders at different potentials acts like a convex lens with a beam of light.

practice for the simple reason that the highest positive potential is applied to the last target, and any electrons released from the cathode, would be immediately attracted right down the tube without passing through the various intermediate stages of amplification.

A Surface for the Targets

The difficulties, therefore, were firstly to find a suitable surface for the targets which would emit a large number of secondaries for every initial impact, and then to guide the electron stream so that all the electrons impinge on the succeeding target.

As the result of many experiments, the most satisfactory surface was eventually found to consist of cæsium oxide on a silver base. It is prepared by oxidizing a matt silver surface, coating the silver oxide with cæsium, and then heating the surface in a vacuum so that the oxygen is transferred from the silver oxide to the cæsium. This surface is very similar to that used in photo-electric cells and this circumstance is not unconnected with the fact that the first electron multipliers have been designed as amplifiers for photo-electric cells.

The second difficulty, that of focusing the electrons into the desired paths, was a more difficult problem. The first multipliers were of the type shown in Fig. 4. The electrons emitted at the cathode were attracted to the first target by means of a positive potential on the target, and scattering of the electrons is prevented by means of the electro-static field between the two short cylinders which form the emitter and target respectively. The difference in potential between the two cylinders produces a radially symmetrical field within the cylinder and this field focuses the electrons in exactly the same way in which a double-convex lens would focus a beam of light. The secondary electrons released at the first target are attracted and focused on to the second target in exactly the same manner.

The "T" Type Multiplier

Another type of multiplier, known as the "T" type is shown in Fig. 6. Both the "T" and "L" types just described require a potential of about 300 volts between each target, and give an amplification of about 8 per stage.

Although it is obviously possible to build up a multi-stage amplifier of the "L" or "T" type, they are not very convenient forms of construction for a multi-stage tube, and the more simple arrangement shown in Fig. 5 was eventually adopted. It will be observed that the electrons are made to describe semi-circular paths between the successive targets.

In Fig. 5, the cæsium oxide emitting surfaces are those along the bottom row, and the multiplication of the electrons is shown in the diagram. The top set of electrodes are electrostatic screens, and assist in the attraction of the electrons away from the emitting surfaces and along the tube.

The bending of the electron paths into the desired semi-circular form is accomplished by the application of a transverse magnetic field from a simple permanent magnet arranged with its poles on either side of the tube so that the lines of force pass between the targets and the screens, that is, perpendicularly to the plane of the paper.

The electrical connections are shown in Fig. 7, from which it will be seen that each target has an increasing positive potential, obtained from the potential dividing system of resistance. The screens are each connected to the succeeding targets as shown, and the total overall potential required is of the order of 1,500 volts.

It will be noted that part of the potential divider system of resistances is shown within the tube in Fig. 7. It was found possible to incorporate them within the tube, some of them may be seen in the enlarged photograph, Fig. 1, and this arrangement has the advantage of reducing the number of leads to be taken through the glass bulb.

Photo-Electric Amplifiers

As was mentioned earlier, these first electron multipliers have been developed as photo-electric amplifiers and the emitting cathode is actually a photo-sensitive surface. Under the action of light, electrons are emitted which are amplified in the succeeding stages. To give some idea of the performance, it may be mentioned that at a recent demonstration, the varying light from a feeble neon lamp operated by a gramophone pick-up was sufficient to operate the photo-sensitive cathode of the multiplier at a distance of about four feet, and the output from the multiplier was sufficient to operate a moving coil loudspeaker without further amplification at sufficient volume to fill a large hall.

As has been stated, these first electron multipliers have been designed as photo-electric amplifiers, but there is nothing in the principle which makes it unsuitable in any way as a replacement for the conventional thermionic amplifier, provided, of course, that the electrons passing from the cathode to the first target are controlled in a suitable manner by the incorporation of an arrangement analogous with the grid of an ordinary valve.

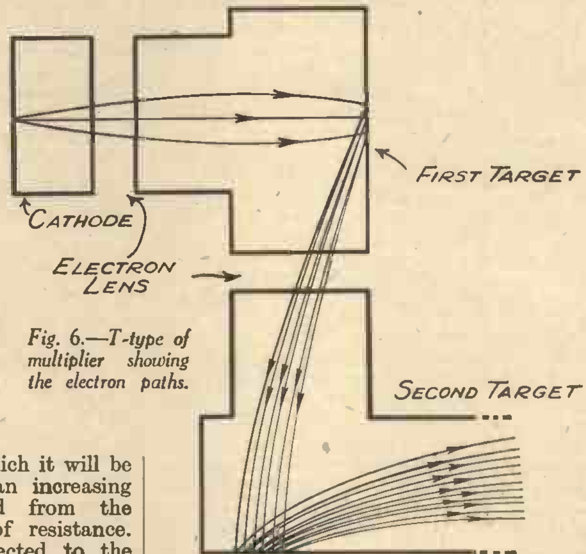


Fig. 6.—T-type of multiplier showing the electron paths.

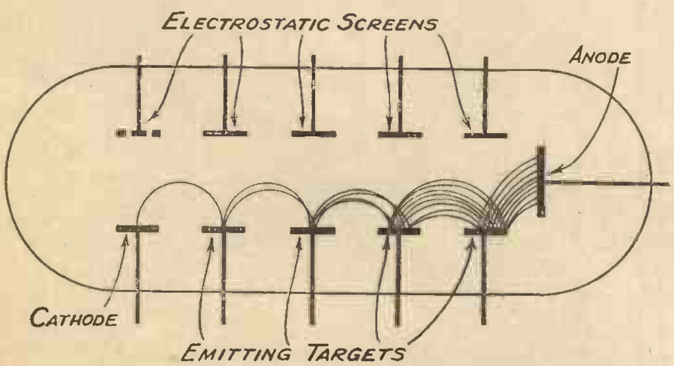


Fig. 5.—Electron paths and principles of a practical electron multiplier.

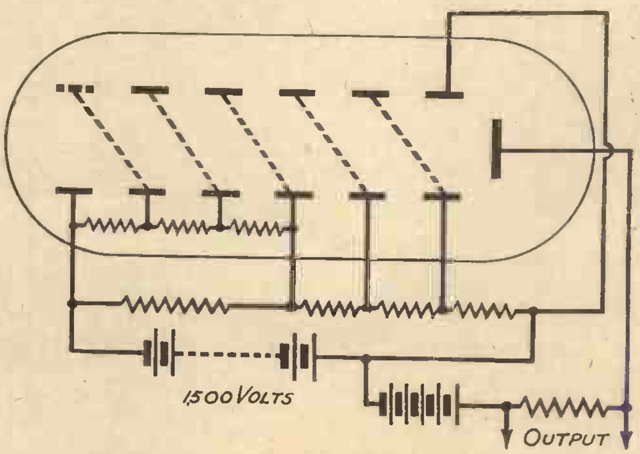


Fig. 7.—Showing the circuit connections.

EXPLORING THE EARTH'S INTERIOR

Many Theories have been put Forward Regarding the Composition of the Earth's Interior. Below is discussed the Fascinating Possibilities of Boring a hole, many miles in depth, Below the surface of the Earth.

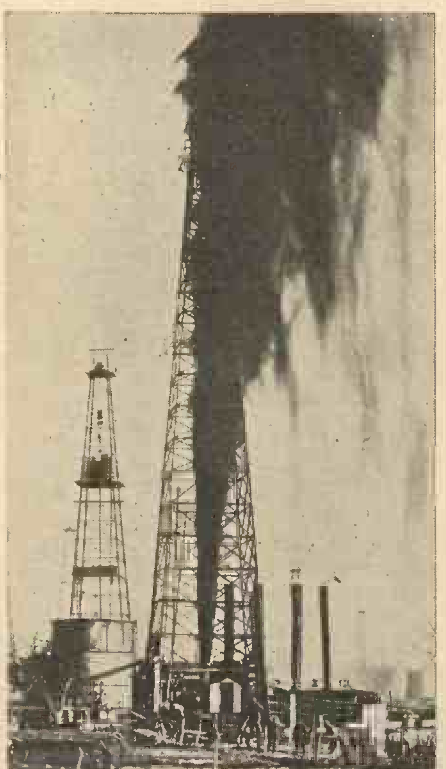
Considered to be the deepest hole in the world, this shaft was sunk by the Shell Oil Co. at Signal Hills, near Long Beach. The illustration shows workmen removing the bit with the valuable geological specimens it brings to the earth's surface.

MAN'S ignorance of the composition, physical and chemical, of the globe upon which he lives and has his being, is almost pitiful. His astute brain has, during the course of centuries, given him the possession of countless facts concerning the heavenly bodies, the majority of which are situated at almost inconceivable distances from the earth. His mechanical ingenuity has enabled him to conquer in a very large measure the problems of aerial flight and to survey much of the earth's upper atmosphere, but as regards a true knowledge of the state of things which reigns many miles beneath his feet, Man, the all-conquering one in many other respects, remains in this matter little more than a child of abysmal ignorance.

The theory that the centre of the earth is composed of a mass of flaming material has long ago been relinquished. In its place nowadays are two main theories concerning the condition of affairs under the earth's crust. The first and, perhaps, the most accredited of these theories has it that the earth's outer crust is about seventy or eighty miles deep. Below this and extending to the earth's centre is a mass of molten material maintained at a very high temperature and pressure. The surface of this molten mass has been termed by some geologists the "isostatic layer." Being fluid, this layer or surface is able to move in all directions and it is supposed that the continual adjustments and readjustments of this layer in consequence of inequalities of the earth's motion through space is the underlying cause of all earthquakes. Such a theory, of course, has many objections, but we cannot go into these here.

A Semi-solid Core

The other main theory regarding the constitution of the earth's interior has it that the middle of our globe is not liquid but, on the contrary, that it is quite solid or, at least, plastic, or semi-solid. Due to gravitational forces, it is almost certain that the heavier constituent's of the earth's make-up have packed themselves near to the centre of the globe. Mountains, it is found, have generally a less density than the earth's surface. As we go deeper into the earth, the density of materials tends to increase.



Sudden escape of high-pressure liquids from the earth's interior will be one of the problems confronting the pioneer earth-depths explorers. In this picture is seen a "gusher" liberating black oil in a pressure stream high into the air.

From these observations we can form a very interesting supposition. The average density of the entire earth is, in round figures, 5, water being taken as having a density of 1. Now, knowing, as we do, the total weight and mass of our planet, it is possible to calculate what its density ought to be, that is assuming that the earth's composition is more or less homogeneous throughout. This calculated density, however, falls far short of the observed one of 5. Hence we can only think that deep down in the earth, near, perhaps, to its centre, exist masses of heavy materials which are very scarcely distributed or are even non-existent upon the earth's surface. Iron, without doubt, is present in large amounts at or near the earth's centre. But iron is by no means the heaviest metal. Gold and platinum are much heavier and it is very possible that such metals are abundant deep down in the earth. The heaviest metal known is uranium, which has an atomic weight of 238. With uranium, the heaviest element, the list of known elements ends. Who doubts, however, that hundreds, nay thousands of miles below the earth's surface, existing under conditions of almost inconceivable pressure, are many elements of higher atomic weight than uranium and which, in consequence of their extreme heaviness, must have some very remarkable and extraordinary characteristics?

Three Miles Into the Earth's Crust

Alas, however, the discovery of such elements is but a very remote possibility. For many years, the record depth attained by man in the earth's crust was but a little more than two miles. More recently, in oil prospecting operations a three-mile hole has been drilled in the oil fields of Texas. When, however, we remember that since the earth's diameter is approximately 8,000 miles and the distance from any place on its surface at sea-level to its centre is about 4,000 miles, it will be realised that, proportionately speaking, the three-mile oil shaft, which constitutes the present-day record for deep boring is far less in depth than is the shallowest groove on a gramophone record. It is, indeed, but the shadow of a scratch upon the earth's surface!

The idea of digging a deep hole in the earth's surface has occurred to many scientific minds at various periods. Until, however, the comparatively recent discovery and application of the diamond drill by a French civil engineer, Professor Rudolph Leschot, the notion of penetrating deep into the crust of our planet seemed enveloped in a maze of impossibilities. Latterly, however, in consequence of the advance of applied science, the idea of drilling deeply into the earth has been shown not to be impossible. It would, of course, constitute an enormously expensive task and it would probably have to be carried out by the pooling of the scientific and financial resources of several nations.

Sinking an Experimental Shaft

That famous engineer, Sir Charles Parsons, renowned as the inventor of the Parsons' turbine, and as the originator of many other scientific devices, has been in recent times the most prominent advocate of the sinking of an experimental shaft deep below the surface of the earth. Sir Charles Parsons first put forward his ideas as far back as 1904. After the war he also enunciated further notions on the same subject. Such ideas received considerable attention at the time, but little was done to consider them from a practical standpoint.

Sir Charles' main idea was to sink an experimental shaft 10, 12 or 15 miles deep into the earth. Compared with the earth's radius of 4,000 miles, even a 15-mile deep shaft would be a mere nothing. Yet such a shaft represents the greatest depth which

The diamond-type rock-drill. Such a drill will cut through the hardest rocks with comparative ease.

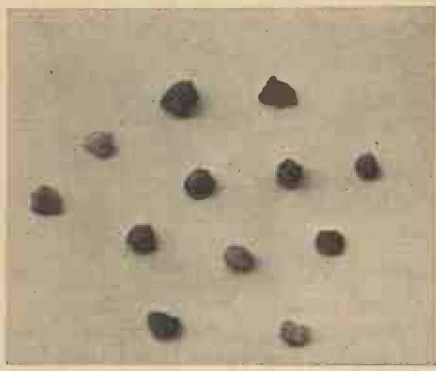
man can hope to attain with his present knowledge and resources.

It was calculated that the cost of the experimental shaft would be something less than the cost of a battleship. That is to say, its sinking would incur an expenditure amounting to millions of pounds. Judged, however, from the standpoint of the advance in practical and first-hand knowledge of the deeper layers of the earth's crust which the drilling of such a shaft would result in, the estimated expenditure could amply be justified.

Deep drilling nowadays is invariably accomplished by means of the diamond drill. For simple rock-drilling purposes, the drill-head is provided with a single large diamond, suitably pointed. Deep-going drills, however, have, nowadays, a diamond "crown." The drill head consists of a hollow steel tube, on the edge of which is set a ring of specially selected diamonds. Such diamonds are not the jeweller's type of stone. They are literally black diamonds, being coloured dark brown or black. For the purpose of rock drilling, such cutting stones are unexcelled.

Drilling for Oil

In drilling for oil, the entire drill shaft is hollow and, as the drill penetrates deeper and deeper into the earth, a steel tube is



Literally "black diamonds." Dark-coloured diamonds of the type used in the making of deep-bore drills.

sunk to prevent the walls of the shaft from caving in. Liquid mud is pumped under pressure down the drill shaft. This lubricates the drill head and passes up to the surface again in the space between the drill shaft and the shaft lining.

The main difficulties inherent in the drilling of a 10-mile shaft are concerned not only with the rotating of an enormous weight of drill shaft but, also, in the keeping of the drill perfectly straight. This latter problem often presents serious difficulties in connection with ordinary oil drilling. In the case of the sinking of a 10 or 15 miles shaft, such difficulties will be enormously augmented. In the instance of the Texas 3-mile shaft, the total weight on the drill head amounted to some 13,000 lb. Under this weight, the drill, when rotating at full speed, performed 200 revolutions per minute. From the above figures, calculate the weight of 10, 12, or 15 miles of steel drill shaft and then form an estimate of the amount of power necessary to rotate such a weight of shafting even at the slow rate of 60 revolutions per minute. Incidentally, the diameter of the shaft proposed in this instance would be about four to six inches. Having worked out your power figure, proceed, now, to an estimate of the very necessary methods of supporting the enormous length of drill shafting which would be required and of holding it straight and preventing it from deviating appreciably from a true vertical line. Figure such considerations out, even hastily, in your head and you will at once be appalled by the number of problems which are bound to confront the future pioneers of earth-interior exploration.

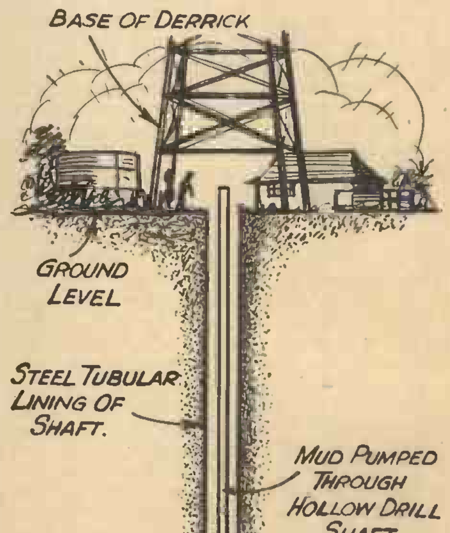
A Possible Method of Boring

A possible way out of the difficulty of supporting a 10 or 15 mile length of shafting would be to do away with the shafting altogether! In its place one would have the drill head connected by a short length of shafting to a specially designed electric motor. The latter would be supported by stout yet relatively light cables and the motor-drill assembly would be lowered gradually into the earth by means of these.

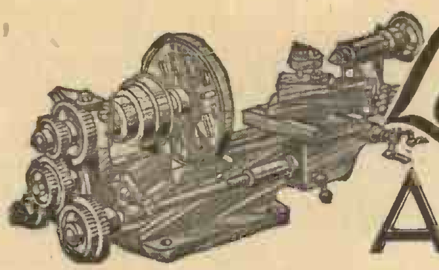
The cutting of an ultra-deep shaft into the earth's surface would not only enable the composition of the earth's deep-lying strata to be determined accurately once and for all, but it would also shed a flood of light upon many of the conjectured physical conditions prevailing deep down under the ground. We know, for instance, that as we go deeper and deeper into the earth, the temperature rises more and more. The earth's centre is supposed to have a temperature as high as 4,000 degrees Centigrade which is somewhat higher than that of an ordinary electric arc. At the earth's centre, too, a pressure of between 30 and 40 million tons per square inch is considered to exist. Such figures, naturally, result from careful theoretical calculation and we have no means of verifying them. It is not impossible, however, that the sinking of a deep shaft into the earth, besides revealing the presence of new materials, would enable scientists to garner much information concerning the conditions of pressure, temperature, magnetic distribution and other states prevailing in the earth's crust.

A New Source of Natural Energy

More practical still, the result of such a deep shaft sinking would almost certainly be the provision of a new source of natural energy, to wit, that of the utilisation of the earth's interior heat.



Illustrating the underlying principle of a deep oil-well boring.



Lathe Work FOR AMATEURS

A Simple Milling Tool

A VERY useful tool, which can be applied to various kinds of milling in the lathe where a milling machine is not available, can be rigged up at a small expense; only a couple of wooden patterns being required, and the machining being all done in the lathe.

Fig. 1 shows the tool. It is designed to fit on the top of the compound rest in the place usually occupied by the tool-post, and attached by the same holding-down nut as is used to hold the tool-post or tool-holder down on the top slide.

A is a cast-iron bracket with a flat bottom and a vertical face at right angles to it. A stiffening rib *B*, is glued into the wooden pattern which is the same shape as the bracket, and can be made of ½-in. stuff for the vertical part, and ⅝-in. for the base.

Adjustment for Height

It has two vertical slots *ZZ* (shown in the part back view inset in Fig. 1). These are to allow an adjustment for height of the milling cutter. The cutter is carried on the end of an arbor or spindle *C*, the lower end of which is tapered as shown, and has a shoulder *D* against which the milling cutter is held up on a parallel portion by a lock-nut. The rest of the spindle is parallel, and fits and rotates in the parallel bore of the bearing *E*. This is another iron casting and its shape is shown at *F* in Fig. 2, which is a plan view of the tool. It is also cast from a wood pattern of the same shape and size. The spindle *C* is of cast steel, turned from a bar of the diameter of the shoulder at *D* (Fig. 1). Its shape and dimensions are shown in Fig. 3. The bearing *E* has a flat back which beds up against the flat face of the vertical part of the bracket *A*, and has four $\frac{5}{16}$-in. Whitworth studs screwed into it to line up with the slots *ZZ* in the vertical face of the bracket *A*. These studs have washers and nuts, and allow for an adjustment of the spindle vertically, so that the cutter may be on a line with the lathe cutter or a little above or below it, according to the work being done.

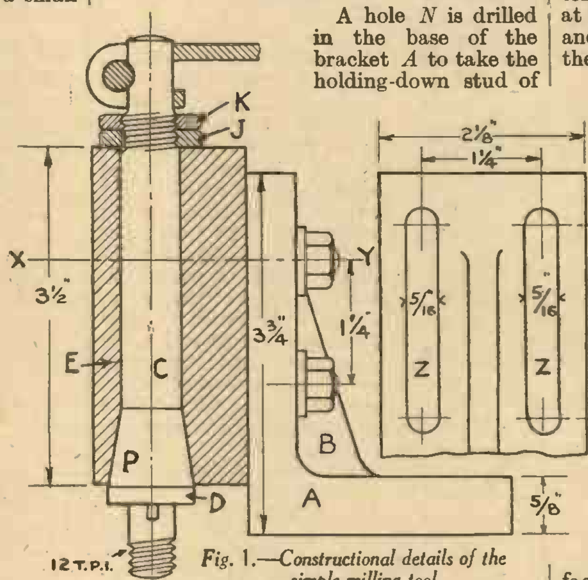


Fig. 1.—Constructional details of the simple milling tool.

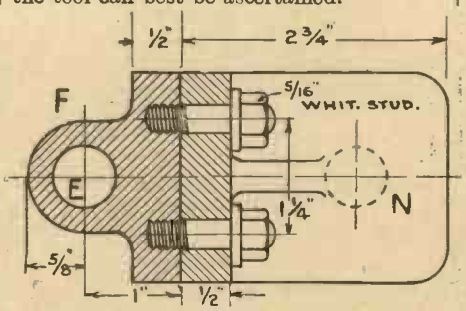
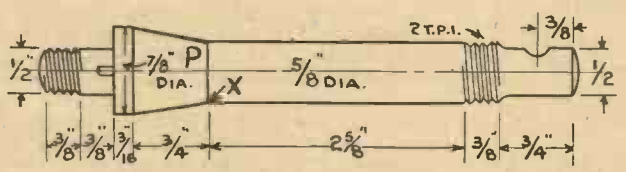
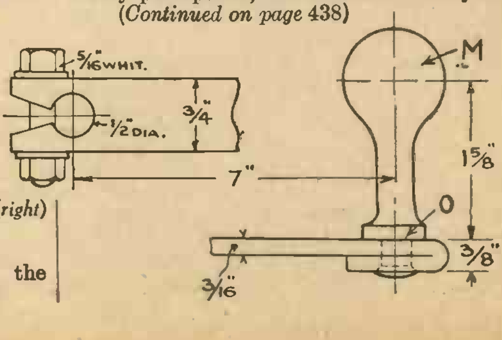


Fig. 2.—A part-sectional plan view of the tool.





Figs. 3 and 4.—(Left) Details of the spindle and (right) the turned handle.

The end of the spindle *C* is screw threaded with a fine thread to take the screwed collar *J* and lock-nut *K*, by means of which the bearing of the spindle can be adjusted to turn without shake. The end is slotted to take the pin which clamps the lever handle on the end, as shown in Fig. 4.

Suitable for a 4½-in. Lathe

A hole *N* is drilled in the base of the bracket *A* to take the holding-down stud of the lathe tool-post, and should fit it without shake. This hole will be drilled last, when the best position on the top slide for the tool can best be ascertained.

The dimensions given are suitable for a 4½-in. lathe but can, of course, be altered slightly to suit the tool-post or top slide for which the milling attachment is intended.

The turning and screw cutting of the spindle will offer no difficulty.

The long bearing for the spindle *C* is bored in the following manner. The casting *F* is carefully centred at each end, and fed up by the lathe back centre to a drill held in the three-jaw chuck. A small hole is drilled each end, and gradually enlarged until a hole is completed right through, but one thirty-second of an inch less than the finished diameter, which is ⅝ in. Then a full-size drill is used to clear the hole, and a reamer is then fed through, just a shade larger, to make a clean bearing.

The spindle (Fig. 3), which is turned later, is oversize so that it fits snugly in the reamered bore. If reamers of the exact size are not available, the dimensions may be slightly altered, so that a reamer at hand can be used, thus eliminating the expense of a new reamer. Next, a taper-reamer is made of cast steel, and hardened and tempered to the angle of the taper bearing at the bottom end of the bore at *P*, Fig. 1, and the bottom of the bore is opened out till the taper is ¾ in. long.

Fitting the Top Slide

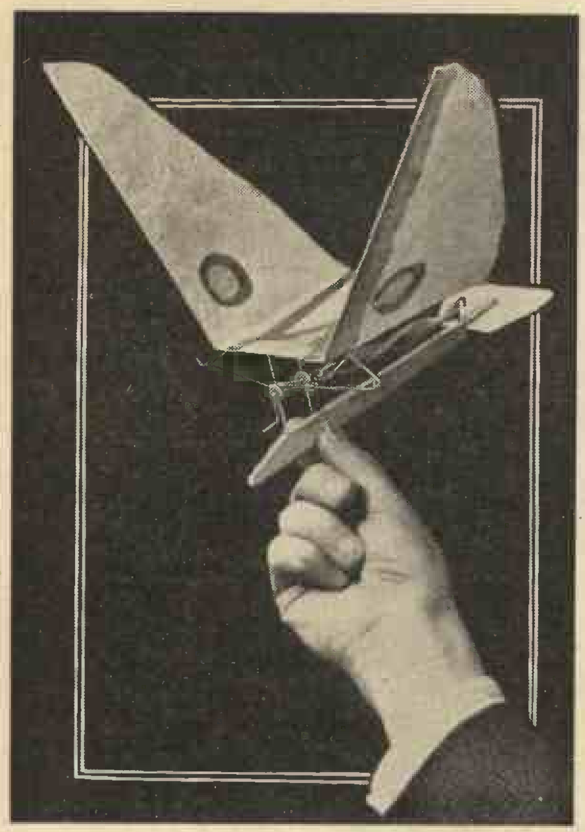
When making this taper-reamer, set the top slide of the compound rest over so that the tool cuts the taper, and mark carefully how much the slide is set over, so that it can be set to exactly the same angle when turning the spindle.

Turn a brass mandrel to fit tightly in the bore. Mount this between the lathe centres, with the casting driven, and face off the ends of the bore. The top end is important, but the bottom is not, so that instead of mounting the mandrel between centres, it can be chucked in the three-jaw chuck, the casting driven on and the end faced. But if this procedure is adopted, it must be ascertained that the bore, at the end of the hole—the top end which we are facing off—runs quite true. Only a light cut will be necessary.

In turning the spindle (Fig. 3), see that headstock and poppet headstock are truly in line so that they turn truly parallel. This is important. Turn along parallel with a round-nose tool to the distance marked for the commencement of the taper, and to the diameter to just fit the bore in the casting *E*, finishing with a honed edge and a very fine cut, and using the casting as a gauge. The spindle should fit it tightly at this stage, but should be capable of being pushed full home with an effort. It is eased with emery cloth later.

Then exactly set the top slide over to the marked angle, and turn the taper at *P* so that it fits the taper in the bearing hole in *E*. Test this with red-lead marking to see that it fits all along the taper, and if it is out, adjust with a dead-smooth flat file. Then turn the slightest radius at *X* (Fig. 3). This is to ensure the taper bedding on the surface and not catching the corner of the taper in the hole. This radius must be barely perceptible, and is intended only to

(*Continued on page* 438)



The complete flapping-wing model.

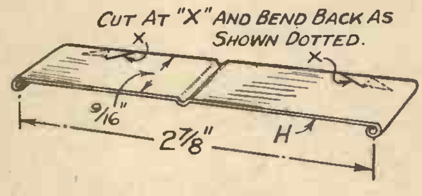
A Successful
How to Build a Simple Model Ornithopter
By F. J. Camm

HERE is something new for the aeromodellist—a simple yet very successful flapping-wing model which really does fly. It is of the Slinn pattern such as is popular in America. This little model flies most steadily and realistically; its duration is not large—from 12 to 15 seconds—but it flies most spectacularly and it is fascinating to watch it in the air. The mechanism is of the simplest character, and is made entirely of bent wire of which full constructional details are given in the illustrations. It is of 17 in. span, and the length of the motor-rod is $8\frac{3}{4}$ in., the motive power being provided by four strands of $\frac{3}{16}$ in. × $\frac{1}{32}$ in. elastic. The mainplane is of paper, and the motor-rod of spruce. I have made the drawings so complete, that I do not think a lengthy description is necessary in order to enable the reader to make it. The wire should be piano wire of 18-gauge throughout. It will be noticed that the crank has a winding handle formed on it, the bearings being provided by two washers soldered to the wing supports.

The Articulating Rods

These are attached in the manner shown in detail 4, whilst the bearings are shown in detail 3. Detail 5 is, of course, the rear hook for the elastic, whilst detail 1 shows how the wing supports are attached to the tin-plate wing mounting. The two limbs marked L which are, of course, made of wire, form the hinge to the wing, whilst J indicates the wire leading edges to which the wing is attached; the paper wing is stitched over this, the rear or trailing edges of the wing being quite flexible. Details of the wings are given on page 398.

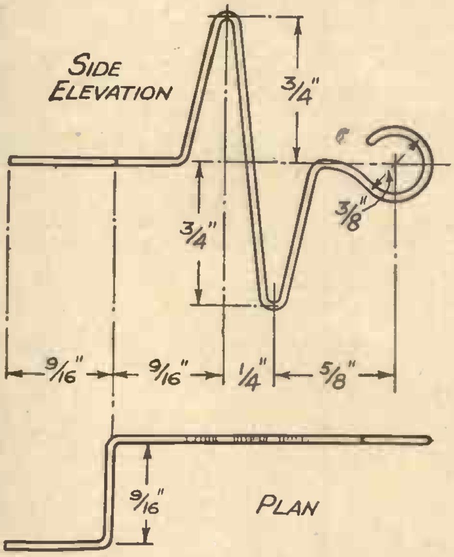
As mentioned last month, I shall be glad to receive details and photographs of any successful flapping-wing model which has been built by readers. One of the chief difficulties encountered with this type of model is to get the model to climb. Usually, they fly at the height at which they are launched, but this one does climb, and the best length of flight obtained at the present (with the model illustrated) is 50 yds. Generally speaking, a flapping-wing model requires a stronger down-stroke than up-stroke, and a rate of wing articulation of eighty strokes a minute at least.



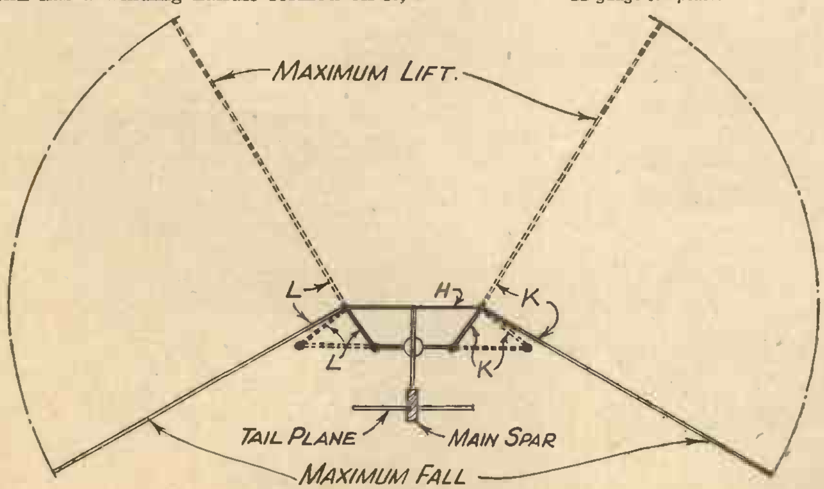
The wing anchorage and hinges. It is made from 22-gauge tin-plate.

Club for Builders of Power-driven Models

The suggestion I made in these pages that the time was ripe for the formation of a club exclusively devoted to the interests of power-driven model aircraft, is bearing fruit, and I have had many letters on the subject. I propose, therefore, in the near future, to call a meeting of interested parties with a view to forming the club and placing it on a sound footing. I have already made arrangements for a President, Vice-President, and am contemplating providing a special workshop equipped with a lathe and other machine tools to encourage the building of petrol, compressed-air, and steam models by those readers whose interest, due to lack of equipment, is confined at present to reading about them. It occurs to me that many people who have had no experience of metal turning and fitting would appreciate such a club-room, for they would then have the benefit of the experience of other skilled members. The chief interest in building power models is not confined to the flying of them; there is extreme fascination in building an engine, and when completed, seeing it jump to life on the test bench. Obviously we could not at the start have these club-rooms all over the country, and I should be interested to hear from my readers so that we can discuss the best location central for all. If sufficient support is forthcoming, other branches of the club could be established from time to time on the lines laid down by the members. I am prepared to

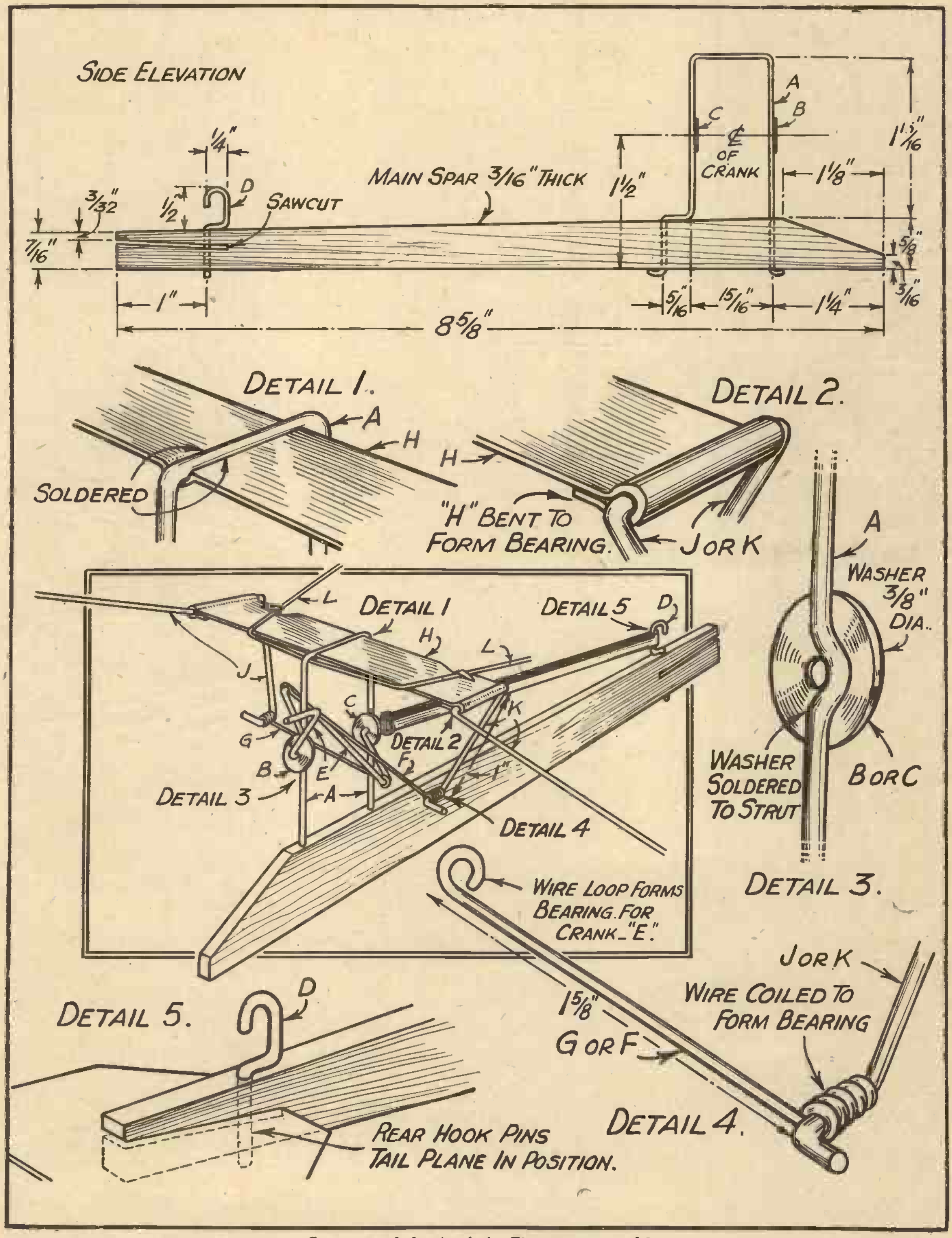


The articulating crank with combined winding handle.



Detail of the articulating mechanism.

Flapping-Wing Model

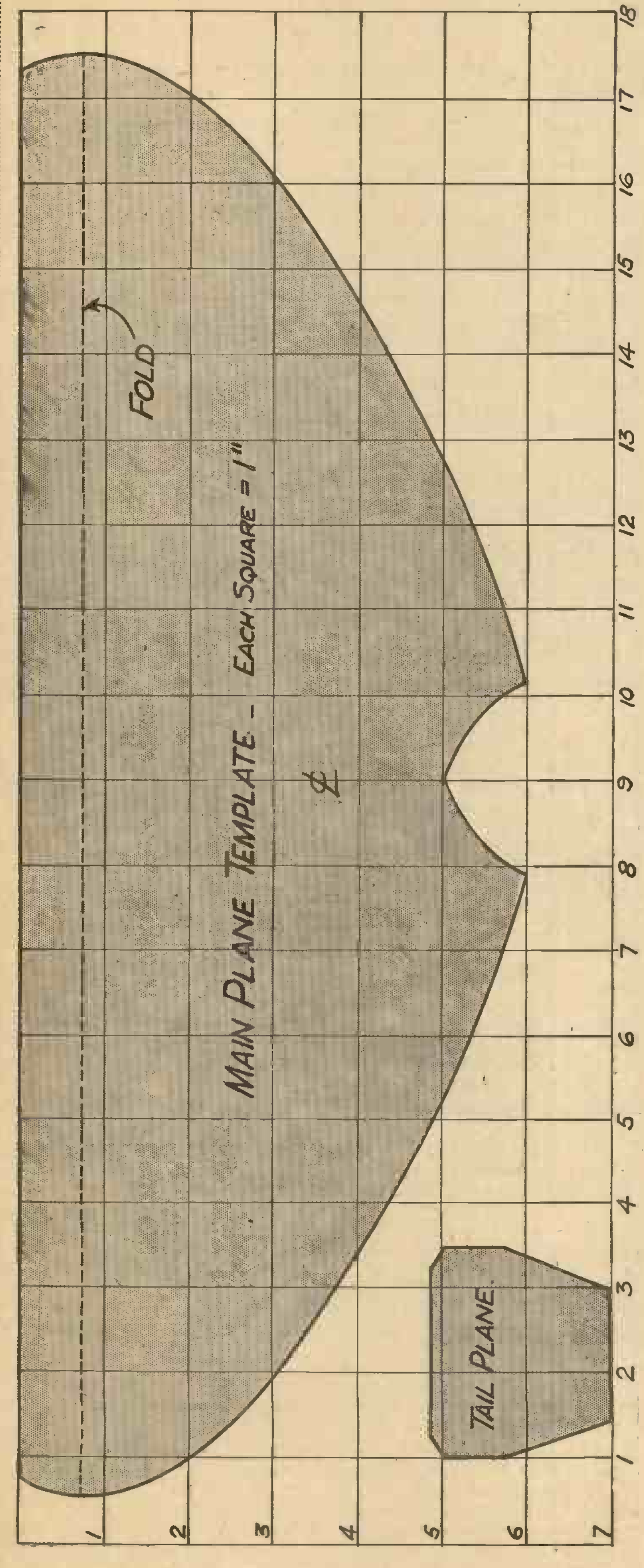


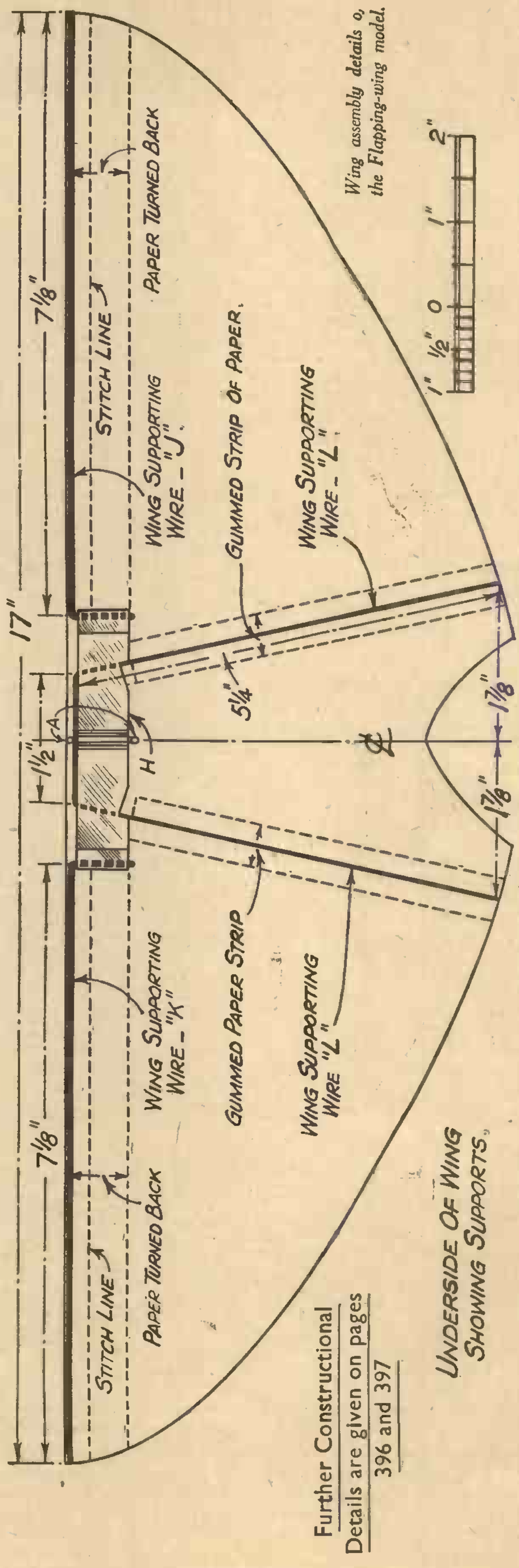
Constructional details of the Flapping-wing model.

contribute a sum of money myself towards the foundation of this movement. If you have any views on the question, I shall be glad if you will communicate them to me at once.

Even Smaller Petrol Engines

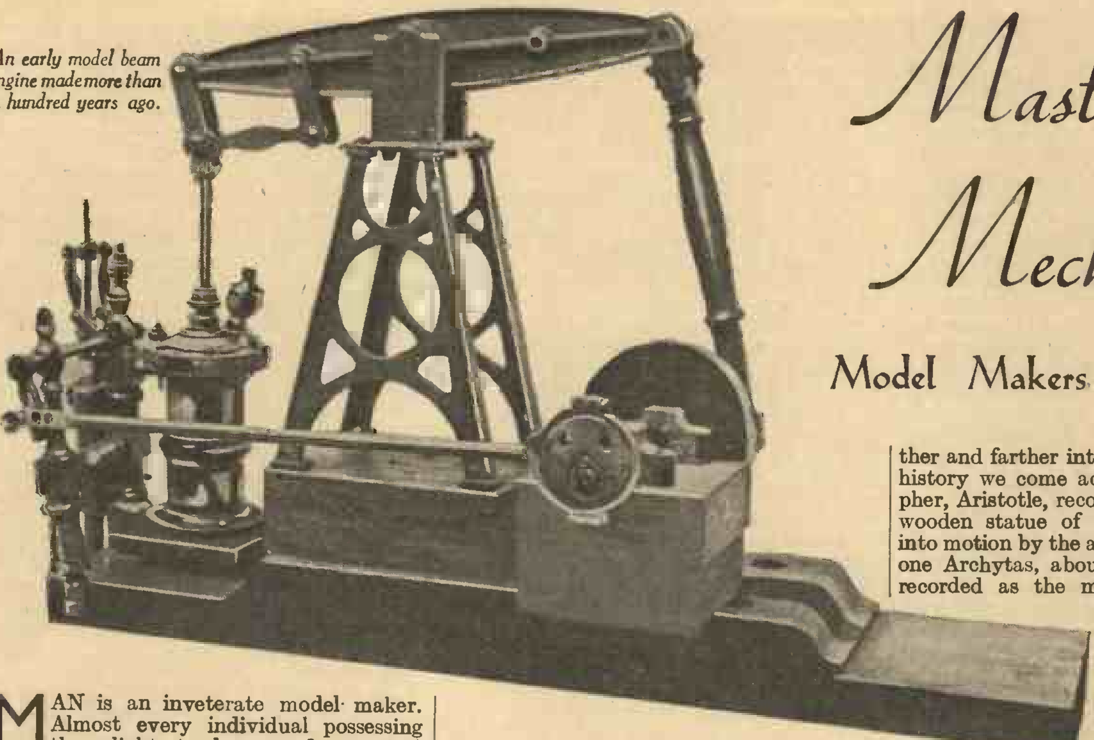
I hear that many engines of only 5 c.c. are being produced in America and that models fitted with them, weighing only 16 oz., are flying successfully for lengthy periods. I feel that there is a large market for a really miniature petrol engine, but I have not yet heard that any English manufacturer contemplates marketing them This leaves the British market open to American and Japanese competition. I do not feel that the future of petrol-driven models can be assured until smaller engines are supplied. There is now no real reason why they should not be produced. Midget coils which were previously the bugbear to a really small and light engine are now available weighing only 4 oz., and with the new alloys such as hiduminium and electron, really light, yet powerful engines, can be produced.





Wing assembly details of the Flapping-wing model.

Further Constructional Details are given on pages 396 and 397



An early model beam engine made more than a hundred years ago.

Masters of Mechanics

Model Makers of the Past

MAN is an inveterate model maker. Almost every individual possessing the slightest degree of practical mechanical ability, particularly if this gift is coupled with a modicum of inventive ingenuity, feels, at one time or another, the urge to construct with his own hands a miniature working representation of something which he has seen or of something which, maybe, he hopes to see. Such constitutes the fundamental basis of model making.

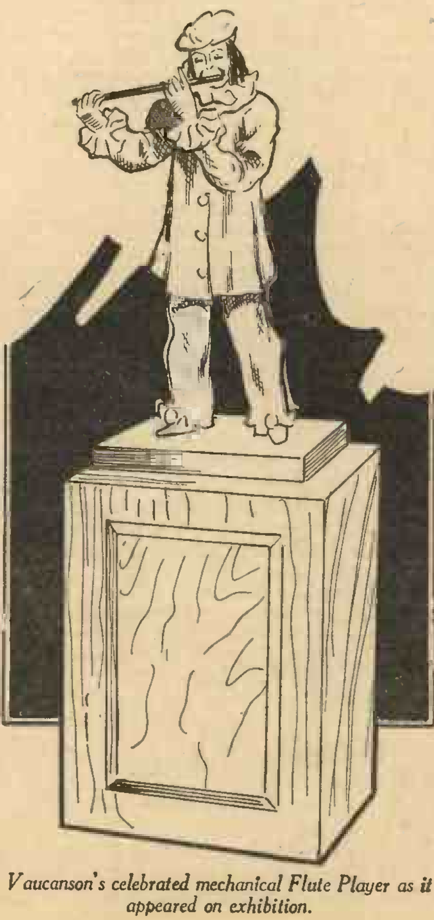
A model may be either a plaything or an object of serious study. Frequently, it combines both these attributes. Few, indeed, are the models which are not capable of providing a certain amount of enjoyment and entertainment, apart from their purposeful demonstration of certain principles which may, often enough, be the sole cause of their existence.

Most of the models made nowadays—or, at least, those to which the epithet "working" may be applied—are actuated by steam or electrical power. Spring- and weight-operated models are becoming fewer and fewer, this, of course, being for the reason that such sources of motive power are, from a practical standpoint, relatively inefficient and undesirable. In earlier times, however, when the first steam engines were being constructed, and when electrical power was unknown, model-making was raised to a very high art at the hands of a few ingenious individuals. The models constructed in those days were laboriously put together by solitary constructors working with the aid of simple tools and equally simple materials. Usually such models took the shape of working representations of human figures, animals, and other living things. These models, which, incidentally, are now included in the category of *automata*, were made to go through a series of actions and perform certain feats in as lifelike a manner as possible. They were, usually, toys for the rich, but their fame spread, and they were widely described and often publicly exhibited.

Automatons

Automaton construction is a very old art if we are to believe all the apparent records of history concerning it. Who, for instance, has not, in his younger days, read of the supposed Speaking Head of St. Albert the Great, which his still more illustrious pupil, St. Thomas Aquinas, is reputed to have smashed to pieces. Friar Bacon, also, was famed as a model maker. He is, indeed, about the first recorded model maker of relatively recent times. But, going back farther and farther into the depths of classical history we come across the great philosopher, Aristotle, recording the existence of a wooden statue of Venus which was set into motion by the action of quicksilver, and one Archytas, about the year 400 B.C., is recorded as the maker of a mechanical pigeon which could flap its wings and fly about in the air.

The ancient Egyptians, it is certain, were very ingenious model makers, and they applied their model-making activities to practical ends. The Chinese also, before them, laboured long and assiduously at the same arts. The great difficulty, however, which confronts the investigator of the above classic models is the fact that they are all merely legendary. Their actual existence cannot be proved or disproved. Usually, however, the present-day mechanician very rightly swallows accounts of such constructional feats with more than the customary sprinkling of salt.



Vaucanson's celebrated mechanical Flute Player as it appeared on exhibition.

Clock Construction

During the eighteenth century, when mechanical inventions were just beginning to arise, a remarkable era of model and automata making set in. Probably such activities on the part of several inventors had their origin in the art of clock construction which was then advancing to a very high degree. Clocks, at that period, were known which, in addition to their normal function of time-telling, set into motion at certain hours trains of mechanical puppets, dolls, and other figures which paraded prominently in front of the dial, and went through a series of actions for the benefit of the onlooker. Cuckoo clocks date from this period. So, also, do time-keepers which play tunes, and give rise to other more or less novel effects at various hours of the day. It is, therefore, not very surprising that in an age which was becoming more and more conscious of its mechanical and inventive powers, many ingenious yet, at the same time, more or less trivial mechanical models were constructed.

A veritable king of model makers and automata constructors was Jacques Vaucanson, whose birth occurred at Grenoble, in France, in 1709. Vaucanson was undoubtedly a genius in mechanical construction, and when only a youth he is credited with the making of several self-moving figures. Vaucanson was less than twelves years of age when he accompanied his mother to the house of a friend. In the house was a pendulum clock, the slow-ticking movement of which attracted him irresistibly. On the occasion of his next visit to the house, young Vaucanson took crayons and paper with him. By this means he managed to make a partial sketch of the clock's mechanism, a sketch which was completed on subsequent visits to the same house. Gradually, an understanding of the clock mechanism came into the mind of the youthful mechanician. Utilising odd pieces of metal, bits of wood, and with such rough tools as he could find or devise, he managed to make a pendulum clock which kept reasonable time.

In this manner Vaucanson's career of mechanical construction and model-making began. The success of his clock whetted the lad's appetite for further constructions. A year or so afterwards he completed the making of a minature represenation of a church interior. In front of the altar, priests in their vestments went through ritualistic actions, whilst wooden angels flapped their wings above them.

The Flute Player

One of Vaucanson's greatest achievements was his famous Flute Player. This remarkable automaton was the product of his younger years and it was, for the most part, constructed during his convalescence after a severe illness. Whatever the exact truth of the matter may be with regard to this assertion, there seems to be no doubting the fact that Vaucanson's Flute Player was really a remarkable model.

The celebrated Flute Player comprised a suitably garbed figure which raised an ordinary flute to its mouth and played in perfect manner several different airs upon that instrument. The figure was a little more than 5 ft. high, and it stood upon a piece of rock, the latter being supported on a square pedestal 4½ ft. high by 3½ ft. wide. A panel was formed in the front of the pedestal. Actually this panel comprised a secretly-latched door which, when opened, gave access to the interior of the pedestal. Within this ample interior was confined a clockwork motor which operated nine miniature bellows, and, also, a large hollow barrel upon the surface of which were set a series of protruding pins. By means of this basic arrangement wind was conveyed to the mouth of the figure, and, operating under the influence of the barrel pins, the fingers of the automaton "stopped" the the necessary holes in the flute. The figure was provided, also, with a movable tongue, through the action of which the character of the music could be modified. This member, too, was operated by means of the pattern of pins set in the revolving barrel.

The Flute Player was first exhibited in 1736. It created an immediate sensation. In Paris, it was received with much suspicion, but when a select committee of the French Academy of Sciences had had its mechanism explained and demonstrated to it, the model was publicly pronounced to be free from deception.

A Mechanical Duck

Another of Vaucanson's famous working models was his Mechanical Duck, a creature which, outwardly, was an exact reproduction of the real thing. Not only did the duck waddle and quack in the approved duck-like manner, but it also took up grains of food in its beak, muddled them in pools of water and finally swallowed them. Not content with reproducing Nature's handiwork thus far, Vaucanson gave to the duck an imitative digestive system in which, by the employment of a simple chemical solution concealed within the body of the duck, the swallowed food was "digested," or, rather, changed in form, and even ultimately excreted.

Other self-moving models of animals, birds, and even insects seem to have poured themselves forth from Vaucanson's workshop in rapid succession. He even made a mechanical serpent to oblige his friend, Marmontel, who had written for stage presentation a version of the tragedy of *Cleopatra*. When, at the physchological moment in the piece, Cleopatra brought forth the serpent, its realistic hissing and writhing in her hands added greatly to the dramatic incident.

Vaucanson's fame as an automaton and mechanical model-maker brought him a practical reward in the shape of a secure appointment as an Inspector of Silk Manufacture at Lyons. There he died in 1782, leaving a large number of his models to the King. The ultimate fate of these historical models is unknown. The famous Flute Player, together with a few other models, was purchased by a Professor Bayreuss, of Helmstadt, at the end of the eighteenth century, but its further transferences, if any, have not been traced. Very probably, the Flute Player has, like its creator, been resolved long ago into the universal dust.

A Famous Model

Philip Camuz, another mechanician, made a very famous model for the amusement of the young King, Louis XIV, of France. It consisted of a coach and horses which, with truly lifelike movement, would set off in the characteristic style of the period. At last, stopping in front of the King, the coach door would open and out would come a lady who, "with *bon grâce*," as it was said, politely curtsied, and presented a miniature petition to the onlooking Monarch. Then, re-entering the carriage, the fair petitioner would nod to the coachman and the equipage would start up again, the horses trotting along just as they had done previously.

Singing birds, bleating sheep, neighing horses, and other clamorous animals were more or less simple products of many clever model-makers of the period. They had their representatives in the speaking dolls which were obtainable commercially in all mid-Victorian toyshops. Alas, however, none of these early automatons has survived the ravages of time. Trivial things they were, and they have long ago disappeared into the oblivion which was apparently reserved for them.

Most readers will be familiar with the musician's metronome, or mechanical time-beater, in which a mechanically-impelled pendulum, contained in a polished case shaped like a pyramid, measures out accurately the time to be kept by the performer. The inventor of this well-known instrument was John Maetzel, a mechanic who was born at Regensberg, Switzerland, in 1772. Maetzel specialised in the construction of what we may now term "musical working models." Most of these worked by clockwork. They blew trumpets, beat drums, played on strings, and performed many other imitative actions.

A Model Exhibition

In 1809, Maetzel opened an exhibition of his models in Vienna. A life-size military trumpeter was the chief attraction of the show. Maetzel wound it up by means of a key inserted into its hip. The model thereupon played military marches upon the trumpet and went through a series of French military exercises and movements. The figure was controlled by means of one or more springs concealed beneath its left epaulet. The mechanism of Maetzel's military trumpeter was never made public. No doubt, however, this ingeniously-constructed figure ended up its working life in the side-booth of some humble travelling showman.

After the time of Maetzel, the prevailing interest in mechanical automata which, no matter how cleverly contrived, were at their best extremely trivial and unimportant in nature, waned. In their place came the more solid interest which mechanically-minded individuals had begun to take in the construction of prive movers, that is to say in power-producing plant.

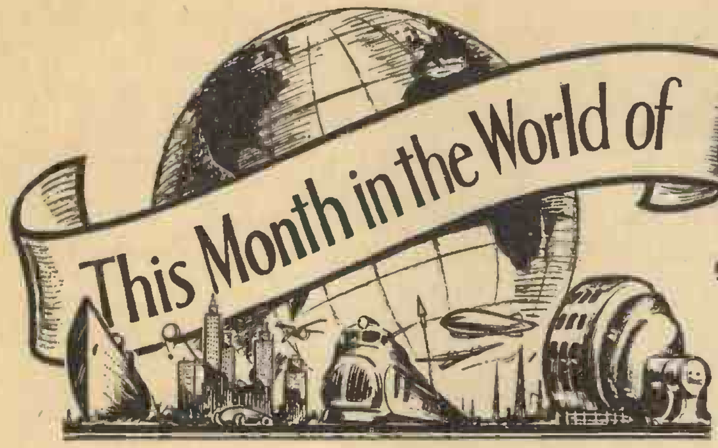
The earliest steam engines were not invariably preceded by models. Very frequently, however, mechanics employed in the construction and operation of early steam engines occupied themselves in making models of their engines. Quite a number of these models, unlike the older clockwork automata, have come down to us. Frequently, they are exquisitely made, every piece, despite its relatively diminutive proportions, fitting its opposite member with perfect accuracy. Such perfection in mechanical model making is, naturally enough, readily obtainable nowadays, particularly in the case of professionally-made models. It should be remembered, however, that the now unknown makers of models of the period under consideration were entirely without precision tools of any description. Every portion of their model was literally "hand-made."

It is a rather curious fact that the makers of the older clockwork automata, and other mechanical models, have remained on record to the present day, despite the almost complete disappearance of their products. On the contrary, the early steam-engine modellists of Great Britain have, so far as their names are concerned, long ago vanished into oblivion. Yet many of their fine hand-made engines have survived, and have come down to us almost unimpaired by the passage of time—a contrast, indeed, between the trivial and the great.

"Tool Making for the Craft-Room," by C. Howell. 80 pages, 25 illustrations. Price 2s. Publishers, Sir Isaac Pitman & Sons, Ltd.

IN this handy little book the author has set out to explain clearly how the students in a school may produce the various tools which are required in the handicraft classes. The book deals with the materials required for use in the craft-room, the method of treating such materials with a view to the production of various types of tool, to lathes and lathe processes, and to the details and working drawings of selected tools. It covers the production of tools for wood-work, for metal work, and for other branches of handicraft, but omits all reference to the production of machine tools. Presumably the author considers that these come beyond the scope of the ordinary craft-room.

The Working Instructions give complete details, with fully-dimensioned drawings for the making of Callipers, Square, Centre-Punch, Cold Chisel and Scriber, Soldering Bits, Hack Saw Frame, Adjustable Square, Tap Wrenches, Sliding Bevel, Pin Vice, Toolmaker's Clamp, Trammel Head, Small Vice, Paper Punch, Light Bench Shears, and a Hand Vice.



This Month in the World of Science,

A Combined Camera and Microscope

THE conjunctional capillary camera shown on this page, was designed principally for detecting hardening of the arteries, and is used for photographing the capillaries of the eyes, which are fine thread-like blood vessels. The instrument is a combined camera and microscope, that works through the eyes of the patient, whose head is held rigidly against a support as the microscope is focussed on the eye, which for the sake of the picture is, or can be, magnified eighty times. The operator moves the instrument in any direction, following the curvature of the eye, and thus studying the capillaries carefully, magnification is sufficient to show the corpuscles of the blood.

The camera-proper, of the new "Candid" type is mounted behind a microscope, set on a tripod stand, shown on the right in the illustration. In the centre is the head support and in front of it a dentist's mirror that reflects light into the patient's eye from the black tube on the left. In that tube, mounted above a voltmeter, are two 32-candle power bulbs behind several condensers. The designers have been experimenting with this camera since 1929, and only recently has it been put into daily use.

Modern Aids to Watch Repairs

WATCHMAKERS are now using sensitive microphones and amplifiers to assist in the diagnosis of watch troubles. Sounds that are too weak to hear with the unaided ear are easily detected by this means, and more rapid diagnosis of escapement troubles is thus made possible.

Adjustment of the escapement to give correct time-keeping is generally a tedious business, but a neon-lamp chronoscope has now been devised by which the escapement can be compared with a standard tuning-fork. A stroboscope disc is timed to rotate accurately at one revolution per second by a tuning-fork, and the ticking of the watch is used to illuminate a neon lamp by means of the amplifier. Unless the tuning-fork and the watch are in perfect synchronism, the stroboscope disc will appear to rotate. The watch is then adjusted until the disc appears stationary, when it may be relied upon to keep almost perfect time.

Temperatures in the Stratosphere

FOR nearly fifteen years it has been known that the air temperature, at extreme heights, was higher than that at ground level, although no very definite evidence had been obtained. Recent investigation by radio methods of the ionised region of the upper atmosphere has disclosed that at the height of the Heaviside layer—about 60 miles—there is little change in temperature throughout the year, but in the region known as the Appleton layer at a height of about 200 miles, the temperature at noon on a summer day is in the neighbourhood of 900 degrees Centigrade.

Diagnosis by Boots

THE medical profession has many remarkable methods by which various diseases may be detected, but the boot-makers have discovered a new one. The Boot Trades Research Association has recently conducted an extensive investigation into the effects of perspiration on the wearing properties of boots and shoes, and the discovery of uric acid in certain samples disclosed the fact that the wearer had a tendency towards gout, while one individual whose shoe leather was found to be impregnated with sugars, was found to be suffering from diabetes!

Astronomical Developments

THE number of stars visible on a clear night to the naked eye is only about 5,000. For studying the more distant stars, telescopes must be used, but even a giant telescope gives insufficient magnification for the most distant stars to be rendered visible, and so photographic plates and long exposures are used instead. A new astronomical lens has just been designed with an aperture of f.o.35, which will be twice as rapid as the previous fastest lens. This lens will nearly double the range of the new 200-in. telescope now under construction at Mount Wilson, and stars whose light takes more than 200,000,000 years to reach us, will thus become available for investigation.

The conjunctional capillary camera which is used for photographing the fine thread-like blood vessels of the human eye.

Invention & Progress

Novel Screw-cutting Machine for Wood

WOOD screws, when mass produced, are generally milled or chased. At the recent Leipzig Spring Fair, a novel screw-cutting machine was shown which renders such work easier and quicker. This machine is suitable both for male and female threads, and no skilled labour is required. A special advantage for mass production is the saving in time and the neatness of the work done.

A Novel Electric Hand-drilling Machine

HAND-DRILLING machines have always had the disadvantage that they could be used only intermittently, on account of the heat developed in the motor. At the recent Leipzig Spring Fair, a novel design was shown, in which the motor and the drilling spindle were separated as such, and only connected by a steel ribbon. The electric motor, consuming 100 watts, was fitted with a fan for air cooling. It was totally enclosed and stood an overload up to 100 per cent. By switching in a gear wheel (of some pressed material) in the ratio of 13 to 1, running was very silent. In steel, it drills holes up to $\frac{1}{4}$ in. diameter, and in softer material up to $\frac{5}{8}$ in. A special advantage is that the drills can be easily exchanged. The price is exceptionally low.

A Novel Drug-cutting Machine

A NOVEL machine for the manufacture of medicaments was recently demonstrated, which will cut up all kinds of drugs, such as rinds, roots, bulbs, and other hard parts, and render them suitable for packing. Pieces can be reduced to a size of .004 to $\frac{3}{8}$ in. width, or cubes of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. sides. The working of the machine is very neat, and whilst working, the material may be screened, and particles of dust removed by means of a shaking sieve fitted to it. A spraying device fitted to the machine allows hard drugs to be moistened before cutting up. The capacity of the machine is up to 330 lb. per hour.

A Novel Device for Tipping Barrels

A CHEMNITZ firm, specialising in implements for drawing off liquids, have produced an ingenious barrel-tipping device; trade mark " Volkstyp." The price is only about double that of an ordinary carboy tipper. With this apparatus, there is combined a barrel lifting and emptying device. It is therefore possible to lift and empty barrels of either wood or iron, and with a capacity up to about 70 gallons gross. No pumping is necessary and no liquid will be lost. The invention has been patented in Germany and many other countries.

Facilities for Electric Wiring

THE fixing of several wires to walls has always been a somewhat laborious work, owing to the large number of clamping devices necessary. A new method of fixing electric wiring on a clamping rail has now been devised. This is plugged into the wall once only and consists of a U-shaped rail, cadmium-plated, and fitted with a series of clay insulators, between each of which a wire may be fixed. Such a device will also allow an occasional dismantling of any wire without disturbing the rest of the plant, and will render the whole installation easier and cheaper.

A Novel Device for Fixing Electric Switches

IN spite of all standardising, the fixing of switches on plastered walls has always met with certain difficulties. A new method is now being marketed which will save the fitter half his time. A metal piece is fastened to the wall by a single plug, into which the screws holding the switch can be easily screwed. If the walls should be damp, and require abnormal switches, the same device can be used, since the bridge for the fixing screws has swinging arms which can be adjusted in accordance with the distance between the screws. The work of the fitter is considerably eased by this novelty.

Warm-water Heating by Electricity

AT the recent Leipzig Spring Fair was shown an electrically operated warm-water heating installation, suitable for up-to-date households, which is independent of any main and pipe connections. Water will be heated in portable radiators. The power required is comparatively small, and as the radiator is extremely light in weight it can be easily moved about to any spot where heat is required. Since the maximum of heat radiation is reached within about twenty-five minutes, the consumption of current is very low. Surface temperature of the radiators is also low so that the heat transmitted to the room is pleasant and mild, and no dust is burne d.

Ten Hours of Light for $\frac{1}{6}$ of a Penny

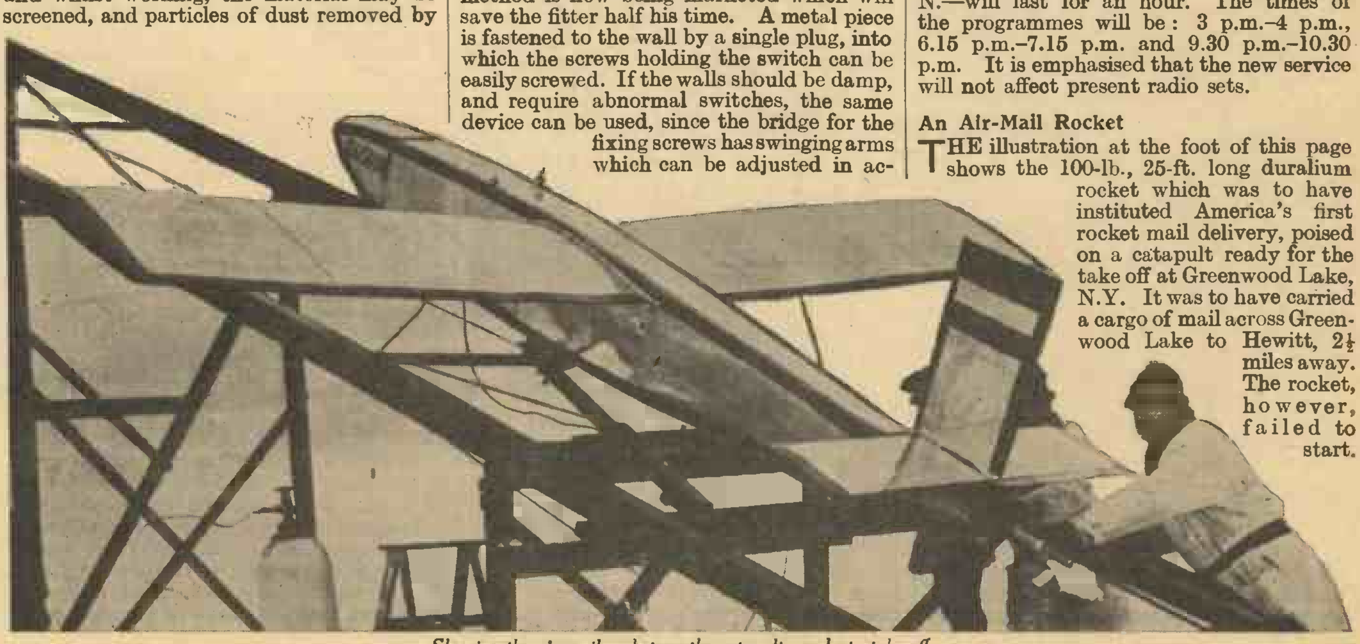
A FIRM of specialists have now produced a novel lamp, which may be connected to any alternating current lighting main and does not require more than 5 watts. The lamp is fitted with a silent transformer and a lamp for 8 volts, 3 amps. Its illuminating power is increased by a concave reflector. It may be screwed into any normal fitting. The lamp is of very solid construction, and is suitable for comparatively rarely used rooms, halls, staircases, lofts, cellars, etc., on account of its cheapness.

Television Programmes

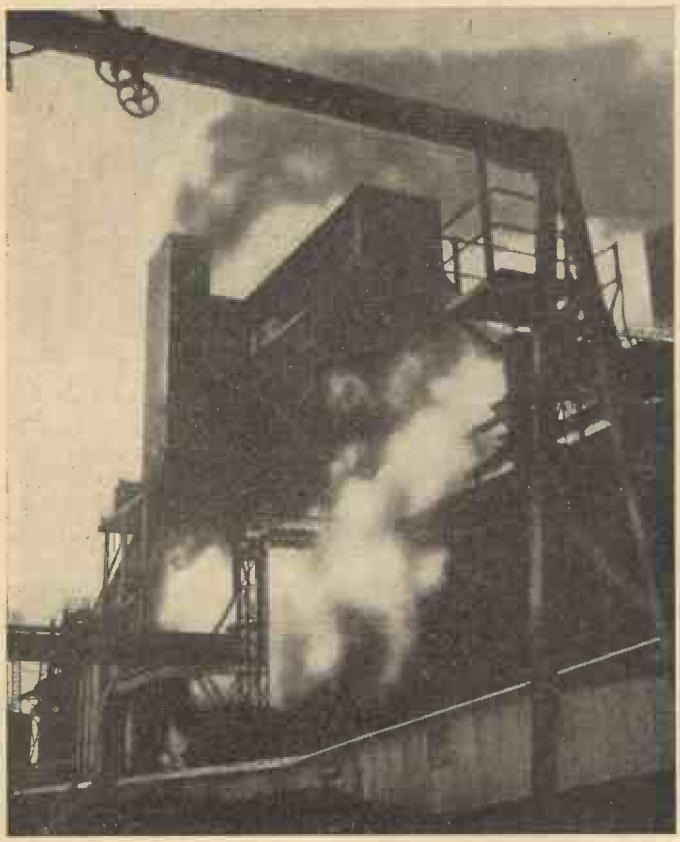
THREE transmissions a day are to take place when the B.B.C. begins its new television service, probably in June. Each of the television programmes—which will be broadcast from Alexandra Palace, N.—will last for an hour. The times of the programmes will be: 3 p.m.–4 p.m., 6.15 p.m.–7.15 p.m. and 9.30 p.m.–10.30 p.m. It is emphasised that the new service will not affect present radio sets.

An Air-Mail Rocket

THE illustration at the foot of this page shows the 100-lb., 25-ft. long duralium rocket which was to have instituted America's first rocket mail delivery, poised on a catapult ready for the take off at Greenwood Lake, N.Y. It was to have carried a cargo of mail across Greenwood Lake to Hewitt, $2\frac{1}{2}$ miles away. The rocket, however, failed to start.



Showing the air-mail rocket on the catapult, ready to take off.



(Left) A modern coke-oven battery. (Right) An impressive view of one of the many chimney-stacks which are dotted all over the country.

Coal Mining Developments

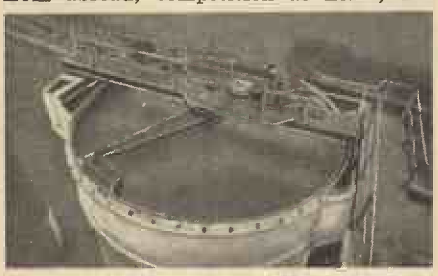
The Beginning of 1936 saw Coal Mining on the Verge of a Crisis. The Underlying Cause of Unrest was that Fuel Technicians had Learnt how to get More Work and Power out of a Ton of Coal. They had not Progressed Far Enough in Their Search for New Uses for the Tons they Save

THREE or four hundred years ago, the first "sea coal" came from Newcastle to London. Gradually it displaced wood from the domestic hearth, and wood charcoal in the iron master's blast furnaces. Then came the steam engine, and the rise of the great cotton and wool spinning industries in the North. Boiler stacks began to smoke, and they rapidly increased in number. Iron foundries with their beehive coke-ovens prodigally burning coal gas, tar and ammonia to waste, multiplied. In 1805 Murdoch started to make coal gas in retorts. Everybody wanted the new lighting. Gas works flared away in every town in the country, often with cressets of flame at their retort house stacks. Production, not economy, was the order of the day in that prosperous, expanding age.

The beginning of the present century did not cry halt to waste, and the coming of the power station only added to the number of wasteful smoking chimney stacks. 1910 is usually taken as the peak year of coal production, and in that year, Great Britain, with a population of 41 millions, consumed 180 million tons of coal. In 1934, 45 million inhabitants needed only 161 million tons for their homes and industries. The decrease is not due to decreased industrial output, but is due to newly learnt economy in coal utilisation.

Competition and Economy

The war marked the turning point and changed the entire outlook. It brought competition into industry, competition from abroad, competition at home, and competition which was far keener than anything experienced before. Abroad, nations had learnt to do without British coal in the war years, and when peace came, they still carried on without our coal. British steel industry for the same reason had to tighten in its belt. At home the motor-car had grown to challenge the railways for monopoly of transport, and electricity started to compete with gas for domestic lighting and heating loads. At sea, oil firing of ships was the order of the day.



A modern coal washery showing the top of the sludge thickener.

What was the result? Competition was fought with economy. On every side, scientific research and engineering skill were called in to economise coal, steam and power, to reduce obvious waste, and to increase mechanical efficiency. In the steel industry, the coke for blast furnaces is no longer made in the old wasteful beehive ovens. Modern by-product recovery-coke-oven batteries are used. They provide coal gas for the steel furnaces which were formerly fired with raw coal.

Gas engineers before the war were content with a yield of 10,000 cubic feet cf gas from a ton of coal. Modern methods give them 14,000 cubic feet. In some cases, by steaming the red-hot coke charge in vertical types of retort, a yield of 16,000 cubic feet per ton is obtained.

Limits of Economy

In 1910 the generation of a million units of electricity needed no less than 2,000 tons of coal. With modern super-efficiency boilers and high-pressure turbines, 661 tons per million units is an average figure. Battersea power station requires only 441 tons per million units, and there is no reason to believe that the limits of economy have been reached. In the most modern installations, a figure near the 300 mark may be reached. At the present day, it is estimated that the economy and greater efficiency of the combined gas, electrical, steel, iron, railroad and shipping industries accounts for a nett saving of 35 million tons of coal per year. If we were as wasteful to-day as in 1910, instead of a deficit of 29 million tons, we should be using 6 million tons more of coal per year.

Thus the position stands to-day. Fuel technologists have learnt how to save coal, but they have not found new ways of using the coal they save. Meanwhile miners and owners suffer from slumped production.

Old and New Methods

Coal suffers in the modern market. It is our greatest national asset and one of the richest and most complex of chemical raw materials. And yet, until recently, it was mined practically regardless of its rich and varied character. It was put on the market with the minimum of preparation, and without studying the real needs of the consumer.

Now, just as coal consuming industries have reorganised to meet new conditions, the methods of coal mining are undergoing a stringent overhaul. Below-ground machinery is coming into general use at the coal face. Coal cutters are replacing the miner's pick, and long belt conveyors are displacing pony haulage. Above-ground coal is being washed free from dirt and shale, and is carefully graded in size to suit special needs. In the laboratories, the coal resources of the country are undergoing exhaustive survey. New methods of coal utilisation are being sought, and the use of pulverised fuel on land and at sea is the subject of engineering development. Coal hydrogenation has come in. At the other end of the scale, experiments are being carried out with the humble domestic fire, greatest of our national coal consumers in an effort to effect a compromise between comfort and smoke abatement.

Fuel Research Board

Most active of all bodies is the government department, which under the title of the Fuel Research Board, was established as far back as 1917 to study coal utilisation and mining. Its activities centre in the laboratories and experimental station at Greenwich, where experimental high- and low-temperature carbonisation plant of several kinds is set up. The use of pulverised fuel, coal hydrogenation, and smoke abatement are amongst the problems studied. Subsidiary laboratories are established on all the important coal fields of Great Britain, thus making the national coal survey, which is already half completed.

Coal Survey

The coal survey is being made in a very thorough fashion. Every coal seam in the country is being carefully examined and followed up. Skilled workers cut complete columns of coal extending from roof to floor, which are taken up to the surface, as nearly as possible, in one piece. There, chemists examine them microscopically and analytically, and in this way a wide knowledge of the history and chemistry of coal is being accumulated. The correct uses and possible developments of every seam in the country will, in the end, be predictable.

Formerly, a knowledge of coal seams was extremely rough and ready. It was known that most South Wales coals were suitable for steam raising, and Yorkshire coals, on account of their high volatile matter content, were best for the gas industry. Durham coals in general gave good metallurgical coke, but to-day this is not enough. Exact knowledge is required if the best is to be got out of coal, and careful scientific examination is the only way to meet modern requirements. Incidentally, examination from the new angle is bringing to light resources of first-class coals in seams which have been long regarded as worked out and useless.

Stratification of coal and dirt by pneumatic cleaning. The dirt is the lighter material at the bottom.

Coal Washing

Coal as mined is by no means a pure substance, as it contains up to 10 per cent. of ash, dirt, shale and other foreign matter which is so much useless dross to the consumer. By proper treatment, all but 1 or 2 per cent of this can be removed, but naturally, coal cleaning costs money. But eventually the consumer will be willing to pay more for clean coal. He will save on carriage, on ash disposal and on many incidental costs in running his plant. In a boiler furnace, it is the ash which causes most damage to the firebrick lining of the furnace. In a gas works, the sulphur in the coal has put up the cost of gas purification, as ash contains much of the phosphorous and sulphur which trouble the steel manufacturer.

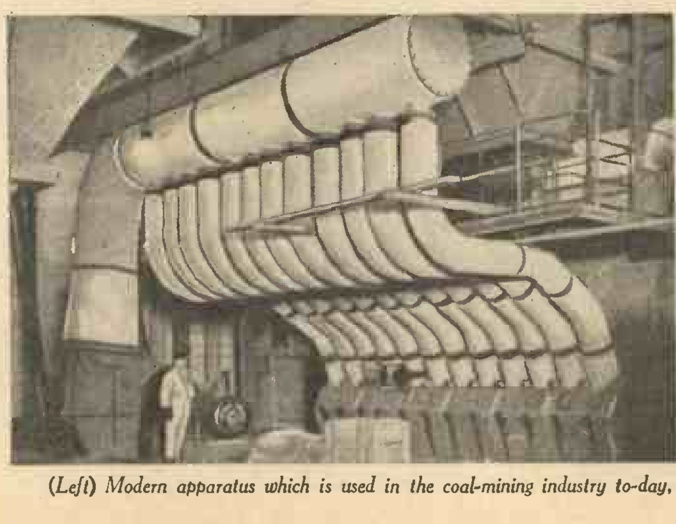
Clean graded coal places the coal industry in a much better position as the supplier of the domestic market. A few years ago oil firing was getting a strong hold on the central heating market. To-day, compact automatic stokers have been devised to work in conjunction with small central heating boilers using a coal of guaranteed size and quality. Owners are actually installing plant at the pithead to cut large coal to sizes to meet new demands. In 1920, practically no coal was washed, but to-day, 40 per cent of the coal mined is specially washed and cleaned.

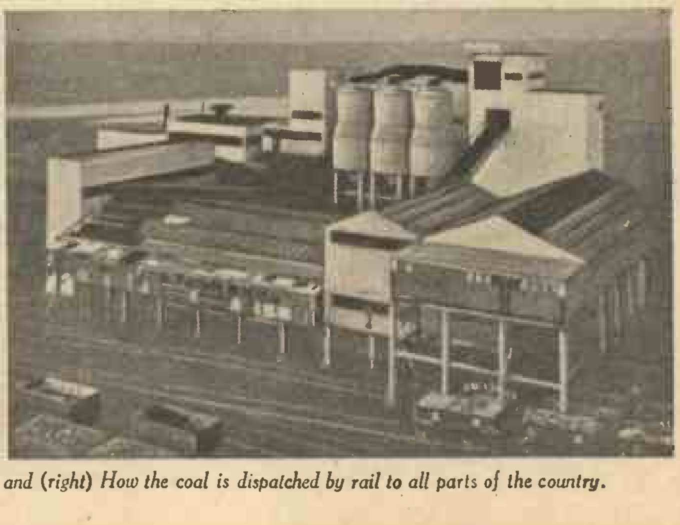
Coal Washing Processes

A new plant recently installed at the Sun Rising Collieries of the Backworth Mines in Northumberland, exemplifies modern methods of coal washing.

Coal is first screened into, over, and under 4 in. size. The over 4 in. size passes to a picking belt where shale and rock are picked out by hand. The under 4 in. size is screened into a number of grades, large, medium and small, and each grade is de-dusted by an air blast.

The large grade is washed by agitating it with a slurry of sand and water, the density of which is so adjusted, that the coal just floats and washes over a weir. The shale and rocky matter sink to the bottom, where it is eliminated through a valve. The medium is pneumatically cleaned, by jigging on a specially riffled table. The lighter coal floats up to the top of the bed, and the shale stays at the bottom. A plough guides the coal off on one side of the table, and riffles, or grooves, guide the shale off on the other side. The small and the dust are cleaned by froth flotation, a process long used in gold mining for concentrating ores. The coal dust is





(Left) Modern apparatus which is used in the coal-mining industry to-day, and (right) How the coal is dispatched by rail to all parts of the country.

stirred up with water containing about 2 per cent. of oil, which wets the coal but not the dirt. The wash is then subjected to a vacuum which causes it to froth up, the coal being carried up in the bubbles, while the dirt stays at the bottom. Froth and coal overflow, the coal settles out to a thick paste which is filtered free from liquid, and finally dried in kilns fired with a proportion of the untreated dust. Extended use of plant of this sort means better quality coal and fresh employment for the miner.

Pulverised Fuel

Pulverised fuel, after overcoming many difficulties, has come to stay. At first, the disposal of the fine residual ash from the burners was an obstacle. To-day centrifugal ash precipitators, electrostatic precipitation and water washing are in common use. Pulverised fuel, on account of its flexibility and intense heating properties, is preferred in many types of plant including boilers and cement kilns. Made up into a slurry with oil, it is being tried out at sea. A few years ago, successful full-scale trials were made on an Atlantic liner, but perhaps the most novel suggestion is to use coal dust in solid fuel injection engines to displace the modern diesel engine. The difficulties are numerous, but the prize is great as the diesel engine is by far the most compact and efficient type of marine power unit. Should success be attained, coal will once more become supreme at sea, and we should regain the 7½ million tons lost to oil-burning ships.

The future of coal hydrogenation is still unpredictable. The I.C.I. Plant at Billingham is at work making 45 million gallons of petrol from over 1 million tons of coal per year, and providing directly, work for over 2,000 men. At Seaham, they are at work on a process of low-temperature carbonisation to give smokeless fuel and creosote, which, when hydrogenated, gives petrol. There is already suggestions in several quarters for setting up similar plant on other coal fields.

The Domestic Fire

Smokeless fuel brings us back to the domestic hearth. The British householder clings closely to the open fire, as it is, undoubtedly the cheeriest and healthiest way of heating a room. On the other hand, it is a most fruitful cause of excessive smoke nuisance. Smokeless fuel or low-temperature coke as it is called, is perhaps the best solution to the problem. But the economic production of smokeless fuel is bound up with the use of the low-temperature tars, by hydrogenation to petrol. Meanwhile, we cannot wait for this, and the Fuel Research Board is tackling the matter by compromise.

It is suggested that free burning but smoky coals be blended with slow burning but smokeless Welsh coals. Suitable blends made up in correctly graded sizes, give free burning mixtures with a smoke production 80 per cent less than that produced from the average open fire at the present moment.

AN EFFICIENT ELASTIC MOTOR

By W. H. Fuller

BELOW is described a simple method of getting more power into a small aeroplane fuselage or boat hull, than is normally possible when using a single loop of elastic. The more usual way of doubling the elastic, or by providing two parallel groups, has the disadvantage that the rubber cannot be wound up to the same extent as with the single loop, and that it runs out very much faster. Increased propeller speed may be obtained by so doing, but the duration is often less than half that of a single loop. This may be desirable in some cases, but not in all.

Strands in Series

The following scheme, however, allows extra strands of rubber to be used in series, each group giving a maximum number of turns and a considerably longer run from the complete motor. A series arrangement is shown in Fig. 1. The propeller bearing is a standard arrangement, and the second loop of rubber is secured by the usual hook. The gearbox at the junction of the two loops of rubber is the only way in which the reversal, necessary with such an arrangement, can be made. The gearbox consists of a thrust plate grooved to take two ball races, in which $\frac{1}{16}$-in. balls are used. Details of such a thrust plate is shown in Fig. 2, but the design can, of course, be modified to suit any particular arrangement of fuselage. The plate can be made of brass, but preferably of mild steel, case hardened. The back cover, shown in Fig. 3, is made of thin brass sheet and serves only to keep the gear-wheels and the ball races in position when no pull is exerted by the rubber. The two small slots in the ends of the cover, clip over the extension pieces at the ends of the thrust plate. The gear wheels are cut from 16-tooth steel pinion wire and are approximately $\frac{1}{16}$ in. thick. The ball groove is turned in one face, as shown in Fig. 4. The gearbox should be fixed solid with the fuselage, it being essential that the ball races are at right angles to the pull of the rubber. Experiments have been carried out using plain bearings and bead bearings, but these have not proved satisfactory, owing to the friction which becomes excessive as the rubber pull increases.

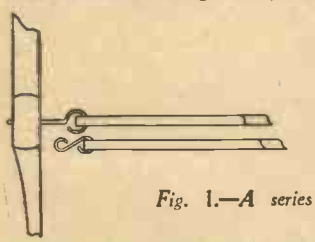
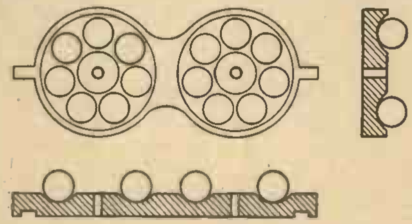


Fig. 1.—A series arrangement.



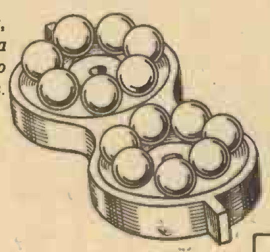
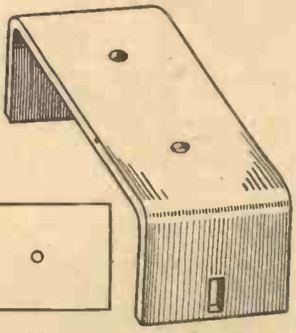


Fig. 2.—The gearbox, which consists of a thrust plate grooved to take two ball races.



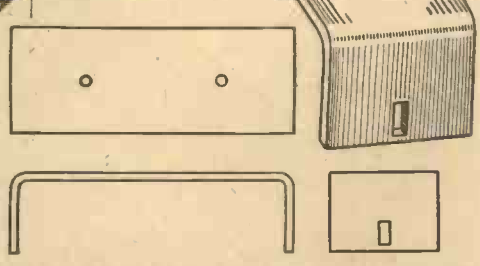
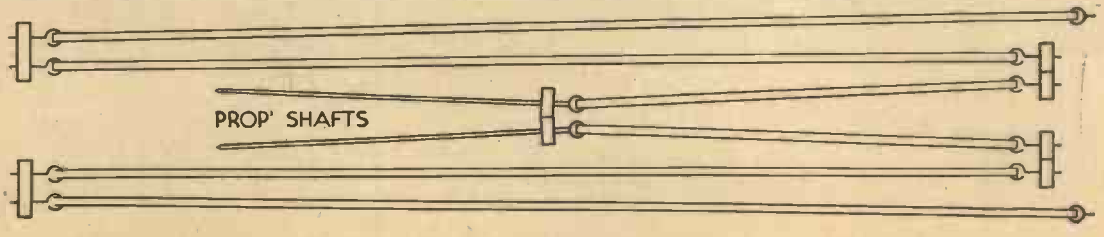


Fig. 3.—Details of the brass cover, which keeps the gear wheels and ball races in position.

An Elastic-Driven Speed Boat

In the case of an elastic-driven speed boat, where weight is not so important, standard ⅛-in. thrust bearings and larger gear wheels can be used, and four or more groups of strands be incorporated. A 30-in. boat, recently built by the writer, has a double arrangement of three series loops, giving a total length of 148 in. between extremities which gives an exceptionally long running period. The arrangement is shown in Fig. 5. The two propeller shafts are geared together, and from each of the shafts a 4-ply group is run right up to the bows. At the bows is a double gearbox, and from there two more groups are run to the stern to another double gearbox. From the stern gearbox, two more loops are taken forward to a hatch, which, fitted in the spray hood to a high-geared winder, saves much time in winding, which might be excessive were the ordinary winder used.



Figs. 4 and 5.—(Above) The ball groove is turned on one face, as shown; and (right) an elastic motor for a speedboat.

MAKING CHEMICAL CRYSTALS

At Very Small Cost and with Little Trouble, many Beautiful Specimens of Chemical Crystals can be Prepared in the Home Laboratory. This Article Discloses all the Necessary Details of Crystal Making

Picked specimens of copper sulphate crystals prepared by crystallisating strong solutions of this compound. The crystals are bright blue in colour.

THE majority of home chemical experimenters begin with crystal making, which is, although in most instances a simple task, a fascinating occupation, inasmuch as many perfectly formed chemical specimens may thus be obtained in a state of purity. If desired, such specimens may be sealed or corked tightly in small tubes or bottles, in which state they will be preserved indefinitely, thus forming the basis of a chemical museum.

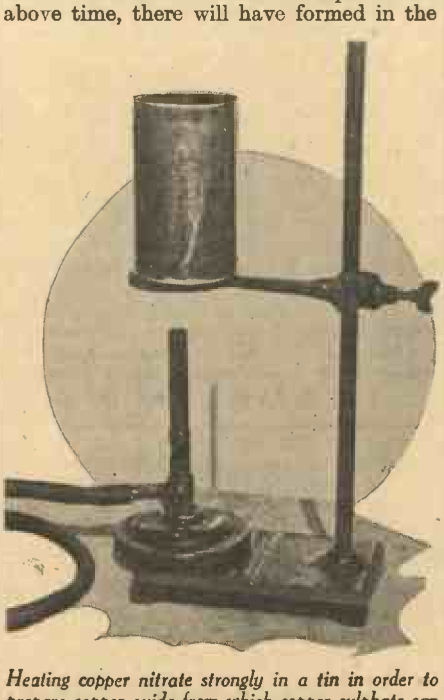
One of the easiest chemicals to crystallise is zinc sulphate. To make this, first obtain some pieces of scrap zinc. Such material may readily be obtained in the form of discarded dry-battery cases which are made of this metal. The zinc case of the battery should be removed and thoroughly washed in hot water in order to rid it of adhering matter. The cleaned metal is then cut up into convenient sized pieces, these forming the supply of zinc for the zinc sulphate preparation.

Sulphuric Acid and Zinc

Obtain a glass beaker or earthenware jam jar and fill it about a third full with dilute sulphuric acid (one part acid to three parts of water). Place a small quantity of scrap zinc into the jar. An immediate effervescence will take place. This is due to the acid attacking the zinc and dissolving it with the formation of zinc sulphate. When all, or most of the zinc has been dissolved by the acid, add more zinc and keep on adding zinc in small quantities until no more of the metal will dissolve. Then pour away the liquid into a clean vessel and heat it gently until its bulk is reduced to about one half.

If a chemical flask or beaker is used for the above heating, the heat can be applied directly by means of a bunsen or a spirit lamp flame placed underneath the vessel, a piece of wire gauze being placed between the flame and the bottom of the vessel to obviate the risk of cracking. Should, however, the above chemical apparatus not be available, the evaporation of the liquid can be carried out quite successfully in a clean jam jar. In this instance, however, the jam jar must not be heated directly. It should be placed in a pan of cold water and the water raised gradually to the boiling-point. The water is then allowed to simmer gently and it will be found that the contents of the jam jar will evaporate quite satisfactorily, if somewhat slowly.

After the zinc sulphate solution, prepared as above, has been evaporated down to about half its original bulk, remove it to a place where it will remain entirely undisturbed for six or seven hours. Cover the jam jar or beaker with a saucer or a piece of card in order to prevent dust from falling into the solution. After the lapse of the above time, there will have formed in the cooled solution a glistening mass of needle-like crystals. These consist of pure zinc sulphate. If, however, the crystals do not form in the solution, it is a sign that the latter has not been concentrated sufficiently, in which instance it will be necessary to heat up the solution again in order to concentrate it further.



Heating copper nitrate strongly in a tin in order to prepare copper oxide from which copper sulphate can be made by dissolving the oxide in dilute sulphuric acid.

Zinc Sulphate Crystals

If the zinc sulphate crystals have formed well in the cold solution, filter them off by means of a sheet of filter-paper or white blotting paper placed in a glass funnel, wash them with a *small* quantity of *cold* water and then set them aside to dry. Do not dry the crystals by heat, otherwise they will fall to powder. The liquid from which the crystals were separated may either be used for the preparation of more zinc sulphate crystals or else a solution of common soda may be added to it. In the latter case a white precipitate of zinc carbonate will be formed. This can, also, be filtered off and preserved.

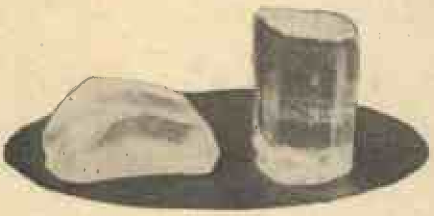
One cannot very well prepare the beautiful blue crystals of copper sulphate by the process of dissolving copper in sulphuric acid for the reason that copper is only soluble in the hot concentrated acid and that, even under these conditions, a lot of by-products, such as copper sulphide, are formed at the same time.

The best way to prepare copper sulphate crystals is to dissolve copper in dilute nitric acid, in the same manner as zinc was dissolved in dilute sulphuric acid in the above-described preparation of zinc sulphate. If the blue liquid which results from the solution of the copper in the dilute nitric acid is very carefully concentrated, it is possible to obtain long royal-blue crystals of copper nitrate. This, however, is a crystallising operation requiring some skill, because copper nitrate crystallises only with difficulty. Even when it has crystallised, it rapidly absorbs water from the atmosphere and so returns to the liquid condition. Copper nitrate crystals have to be gathered as soon as they are formed and preserved in sealed glass tubes.

Copper Nitrate Crystals

Apart, however, from the preparation of copper nitrate crystals, the blue solution of copper nitrate should be evaporated down to dryness. Then it should be carefully collected and placed in a clean tin. In this receptacle it is strongly heated, during which process it will give off red fumes of oxide of nitrogen (these are fairly poisonous and should not be breathed in quantity) and will ultimately be converted within a few minutes to black copper oxide. Remove the copper oxide from the tin and dissolve it in dilute sulphuric acid, in which liquid it is easily soluble. A blue solution of copper sulphate will be formed and when the sulphuric acid will dissolve no more of the copper oxide, filter off the blue solution and concentrate it by evaporation in the manner explained above. After concentration and cooling, bright blue crystals of copper sulphate will be obtained.

Copper sulphate has one remarkable property. If it is carefully heated, it looses water and turns white. This is the anhydrous or perfectly dry form of copper sulphate. Exposed to the atmosphere, however, such material will gradually absorb moisture from the air and return to its original blue condition. This effect may



Large crystals of Rochelle salt prepared from "seed" crystals.

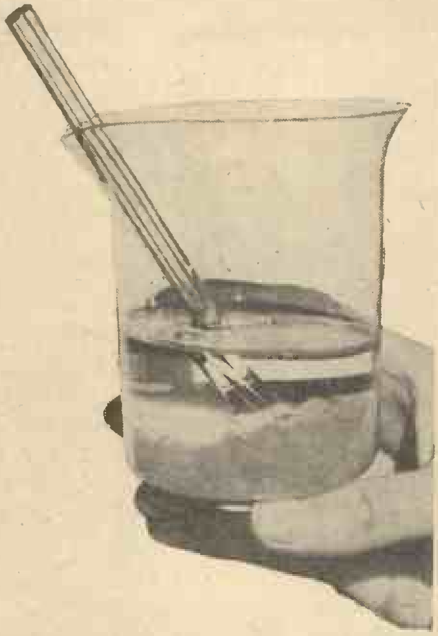
be carried backwards and forwards for an unlimited number of times.

A very large number of chemical crystals may be prepared on the lines indicated above, viz. by dissolving the metals or their respective oxides (or carbonates) in the requisite acid. Copper carbonate, for instance, dissolved in acetic acid, gives copper acetate. Nickel oxide acted upon by nitric acid forms nickel nitrate, a difficult crystallisable substance. Scrap-iron dissolved in dilute sulphuric acid produces, ultimately, beautiful green crystals of iron or ferrous sulphate.

Even the commonest of chemical materials, such as common soda, salt, borax, and alum can be obtained in the form of shapely crystals if they are dissolved in hot water until the water will take up no more of them. Then filter the strong solution, concentrate it by heating and set it aside to cool. After a few hours, the required crystals will have formed in the solution.

Large Crystals

It is a rather more difficult task to obtain large single crystals, but in many instances this can be accomplished by the exercise of a little patience. What is known as "Ro-



A quantity of pure zinc sulphate crystals prepared according to the directions given in this article.

chelle salt" (sodium potassium tartrate) forms large crystals the most easily, but common alum is a close runner-up in this characteristic. Big crystals can also be grown from copper sulphate, iron sulphate, nickel ammonium sulphate, common salt, chrome alum, and other compounds.

To make these oversize crystals, first of all prepare a saturated solution of the salt which has been chosen for crystallisation. By "saturated solution" is meant a solution which will dissolve no more of the salt. Such a solution is, as it were, on the verge of crystallising. Now, having prepared this solution, place it in a perfectly clean glass jam jar or other suitable vessel and suspend in it one or two tiny crystals of the salt of which the solution is composed. These "seed" crystals, as they are called, are best nearly tied on the end of lengths of cotton and allowed to dip half-way down into the solution. Leave the seed crystals absolutely undisturbed for 24 hours. After the lapse of this time they will be found to have increased in size. If other smaller crystals have formed in clusters around them, these latter must be carefully removed and only the original seed crystals preserved. If the solution is concentrated enough, the seed crystals will daily grow in size until, after a week or so, they will have attained the dimensions of an inch or more in length and in breadth. The only conditions necessary for the formation of these giant crystals are that the solution must remain at the same concentration, at the same temperature, and that it must remain absolutely undisturbed.

Quick Crystallisation

This is an experiment which many chemical amateurs may like to perform. Take a quantity of ordinary photographic hypo (sodium thiosulphate) and dissolve it in the least possible amount of very hot, or even boiling water. It will be found that a very large amount, relatively speaking, of hypo crystals can be dissolved in a given quantity of boiling water. When no more hypo will dissolve in the water, pour off very carefully the solution into a warmed vessel and set it aside to cool, covering the opening of the vessel with a card in order to prevent the ingress of dust or dirt. When cool, the hypo solution will present the appearance of a cloudy and somewhat yellowish liquid. Such a solution is said to be "super-saturated." If, to this solution, one small single crystal of hypo is added, the whole of the solution will almost instantly crystallise and become solid. The experiment is, indeed, a very striking one.

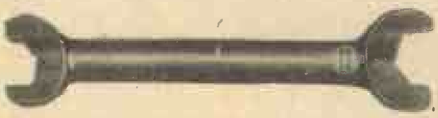
Growing giant crystals in the manner described in the article.

Crystals of sulphur are very interesting and easily obtained objects. Melt a quantity of sulphur in an open vessel such as a deep tin lid and then allow the molten sulphur to cool. As it cools, a crust will form over the surface of the material. After this has formed, wait for a few seconds, and then break open the crust with a spoon handle or a knife blade. Underneath it will be found a mass of long needle-like yellow crystals. When the sulphur has cooled down sufficiently, these can then be picked out and examined. Unfortunately, however, they cannot be preserved as specimens for more than a week or two, since, with the elapse of time, they fall to powder, even when kept in sealed glass tubes.

TRADE NEWS

A Fixed "Ratchet" Spanner

THE spanner shown on this page has all the advantages of a fixed spanner, but, owing to the scientific design of the profile



A fixed ratchet spanner which automatically ratches without being removed from the nut.

of the jaws, also operates as an exceptionally efficient ratchet. One jaw of the spanner is comparatively short and the other follows a special curve. This patented design permits the spanner to ratchet round the nut in one direction, while in the opposite direction it is drawn deeply into engagement by cam action directly pressure is applied to the operating end of the tool. Thus it automatically ratchets without removing the spanner from the nut, and in consequence works at double the speed of any fixed spanner. It will also grip a worn or damaged nut, since the cam action created in operation forces the nut into intimate contact with the back faces of the spanner. It is made in eleven sizes and the price ranges from 1*s*. 3*d*. to 7*s*. 3*d*. [154.]

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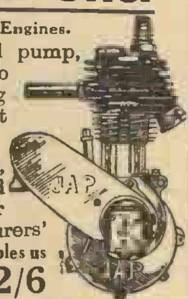

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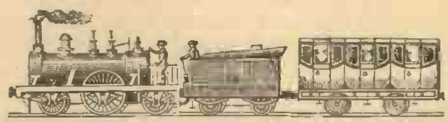

THE 1936 MODEL RAILWAY EXHIBITION

★ **Turn to Page 434 of this issue for full details of the 1936 Model Railway Exhibition, to be held at the Central Hall, Westminster, from April 14th to 18th.**

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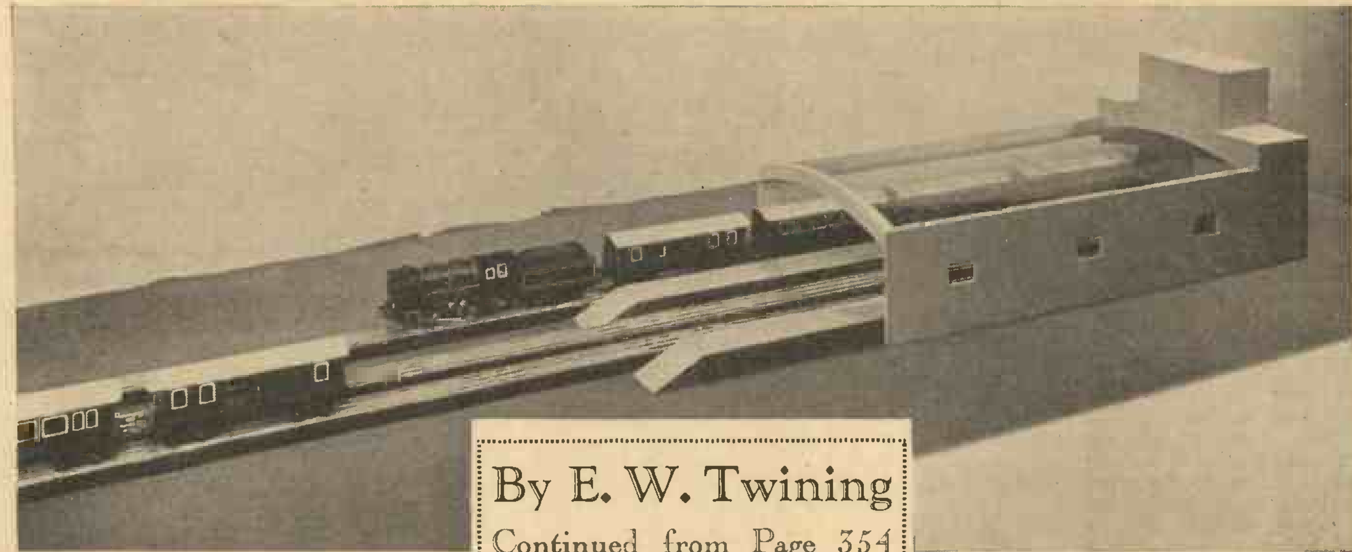


By E. W. Twining

Continued from Page 354 of Last Month's Issue

THE first suggestion for converting the existing Twin-train locomotive is for a type of engine which, although it may not be liked by many, will perhaps appeal to some people who, not having the space available for a complete railway system, would care to build a model of a colliery, a factory yard or something of the sort consisting chiefly of sidings with points and switches where shunting and marshalling of trains can be carried on. As everyone knows, for colliery working at the surface, four-wheeled shunting tanks, usually saddle tanks, with outside cylinders are employed, and in Fig. 5 the model is made to represent one of these as built by Messrs. Peckett & Son, of Bristol. Such a model as this, when it is modified as regards the superstructure by the addition of a higher cab, and the saddle tank with the boiler mountings, all as shown, increases the height to such an extent that the scale can be no longer either 3½ mm. or 4 mm. to the foot. As a matter of fact, it works out at about 5 mm. to the foot and the gauge of track would be 3 ft. 6 in. in the prototype: quite a common gauge, of course, as it is the standard gauge throughout South Africa.

No Alteration to Chassis

The saddle tank engine will be one of the most simple which the reader could adopt which, when finished, shall bear a very close resemblance to a definite prototype and which involves the least amount of labour, for, as will be seen from the drawing, no modification whatever has to be made to the existing frames, wheels, motor and reversing unit. In fact, all one needs to do is to take off the present die-cast boiler and cab and construct a new superstructure from either thin tinplate, thin brass or, if the engine is going to be very carefully handled, from Bristol board, a new buffer beam at the front end being provided made from a strip of hardwood. The dome and chimney must, in any case, be made of brass turned in the lathe and the base filed to shape and fitted to the curvature of the top of the tank. Obviously it will make the best job if thin metal is used, expecially for the cab.

Another alternative way of dealing with the boiler and tank will be to extend the existing die-cast boiler by turning a small cylinder of hardwood and screwing this to the front of the present smokebox, then over the whole of the new wooden smokebox and the existing boiler to fit a hollowed out half cylinder in hardwood to form the tank. If such a wood as beech, which has the merit of showing no grain, is used, a very high finish can be obtained with No. 0 glass paper, which will have the appearance of metal when enamelled. If this idea of putting on a wooden tank is adopted it will not be necessary to scrap the existing boiler die casting at all, but merely to cut away the cab and build a new one of the shape which I have shown. The dome of brass should be polished bright and the top of the chimney is also bright, though this should, strictly speaking, be copper.

A 2-4-0 Tender Engine

In the first article it was mentioned that even a 2-4-0 type engine was impossible on the standard radius curves as already manufactured. It should have been explained that this referred to one of the old types of 2-4-0 engines such as were common thirty or forty years ago on all railways. These locomotives, of course, had a fixed wheel base. The design which is now given in Fig. 6 for a 2-4-0 really has no existence in full size practice, but it is nevertheless a practicable and quite modern type. The wheel base in this case is not rigid, but a leading radial pony truck is provided which will enable the model to take the standard radius curves quite readily. It will have

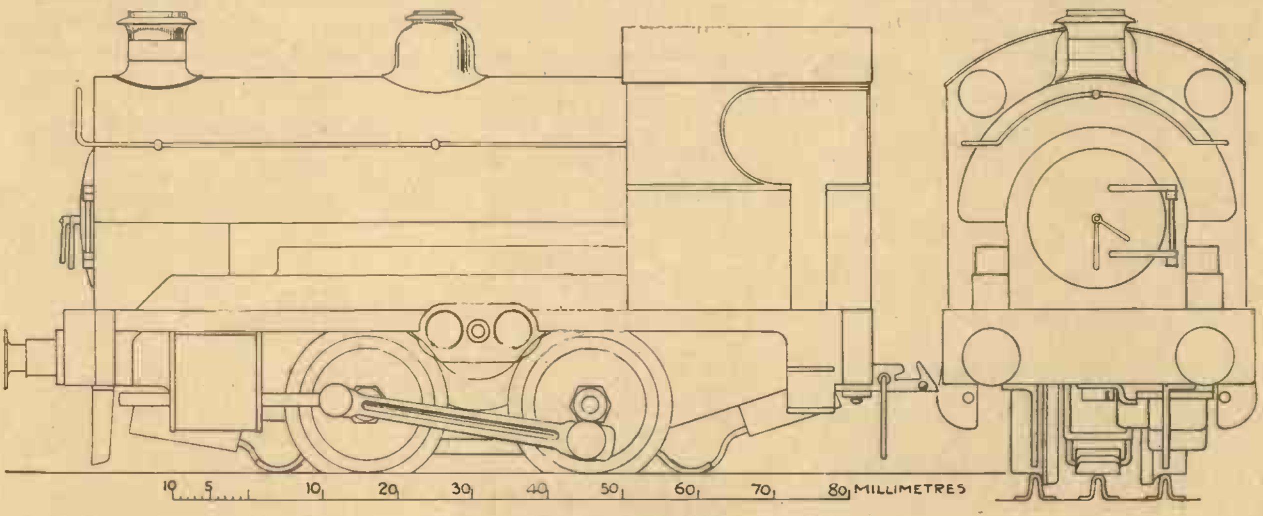
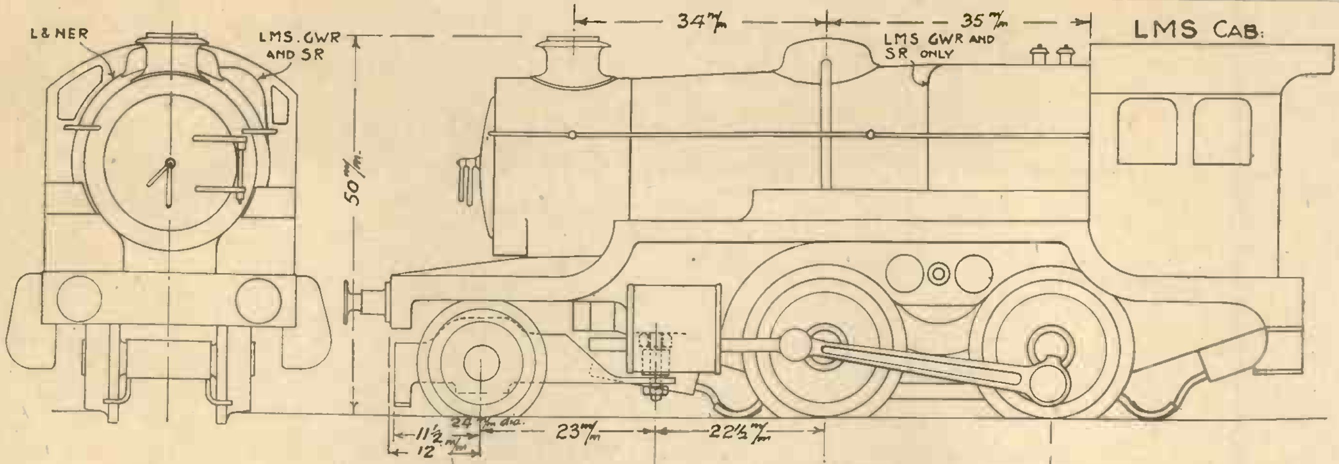


Fig. 5.—A model of a Peckett saddle-tank engine.



an excellent appearance and look far more like a British engine; not an express perhaps, it is more like a mixed traffic type. It lends itself readily, by a slight modification in the boiler mountings and cab, to any one of the four British railway groups. Fig. 7 shows the necessary modifications.

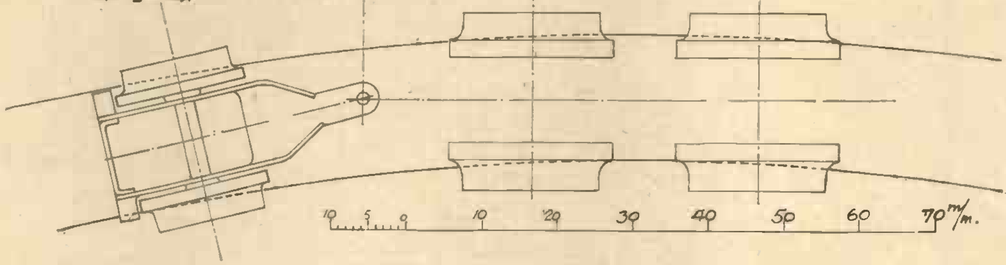


Fig. 6—Design for a 2-4-0 engine with radial truck.

The Taper Boiler

As everybody knows the taper boiler has become a standard feature in the latest engines of all the English railways. The Great Western introduced it long ago, then followed the London & North Eastern in the "Flying Scotsman" 4-6-2 class; next the Southern Railway adopted it and lastly the L.M.S. when Mr. Stanier took over the locomotive department after leaving the Great Western. We shall, therefore, be quite in order in fitting such a taper boiler on the model shown in Fig. 6 whatever the Railway Company it be made to represent.

As I have said, it is in the boiler mounting and cabs where differences will have to be made and in this respect I think that Fig. 7 will be self-explanatory. The L. & N.E.R., L.M.S. and Southern will all have domes on the boiler, whilst the Great Western will only have the bell-topped conical safety valve casing.

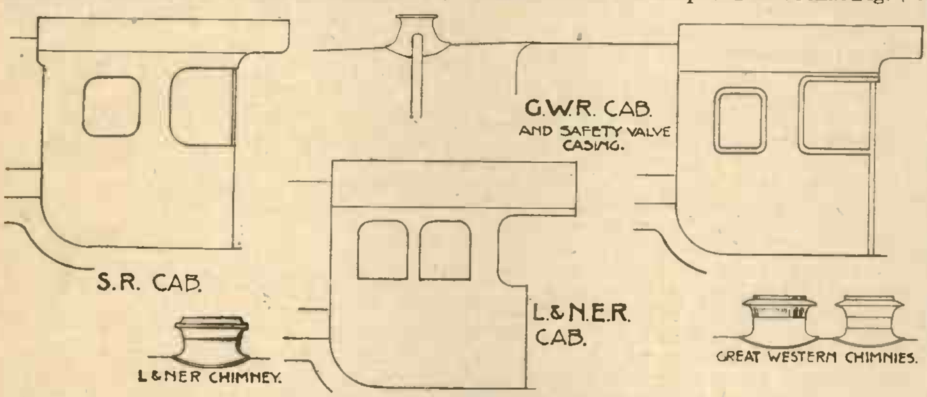


Fig. 7.—Alternative details for 2-4-0 engine.

The chimney shown in Fig. 6 will do equally well for the L.M.S. and Southern, also for the Great Western if the top be turned and polished bright. It should be noted, however, in connection with the shape of this Great Western chimney that in Fig. 7 I have shown two patterns. Now most railway enthusiasts know that two entirely different shapes of chimney are used on the Great Western. Those having bright copper tops are large in diameter, and are fitted only on the passenger engines. The mixed traffic, goods and mineral traffic engines taper with the large diameter at the top where they are finished with cast-iron caps. There is some doubt as to whether the whole chimney is not cast in one piece, but that is immaterial. The point is whether the passenger or the goods traffic type should be put on this little model. Personally, I should prefer the copper top, but the reader must decide for himself.

A Belpaire firebox is shown in Fig. 6, but this should be of the round topped pattern for the L. & N.E.R.

Modification to Chassis

With regard to the chassis, there will be practically no modification necessary except

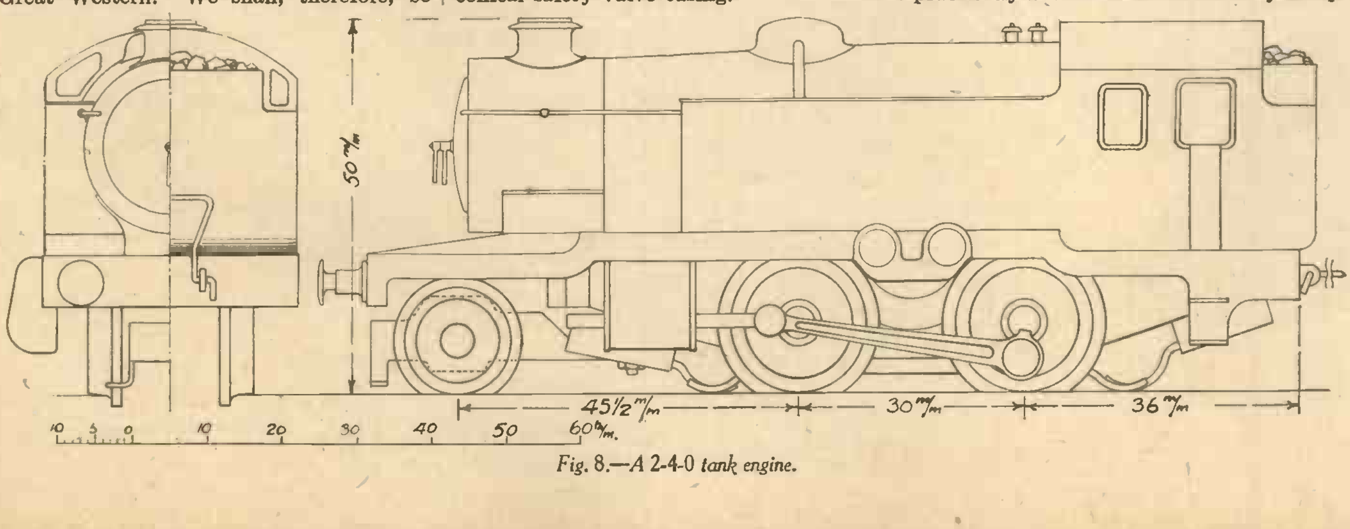


Fig. 8.—A 2-4-0 tank engine.

that the screw which holds the front-running rail current pick-up will be removed and a stud screwed in its place. A nut will be run on this stud to clamp the current collector, then over this a loose collar and next to the collar the flat arm of the swivelling radial truck. Finally, to secure this—and it must, of course, be left quite free, another nut is put on the end of the stud. The extension of the frames of the engine from the existing chassis to the new front buffer beam can very well be made from a bit of hardwood. Such piece of wood should extend backwards as far as the field magnet of the motor. It can be secured by a couple of screws passing through the die-cast chassis frame and, in addition by, the stud previously mentioned.

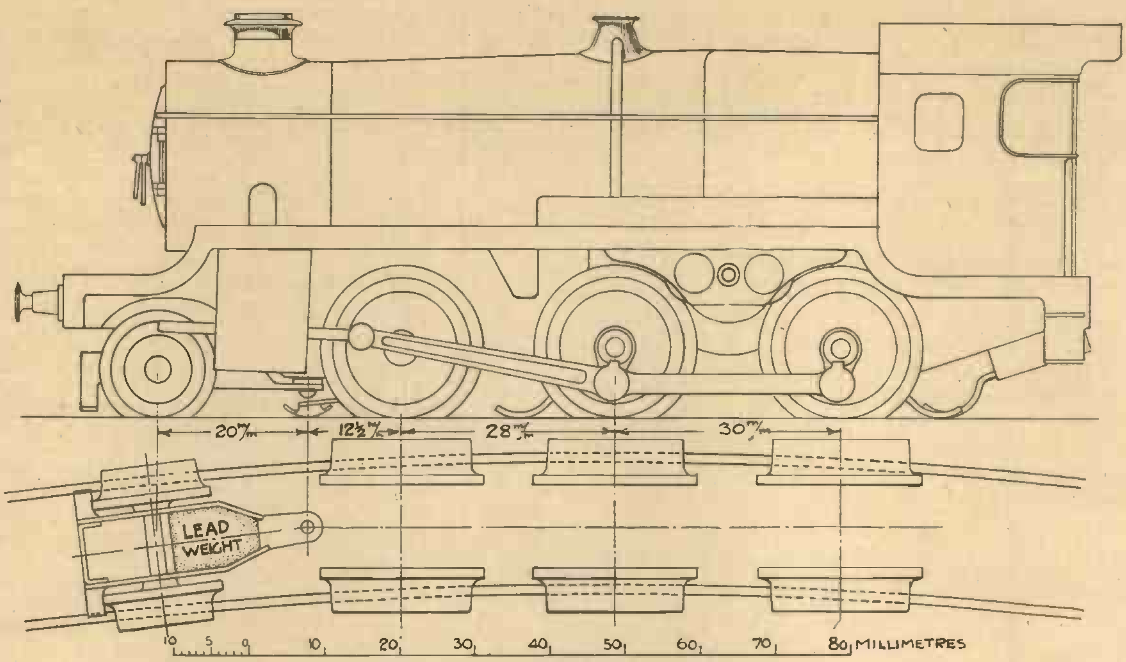


Fig. 9.—A 2-6-0 G.W.R. type 2 ft. radius.

Insulated Radial Truck Wheels

It will be obvious from what has been said previously, that for electrical reasons these wheels and axle cannot be made of metal in the usual way. Of course, one way to make them will be to turn them in brass, bore them larger than the axle and fit insulating bushes in the same way as done by the manufacturers for insulating the driving wheels, but it is thought that this method would probably be a little beyond the scope of the amateur. For one thing, a sufficiently hard material for insulation will not be available. Ebonite is of no use and there is some doubt whether red vulcanite fibre could be turned sufficiently small or would make a satisfactory job. The best way is to turn the wheels from the hardest bits of boxwood which can be found. The particular kind of wood can be recognised by the deep yellow colour which it reveals on being turned. Some boxwood is very pale and white, and although this is tough, it is not so hard as the yellow variety. It is suggested that the axle be made of steel shouldered down at the ends very slightly and the wheels drilled so that they are a driving fit on the axle. It would be advisable to leave them perhaps $\frac{1}{32}$ in. larger in diameter than is required before they are driven on, then, after both wheels are fixed, and, of course, the truck frame placed between them on the axle, the pair of wheels is mounted in the lathe again and a very light cut taken over the threads and flanges: this in order to ensure their running dead true. This engine will take the already-made standard tender as supplied with the model.

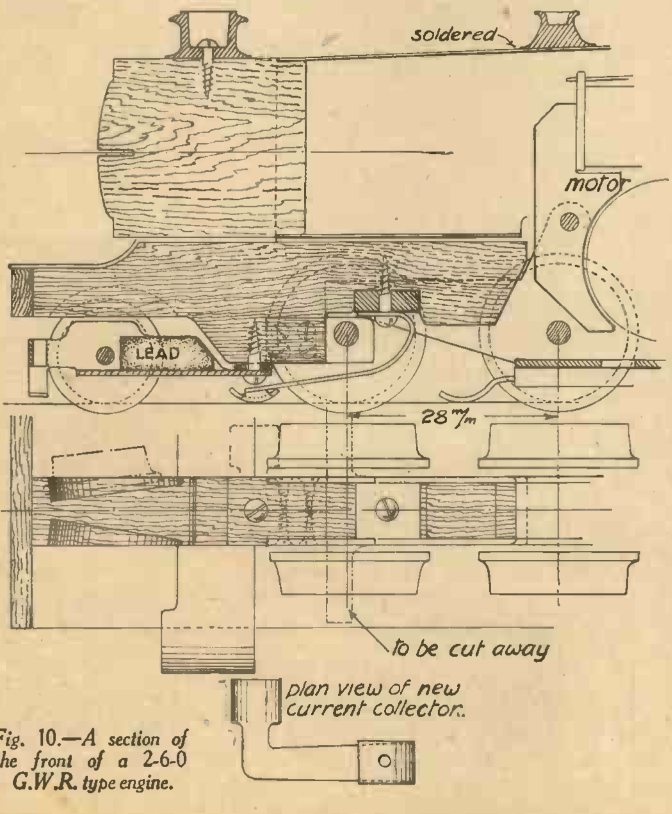


Fig. 10.—A section of the front of a 2-6-0 G.W.R. type engine.

A Side Tank Locomotive

If the reader is going to have a variety of types on the railway, he might very well convert one of the models into a tank engine and let it have exactly the same wheel arrangement. In Fig. 8 is shown a side tank having a closed-in cab with a coal bunker at the rear; the shape of this bunker is indicated in the end elevation. This end view also shows a coupling loop of practically the same pattern as is used on all the coaches and wagons of the trains: its shape and use will be obvious, I think. In order to prevent it from dropping below the horizontal two ends are bent downwards to rest against the buffer beam.

When a tank engine such as this is made it is advisable that the original die cast boiler be done away with entirely, and the whole superstructure built up. The footplating can then be lowered as shown and the side tanks brought down to enclose the whole of the motor and reversing gear, two half round notches being cut from the footplate angle and bottom edge of the tank on the left-hand side to avoid the brush holders of the motor. Care must, of course, be taken to see that the new metal work does not come in contact with the brush holders.

A 2-6-0 Type Engine

A miniature locomotive for the twin-train system having the 2-6-0 wheel arrangement and retaining the original driving wheels, is about as far as it is possible to go in making one of these models resemble an actual prototype. Although not by any means strictly to scale it will bear a very close resemblance to this numerous class of engine working on all the British railways. So far as the amateur is concerned, it involves more structural additions than any of the other previous examples. The model shown in Fig. 9 has, as will be obvious, Great Western outline, but by adopting any of the alternative fittings shown in Fig. 7, it can be made to suit either of the other three railway groups. An important point, however, that should be mentioned, is that this engine will definitely not negotiate the standard curves of the twin-train system, and it will only be of use to those readers who are going to lay their own permanent way; that is to say, those who are prepared to make up their own track. For this model, the radius of curve advocated by Mr. Beal has been adopted; namely, a radius of 24 in. giving a circle diameter of 4 ft. The curve set out in plan in Fig. 9 is drawn with the outer rail of 2 ft. radius. (*Continued on page* 426)

Figs. 1 and 2.—(Left) The Monocoque fuselage of the small low-wing model. This is a hollowed out Balsa block suitably strengthened where the undercarriage fittings, etc., are attached. (Right) The Monocoque fuselage of the biplane. This fuselage is fitted with a "Comet" 18 c.c. engine.

Monocoque Fuselages for Petrol-Driven Model Aircraft

By C. E. Bowden

In which the Author Discusses the Possibilities of a Perfectly Streamlined Fuselage for Petrol-Driven Model Aeroplanes

MOST model experimenters interested in the I.C. Engine as a power unit, have hitherto been more concerned with questions of stability and general arrangement of the model, than with beauty of outline. Also the quest for speed is not desirable in a general-purpose petrol model. In fact, rather the reverse. A slow-flying model is the safest and most easily operated. Therefore, a perfectly streamline fuselage has been the last consideration with which we have been concerned.

But I think that, now we have more or less solved the main difficulties of successful petrol models, it is time we thought about making them more attractive to the eye, and more nearly approaching the most modern type of full-sized aircraft. To do this, it is evident that the oval Monocoque construction of the fuselage gives the model a far cleaner and more pleasant appearance.

To this end I have been experimenting this year in different forms of Monocoque construction, and I find that although in the main a little more work is required, the finished article is both stronger and slightly lighter, if designed along certain lines that I propose to discuss.

A Low-wing Model

The second petrol model I constructed after the war was an oval shaped low-wing model. The streambuild oval shape was obtained by stringers over oval formers cut out of thin 3-ply wood, and then covered direct with silk and doped.

But I quickly discovered that this model was too ambitious with the limited experience I then had of petrol model requirements. The model had a few flights, but so much damage was done on landing I decided I would get to know a bit more about petrol models in general, including high and low wing, and biplane design before I tackled beauty of line! I decided it was more important to have eliminated all the snags in engine mounting, undercarriages, etc., and general stability.

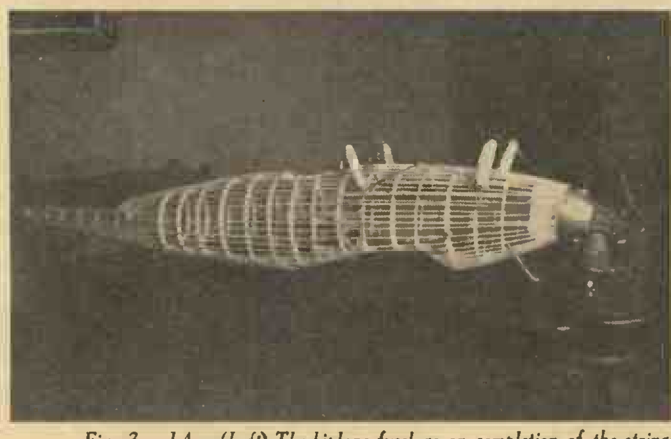
I therefore went back to my original biplane petrol model "Kanga" that had put up the first post-war record, and set about designing rectangular fuselaged high and low wing models and more biplanes.

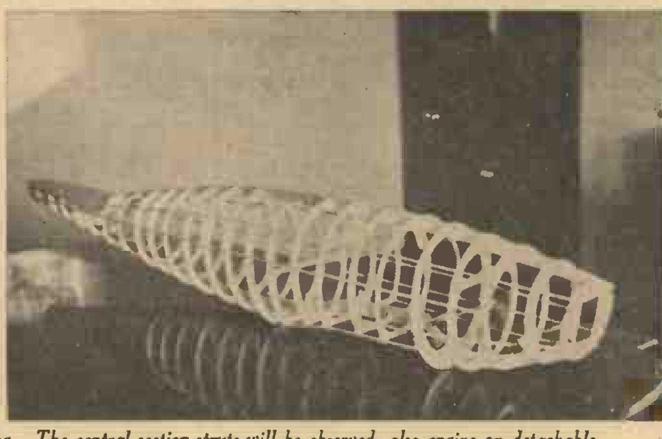
There have been very few Monocoque models constructed, as far as I have discovered, up to the present time.

Mr. Camm produced a very excellent oval fuselage mid-wing model last year which was described in PRACTICAL MECHANICS, but this was not a true Monocoque. It was a strung fuselage covered with fabric. I have seen one pretty example of a true Monocoque fuselaged low-wing which was produced in the Midlands. But from the stability and practical point of view, the design closely resembled my second petrol model mentioned at the beginning of this article. I rather imagine it may have similar flying troubles. But so far I have been unable to obtain any further news of it.

This article, however, is not dealing with the question of stability in design, but the intention is to put on record some experiments in construction that may help those who are considering Monocoque construction on their next models.

I have tried two types of Monocoque construction which have both been found a success, and I have been in close touch with a third method being tried out by a friend, and a well-known rubber model constructor, whom I have interested in petrol models. He tried out the third method as opposed to the other two in order that we might eventually make useful comparisons.





Figs. 3 and 4.—(Left) The biplane fuselage on completion of the stringing. The central-section struts will be observed, also engine on detachable nosepiece. (Right) The commencement of the stringing process, for which $\frac{1}{8}$ in. × $\frac{1}{8}$ in. balsa lengths are used. The oval formers are also of balsa.

Unfortunately at the time of writing this article he has not quite finished his fuselage, and I shall have to content myself with giving a rough description of the method, and leave the criticisms at the moment.

Stringing and Stressed Skin Method

My first method I have called the stringing and stressed skin method, for the want of a better description.

This method I find is about the same weight as a stout rectangular fuselage, but a lot stronger.

I should mention here that I believe in building all my fuselages with a high factor of safety, and whilst keeping those portions that get very few stresses light, I have plenty of strength where active flying experience has shown me that the fuselage gets most stress, i.e. engine stresses, wing attachment and undercarriage loads.

Briefly the main points on my first type of construction are:

(1) A backbone.

(2) ½ oval formers stuck on both sides of the backbone.

(3) Stringing the whole fuselage with thin balsa stringers.

(4) Filling in the highly stressed nose with solid balsa slighly hollowed out in the centre.

(5) Covering the whole with sheet balsa.

(6) Covering with silk.

(7) Doping and colouring the fuselage.

If the reader will inspect Fig. 8, he will notice the pleasant shape and smooth finish of a fuselage constructed on the above principle—in the case of a low wing model fitted with a "Brown Junior" engine.

The photograph depicts the fuselage with the detachable low-wing removed in order to make the shape of the fuselage more clear.

Actually a small streamline cabin has been added after the photograph was taken. This cabin on top of the fuselage houses the clock timing device to regulate duration of flight.

Now study Fig. 2, which also has had its detachable wings removed. It is a large biplane with an 18 c.c. "Comet" engine.

It will be noticed that both fuselages have a shaped out under portion forward. This is to take the detachable low wing in the case of the first model, and the bottom plane in the case of the biplane.

Both models also have detachable tailplanes, but in the case of the biplane fuselage this had been removed also for the photograph.

The Backbone

The backbone upon which the whole structure is built is composed of 3-ply wood forward where the engine and undercarriage stresses occur. From about one third back, the backbone is composed of ⅛ in. thick balsa cut out to the outline side elevation of the fuselage. The centre is then cut out for lightness. (See Fig. 5.)

The tail portion has the top half removed. The detachable tail unit and fairing fits into the finished Monocoque fuselage here.

Referring back to our second constructional point, the oval formers are cut in two halves, one half is stuck with glue on to one side of the backbone and allowed to get hard. These half formers are kept upright by placing a child's stone bricks on either side until the glue dries hard. Durofix glue is used. Reference again to Fig. 5 will show the first set of half ovals stuck in place. These formers are made of ⅛ in. thick soft balsa wood. Where spaces can be observed it is intended that 3-ply wood formers shall be used. These are situated wherever engine or undercarriage fittings are placed. In the case of the undercarriage duralumin tubes are bound with thread across the fuselage and inside to receive the detachable legs of the simple but robust detachable type undercarriage as now used on all my models.

Fig 5.—The backbone upon which the whole fuselage is built up.

A description of the construction of these undercarriages and their merits was published in PRACTICAL MECHANICS some time ago. A stout ¼-in. thick 3-ply nose is fitted to take the detachable engine mounting. A description of these engine mountings was also published in PRACTICAL MECHANICS.

Fig. 6 shows both sides of the half ovals glued into position on to the backbone. The 3-ply formers are also now in place. The tailplane cut away portion of the fuselage can be seen very clearly.

Fig 6.—Both sides are shown completed on the backbone.

It should be mentioned here that the mainplane is held in position by stout elastic bands. In order not to look unsightly by passing completely around the tops of the fuselage these bands only go about ⅓ of the way up the sides of the fuselage to wire hooks which stand out and are permanently fixed by thread binding and glue to suitably spaced and stout 3-ply formers. The same type of hooks are used for the retaining elastic bands of the detachable engine mounting.

Stringing the Fuselage

The next operation is the stringing of the whole fuselage. If the reader will examine Fig. 4, it will be noticed that a few ⅛ in. × ⅛ in. stringers have been added to the *biplane* fuselage skeleton. These preliminary stringers are of birch, and are situated where centre section struts join formers, etc. The remainder of the stringers are all of ⅛ in. × ⅛ in. balsa wood of the light soft variety. Fig. 3 shows the completely strung biplane fuselage.

The stringers are merely kept in position by small touches of durofix glue and are kept to the formers until dry by a few turns of model aeroplane elastic wrapped around the fuselage.

The next operation is the covering of the whole fuselage with sheets of $\frac{1}{16}$ in. thick balsa wood of the light white variety.

This balsa wood is obtained in large lengths about 6 in. wide and 4 ft. long, and cut as desired. Sections are covered at a time and where there is a double bend a section is left in boiling water to soak for about five minutes before being stuck on to the top of the stringers with plenty of glue.

Elastic is wrapped around the fuselage and over these sections until the glue is dry. It is then removed and another section is completed.

Covering the Fuselage

When the entire fuselage is covered with its skin of $\frac{1}{16}$ in. thick balsa, any bad cracks at joins are filled in with touches of plastic wood. The whole fuselage is then carefully sandpapered until a perfectly smooth finish is obtained.

The fuselage is then covered all over with thin jap silk, and it is this silk over the balsa wood covering that provides the exceptional strength of this type of fuselage. Of course the oval shape also has a lot to do with the strength.

It will be observed that we have now got a fuselage of exceptional strength practically entirely constructed of balsa wood of a light grade.

To attempt to obtain the same strength from an equal weight balsa wood normal rectangular fuselage would be quite impossible.

When covering with silk, Kodak photopaste is *liberally* smeared on to the fuselage. The silk is then worked taut by the fingers. This photopaste also has another

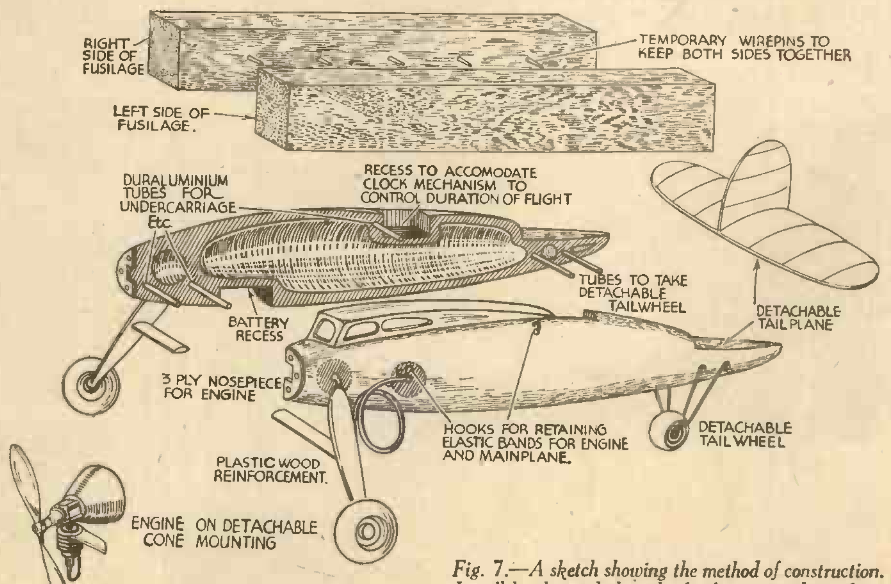


Fig. 7.—A sketch showing the method of construction. It will be observed that the fuselage is made up from two rectangular blocks of soft white balsa wood.

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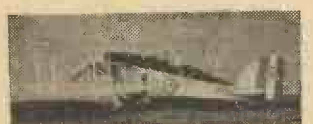

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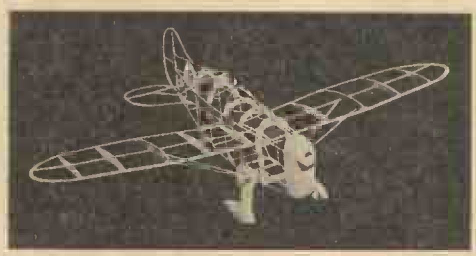

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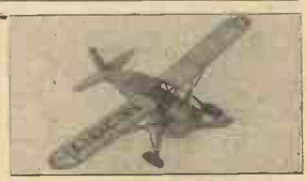

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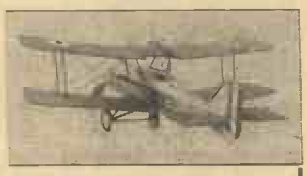

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purpose. It quickly dries and fills up the porous surface of the balsa wood sheet.

This prevents an undue amount of dope and paint sinking into the balsa wood and so adding too much weight.

It is surprising how much weight can be collected due to dope and paint sinking into balsa wood. The photopaste does not seem to sink in much.

After covering entirely with silk the whole fuselage is doped with full-sized Cellon Clear Aeroplane Dope.

When dry the constructor will be delighted with the smooth hard skin that has been formed.

A final coat or two of coloured dope can then be added to waterproof.

Monocoque Construction Type No. 2

In my second method I use a well known type of construction in the American rubber driven model world, but as far as I know it has not been tried in England for petrol models yet. Or if it has the constructor has kept it dark so far. The method is merely the hollowing out of a solid balsa wood block to form a streamline shaped fuselage. The basis of the idea is simple, but it presents certain other problems connected with reinforcement of the balsa where the engine, under carriage and wings are attached.

I am very much intrigued with this method of construction for the smaller sizes of petrol model, and on the small model that I am about to talk about have found that I have been able to produce an unusually strong model at a slightly reduced weight from my normal run of similar sized models. In addition I have a very portable and a streamlined model.

In the case of larger models I think I recommend my first method of stringing and covering with balsa, although I see no reason why this hollowed out block method should not be used for a large model except that to obtain the necessary strength one might have to produce a rather heavier model.

The model I have experimented on is a small 6 ft. 6 in. span, oval fuselaged, high wing model, very similar in general layout (but smaller of course), to my record model, the 8 ft. span high wing "Blue Dragon."

In this case a special inverted "Brown Junior" engine is fitted.

Method of Construction

The reader should refer to Fig. 1, which shows the completed Monocoque fuselage only, with the detachable wings and tailplane removed for clearness of illustration. The fuselage is 40 in. long, and as in the case of the other fuselages already described has a portion cut away from the tail end to accommodate the detachable tail.

Fig. 7 is a sketch of the method of construction. It will be observed that the fuselage is made up from two rectangular blocks of soft white balsa wood.

The blocks are temporarily pegged together with wire pegs and a few blobs of glue that can easily be broken later.

The main shape of the fuselage is then carved out, and the fuselage roughly sanded down. For those with a poor "eye" for shape, outside templates must be used to check up the shape at various lengths of the fuselage.

The two sides are then separated and the internal hollowing out of the fuselage begins. This is done by the means of a gauge with a curved shaft which permits the worker easy access to awkward parts inside.

In the case of a petrol model it is unnecessary, and I consider undesirable, to make the walls of the fuselage shell too thin. The raised sides of the gouge cuts help to strengthen the shell, and if one reflects for a moment. If the inside be cleaned out smooth, this strength is lost and the weight saved would only amount to about 2 oz. Two oz. makes no difference to a petrol model, and is worth carrying if it improves the strength.

Fig. 8.—The Monocoque fuselage of the low-wing model. Note the cut-away portion to take the detachable low wing.

Where the detachable undercarriage legs fit into their duralumin tubes, the fuselage is left solid. Therefore the tubes have a sound and firm basis. Also near the ends of the tubes where they emerge from the sides of the fuselage, portions of the balsa-wood shell are cut away and a filling of plastic wood is put in around the tubes, to help take the loads on landing.

The Engine Nosepiece

The engine nosepiece is the former constructed from ¼ in thick 3-ply. This is attached on to the solid balsa left at the nose of the fuselage. Long 2 in. thin wood screws are used for this purpose.

On my model I have cut away an external recess for the flash lamp battery and a well on top to take the clock mechanism to regulate the duration of flight. In this way the whole fuselage is waterproof with an air space inside and no external leans, for I am intending to eventually use the model as a seaplane.

The fuselage halves after being hollowed out are stuck together with glue and left to dry, after which any bad jointing is filled up with plastic wood. The whole is then carefully sandpapered until smooth and finally covered entirely with thin Jap silk as in the case of the previously described fuselage. Photopaste is liberally used to prevent the dope sinking into the balsa wood and to also retain the silk in position.

The fuselage is then doped with the same *full strength* aeroplane clear dope, and finished off with a coloured waterproof dope.

I should have mentioned that a cabin is constructed on top of the fuselage to form a firm base for the detachable high wing, and a detachable tail-wheel is also fitted. In this way the undercarriage and tail wheel can both be removed and floats fitted into the tubes provided.

In Conclusion

Before I conclude I will give my readers a few details of the third method my friend is trying out for purposes of comparison. I mentioned these activities at the beginning of this article.

Briefly the fuselage is formed like my No. 1 method, but is covered with a great multitude of small $\frac{1}{16}$ in. thick balsa planks—instead of balsa shell. These planks are placed edge to edge and glued to each other, as in the construction of a boat hull. The method cuts out the balsa stringers and therefore eliminates a little weight, although this is not anything very much. The whole is then sanded down and covered with silk and doped.

I am unable to give any conclusions on this last method as the fuselage in question is not yet completed.

With regard to my own two methods I feel that they are a distinct advantage on my previous models for they look well and are as light if not lighter, and are considerably more rigid and are stronger. I think that the first method is more satisfactory for larger models and the second method the most suitable for small petrol models. It is interesting to note that the solid balsa block for the 6 ft. 6 in. span model weighed 5 lb., and the finished fuselage turned the scale at just over 1 lb., whilst the completed model with heavy doughnut "Dunlopillo" wheels weighed complete and ready for the air 5 lbs.

Book Received

"Rockets through Space," by P. E. Cleator. Price 7s. 6d. 246 pages, 22 plates, 21 line illustrations. Published by George Allen & Unwin, Ltd., 40 Museum Street, London, W.C.1.

THE subject of Interplanetary Travel has intrigued man since the earliest days, and volumes of fiction have been written round the possibilities of journeys to the distant planets and unknown worlds. Science has, however, during the past thirty years made great strides in the design of apparatus with which it may eventually be possible to bring these dreams into the realms of possibility, and it would appear from the majority of experiments which have taken place that the ultimate "space ship" will take the form of a rocket as distinct from an aeroplane as we know it to-day. "Rockets through Space" gives some interesting details of the various experiments which have taken place, of the evolution of the rocket motor, and of the present-day rockets which are employed in various parts of the world for the conveyance of mails. The illustrations show some of the experimental apparatus, disasters overtaking experimental rockets, and some of the successful schemes which have rendered the rocket-ship a more-or-less successful venture.

ALUMINIUM AND

Aluminium is a Metal Most Typical of the its Alloys, a material which is Extremely and is a Substance Ideally Suited to Transport and

A canoe made of aluminium and weighing only 18 lb.

WITH the exception of silicon, aluminium is the most abundant material in the earth's crust. Curiously, of the common metals, it is perhaps the most difficult to extract from its ores. This characteristic it owes to the tenacity of its bond with oxygen in its oxide. Early chemists used metallic sodium and potassium to break the bond. Both these metals are expensive, and early samples of aluminum were rarer and costlier than any precious metal.

agent, and then only under especially peculiar conditions.

Bauxite is the raw material used. It is a mineral consisting of iron and aluminium oxides. The aluminium oxide is first extracted from this by dissolving it out with caustic soda. The alumina is then seeded out so that it is regained in a pure form. It is filtered, pressed, dried and then calcined to drive off the water. The alumina (aluminium oxide) is already so pure at this stage, that the final metal will be of 99.5 per cent. purity. Fine iron oxide is a by-product of the process, and is used for making iron oxide paints and coal gas purification.

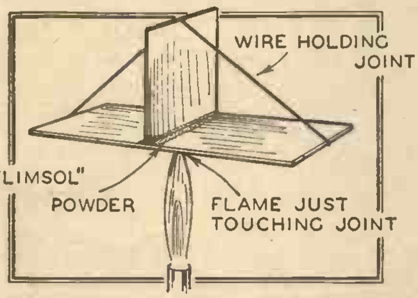
Disruption of the Oxide

The next stage is the disruption of the oxide by electrolysis at red heat. The cell used is simple in construction, and consists of a shallow bath lined with carbon plates, into which are dipped block carbon elec-

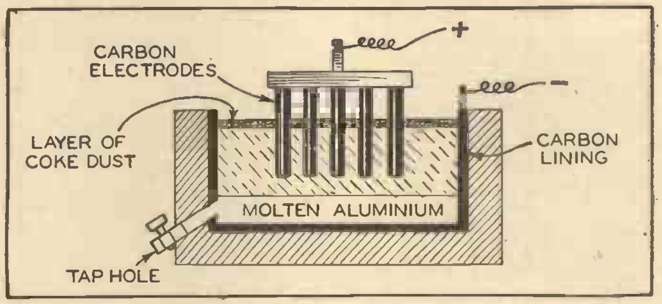
Kinlochleven and Lochaber in the Highlands. The Lochaber works is supplied with water power by a tunnel fifteen feet in diameter, which pierces the Ben Nevis range for a distance of fifteen miles. It carries sufficient gallons of water per day to meet the demands of practically half the population of Great Britain. It is one of the most outstanding engineering feats of modern times.

Strength and Lightness

First and foremost of the properties of aluminium comes its exceeding lightness, as it is three times lighter than steel. By itself, it has only one-fifth the strength of steel. But metallurgists have put this right by discovering a remarkable series of alloys, most of which are over 95 per cent. pure aluminium. All of them will stand up to a force of over 25 tons per square inch. The safe limit for steel is somewhere about



(Left) A method of making a T-joint with "Flimsol" solder. (Right) An electrolytic furnace cell for the manufacture of aluminium.



About 1886, Hall, in America, and Heroult, in France, discovered the method of electrolytic reduction which is in use to-day. From that time the price of aluminium tumbled, and production was only limited by demand. The Cinderella of metals, it started in the kitchen. It was light, clean, highly conducting and pleasing. From the humble saucepan of 1890 it has become the most-used metal for the vast vats, pans and condensers of the brewing, food and chemical solvent trades. The lightest of metals, it started its invasion of transport as the tubular frame of a bicycle. To-day it has made possible the highest speed achievements on road, rail, in the air and on the water. Demands have so increased that immense aluminium refineries have arisen in Scotland, Norway and America, wherever great forces of water power are available to provide the vast quantities of electricity needed in its production.

Production

Most metals are won by releasing them from their combination with oxygen in their oxide ores. Thus oxygen is torn from iron ore by heating with coke in a blast furnace. The bond between aluminium and oxygen is not so easily broken. The tearing force of electricity provides the only practicable

trodes. It is packed with a mixture of alumina and cryolite, the latter being a mineral from Greenland consisting of mixed sodium and aluminium fluorides. It provides a fusing melt for the alumina, which itself is one of the most refractory of substances and does not melt below intense white heat.

Across the poles of the cell a heavy low-voltage current is turned on. The resistance of the bath causes a rise in temperature which fuses the metal, and electrolysis of the aluminia proceeds. Aluminium goes to the negative pole provided by the carbon lining, and sinks to the bottom where it remains in a molten state until it is tapped off into moulds. The oxygen, which is the other product, goes to the positive carbon-block poles which it gradually burns away with the formation of carbon dioxide. The cryolite flux does not decompose at the voltage employed, and remains unaltered. Operation is continuous. Alumina is fed into the bath, and aluminium is drawn off at the bottom. The carbon poles are fed continually downward as they burn away.

The provision of power in bulk is the great problem of the process. It can only be met cheaply by generation from water power. Thus the British Aluminium Company's works are located in Scotland, at Foyers,

thirty tons per square inch.

There is a popular misconception that aluminium alloys are difficult to make, and that metallurgists are still in search of the ideal alloy which is at the same time both light and strong. The list of alloys available for use is long. They vary from

Loom spindles made of aluminium facilitate handling.

ITS ALLOYS

Present Era. It Provides, with Light, Strong and Silvery, the Demands of Modern Construction

A torpedo bombing plane. Aluminium is used in the plane and torpedo construction for lightness.

Silmalec, which is aluminium with only 1 per cent. of added magnesium, to the complicated series of Rolls-Royce alloys which are 95 per cent. aluminium with varying additions of iron, copper, magnesium, manganese and silicon. The National physical laboratory discovered the famous Y alloy used for air engine pistons. Duraluminium containing half per cents. of magnesium and manganese with 4 per cent. of copper, is over twenty years old. It is very remarkable that such small additions should change aluminium from a soft ductile metal to a substance reasonably hard and as strong as steel.

The list is long and varied because there is no one aluminium alloy which serves equally for all purposes. Each of its alloys develops its strength in special circumstances. It is in finding these circumstances and conditions that the modern metallurgist, armed with X-ray spectrascope and crystal seeking microscope, has shown his resource of ingenuity. Some, like the RR alloys and Y metal, acquire their strength when cast and heat soaked. These are then ideally suited for making piston castings, cylinder heads and connecting rods. Others only develop their strength when worked by rolling and drawing as in the manufacture of aeroplane longerons, the frames of boats and sheet metal. An example of the latter is Birmabright of the Birmingham Aluminium Casting Company. Birmabright has the additional property of resistance to sea water corrosion, hence the series of speed boats and cabin cruisers supplied by Birmal Boats Ltd.

Resistance to Corrosion

In 1884, a Philadelphia metallurgist presented a pyramid of pure aluminium weighing 100 ounces to provide a cap for the Washington Memorial in the American Capital. After half a century's exposure, the cap remains untarnished and undiminished in weight. Aluminium is self-protective against corrosion. It instantly forms a tough coating of oxide over its surface of sub-microscopic thickness, which effectually seals the underlying metal from further attack.

It is the rule with aluminium, that anything which oxidises it will not attack it. Anything which can dissolve its oxide film will destroy it. Thus, concentrated nitric acid is shipped in aluminium drums. But the mildest caustic alkalies attack aluminium avidly, because they dissolve its oxide. Aluminium is never used chemically in contact with soda. But in the food and brewing industries where an absolutely clean, non-soluble metal is required, it finds almost exclusive use.

There was one curious example of a large and expensive brewing vat that suddenly became moth eaten with tiny holes No one could ascribe a reason until a chemist discovered traces of mercury on the surface of the vat. A little detective work showed that a workman had broken a mercury thermometer in the vat. The mercury alloyed with the aluminium, and so broke the oxide film. The aluminium quickly passed into solution via the amalgam.

Anodising

An extra tough coating of oxide can be given to aluminium by making it the positive pole in a bath of sulphuric acid. This is called anodising. Any thickness of coat can be produced from transparent silver to opaque grey. The coating may be polished. Colour can be imparted by including a dye in the bath, and by this means, aluminium is improved for structural decorative purposes. Anodising was originally devised during the war to make flying boat hulls and seaplane floats resistant to sea water corrosion.

High conductivity and non-corrodability cause aluminium to be chosen as the material for the overhead cables of the Grid. 20,000 miles of steel cored, aluminium cable weighing 12,000 tons have been used in the last ten years for this purpose. Copper would have served as well, but aluminium wins on lightness and cheapness.

(Right) The British Aluminium Co's. Lochaber Works in the Highlands. In the foreground can be seen the great pipes which carry the water for supplying the power.

(Left) Aluminium is used extensively in speed - boat construction. The illustration shows a high-speed cabin cruiser in the course of construction.

Aluminium in Transport

Many and ingenious are the applications of aluminium in transport, on rail, on the road, in the air and at sea. It was even used for constructing the gondola for the stratosphere balloon.

On railroads, aluminium means less dead weight of coach body per passenger carried. By substituting aluminium for steel in coachwork construction, bigger trains can be hauled for the same engine power. A drop in dead weight means swifter acceleration, a vital factor in the speeding up of suburban services. The faster the get-away, the higher the average speed over the whole route, and the more trains per hour on a given line. The new tube railways in Moscow employ aluminium exclusively for their rolling stock. Aluminium double-deck cars are becoming invariable on Paris and New York metropolitan services.

British Railways have been backward in adopting aluminium construction.

Aluminium saves two tons weight in ten over a vehicle made of wood and steel, and converts dead weight into carrying capacity. The huge tanker you see on the roads is invariably constructed of aluminium, and is frequently insulated by shredded aluminium foil. This ingenious substance weighs only one thousandth the weight of cork or other insulating substance.

The diesel engine owes its vast development to extensive use of aluminium alloy to cut down dead weight of pistons, connecting rods and cylinder heads. It has made it possible as an air power-unit. Reduction in weight of moving machine parts cuts down inertia and strain on bed plates and bearings. The modern locomotive has aluminium alloy connecting rods. Machine parts in aluminium, tool holders on large machines, even the proverbial weaver's beam become so absurdly light, that a man with one hand can carry a part which formerly required a block and tackle to lift it.

Afloat, aluminium is used extensively in speed-boat construction, but yachts and even racing sculling boats have been built of it. Modern battleships, limited in tonnage by naval agreements, have used aluminium wherever possible in fittings, so that they can devote more dead weight to armour plate, engines and armaments. But there never was yet a scientific discovery which did not find misuses.

Not even the future will see the all metal city. But internally and externally, aluminium enters extensively into the modern architectural field. Internally it provides large clean, shining metallic surfaces. Externally it replaces steel and lead in the spandrils of windows, pipe-work and roof sheeting. Most modern American skyscrapers use it both for its appearance and weight saving.

Aluminium and its alloys can be spun, drawn and beaten, or cast with great readiness. It is a material with which the amateur mechanic should experiment. Jointing offers no difficulties, since special fluxes and solders have been developed for welding and soldering it. Soldering aluminium is far more simple than soldering by the ordinary tinning methods. Ordinary solder is not used, since the tenacious film of oxide on the surface resists tinning. A chemical powder of zinc, aluminium and ammonium salts is substituted.

Repairing Flat Spiral Springs

When the Main Spring of a Clockwork Mechanism is Broken, it is Generally Discarded. Below is Described How they Can be Repaired with a Minimum of Trouble

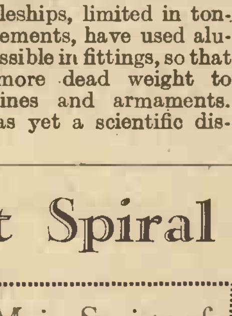
PERHAPS the most common cause of clocks, watches and toys failing to perform, is the breakage of the main spring In the majority of cases, the breakage occurs near or at one end, and more often than not, at the centre. It can, of course, be understood that the sharp curvature of the metal, owing to the small diameter at the centre of a spring, together with the fact that more movement takes place at this point, is responsible. Breakages are more likely to occur in cheap movements, because the quality of the material used is not so good, and that the coiled spring is produced from flat strip stock already hardened, and is wound by the assembler of the movement when the parts are put together. A high-class spring, however, is first wound while it is fairly soft, not down to the final diameter, but slightly larger and is then tempered in this form, thereby greatly reducing the tendency to fracture when it is finally wound. Another cause of breakage is non-lubrication. The friction caused by the surfaces of the convolutions of the spring winding together, particularly at the centre, is fairly large, especially if the spring is wound tight every time. It is good practice, and often advised by the manufacturers of good movements, to make a note of the number of turns required to tight-wind the spring, and on succeeding occasions to wind one turn less, to prevent the spring from being wound too tight.

Coiled springs can be lubricated with any clean non-evaporating oil, and any excess which is exuded on winding the spring should be wiped away to prevent the collection of dust.

Unwinding the Spring

Most springs are hinged to the main spindle by a projection of some kind on the spindle itself, this projection engaging in a hole in the end of the spring. To effect a repair, it is only necessary to remove the broken portion and make another hole. The first difficulty which presents itself, is getting at the centre of the spring, but with the device shown in Fig. 3, this becomes a very simple matter. A piece of flat hard wood, preferably thicker than the width of the spring, is cut through on the curve with a fret saw and the two pieces screwed to another piece of wood, leaving a gap sufficiently wide to take the thickness of the spring. The outside end of the spring is then dropped into the slot, and the remainder of the spring fed and pulled through the gap until the inside end is reached.

Fig. 1.—(Below) This type of spring end is becoming increasingly popular, as it dispenses with the usual type of hole locking arrangement.



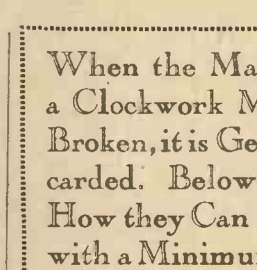


Fig. 2.—(Above) Repairing a spring by mortising the two ends together and soldering.

Bend this end of the spring outwards with a pair of pliers, and then make it red-hot and allow it to cool off, thus making it reasonably soft. Do not soften too much of the spring, but just sufficient to make the repair. Cut off the broken end and take off any rough edges with a file. Centre punch the position of the new hole and drill. If the original spring had a shaped hole, then it is best to make the new hole of the same shape by cutting out with a small file. Then wind the end of the spring round a rod of slightly smaller diameter than the spindle and run the whole of the spring through the device, Fig. 3, during which a lubricant may be applied, to obtain its original form. The inside end of the spring may require a slight wind inwards to ensure the projection engaging in the hole.

Other Springs

Another type of spring end which is coming into increasing use, has no hole but is merely bent back on itself as shown in Fig. 1. The end of such a spring should be softened and the end filed off at an angle, this detail being shown in Fig. 1, to assure the end of the spring drawing down to the base of the projection on the spindle. Make the end red-hot, bend over and close up tight while still hot. Do not over-do the folding and so crack the sharp bend. Another type of repair, that occuring in the centre of a spring, which may be necessary if a new spring cannot be obtained, may be carried out in two ways. The first is simple and effective, but if the spring is enclosed, the bulge may affect replacement. The two broken ends are softened and the ends cut off clean and folded over as shown in Fig. 1. The length of the folds should be sufficient to prevent the ends disengaging as the spring runs out, but if the mechanism is wound early enough, this is not likely to happen. It is essential that the ends are folded over square, or the pieces may slide sideways. This may be prevented by shaping the ends of the spring and cutting small slots in the side of the bends as shown in Fig. 2.

The second method is to mortise one broken end into the other as shown in Fig. 2, and to silver solder the joint. In this case, a reasonable length of spring should be softened on each side of the joint. Excess solder must be filed away to allow the surfaces to slide easily against the normal faces of the spring.

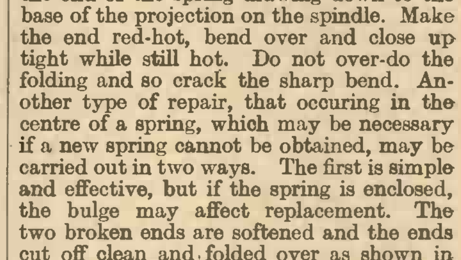
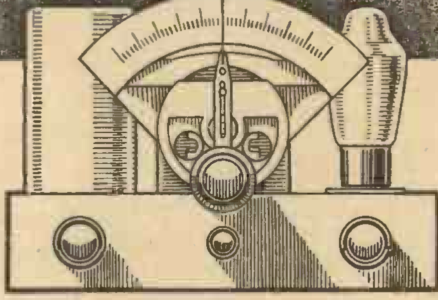


Fig. 3.—A simple device which enables one to get to the centre of a spring.

The PRACTICAL MECHANICS WIRELESS EXPERIMENTER



THE SHORT-WAVE MAINS THREE

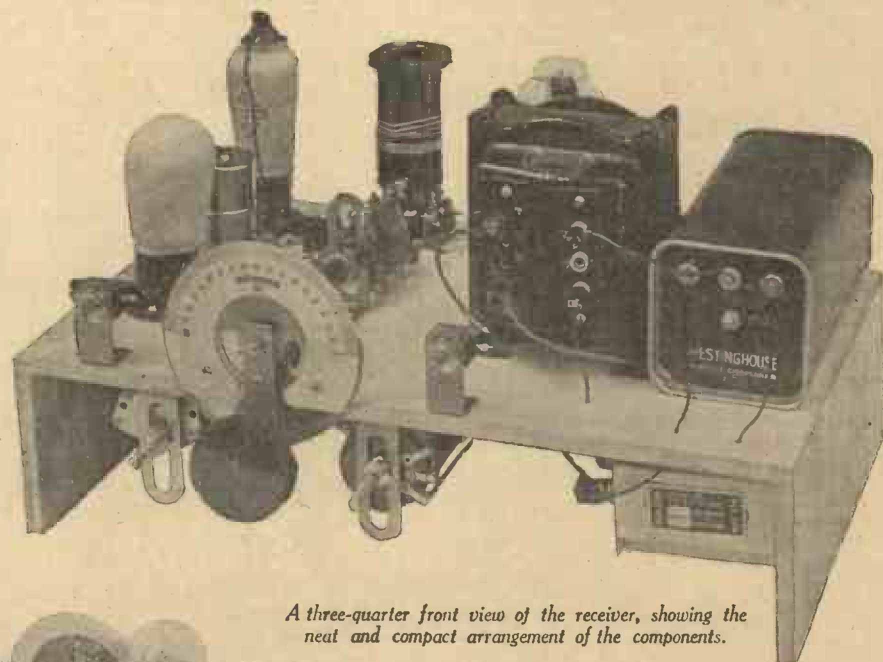
Constructional and Operating Details of an Efficient All-Mains Short-Wave Receiver

MOST of the short-wave receivers we have described in the past have been of the battery-operated type, as the demand for the latter has been greater than for the mains type of set. The popularity of the battery-operated type has probably been due to the silent background that can be obtained. Recent improvements in rectifying and smoothing apparatus have made it possible to design a mains-operated receiver having as silent a background as the battery type of set, however, and our correspondence during the past few months definitely indicates that there is a growing demand for mains-operated short-wave receivers.

Although superhets. have proved very satisfactory for reception of the short wavelengths, the straight type of receiver has advantages over the superheterodyne type. Reaction is more easily obtainable with the straight set, and therefore reception of continuous-wave stations is facilitated; it is also more easy to convert the straight receiver for all-wave reception than the superhet. We have received a number of letters from readers who have constructed our short-wave superhets., in which they have complained that they have been unable to pick up morse transmissions. They evidently overlooked the fact that most of the morse transmitters use continuous waves, and therefore cannot be received by means of a superhet. unless the intermediate or second detector stage of the latter has been purposely rendered unstable. As a large number of short-wave enthusiasts are very interested in the reception of morse, we have decided to make the first all-mains receiver to be described in this journal a straight type, using a well-tried circuit arrangement.

Circuit Arrangement

A study of the theoretical diagram will indicate that the circuit comprises an untuned H.F. stage, coupled by means of a tuned H.F. transformer to a triode detector valve, with a parallel-fed L.F. transformer coupling this valve to an efficient directly heated pentode. It has been found that S.G. and H.F. pentode valves do not provide a very high degree of amplification on wavelenghts below 100 metres, but, nevertheless, an H.F. stage is very desirable as it eliminates annoying aerial effects, and consequently stabilises the reaction control. There is no advantage in tuning the input circuit of the H.F. valve, however, and therefore we decided to couple the aerial direct to the grid of the first valve. It will be noted that the H.F. transformer following the first valve is parallel fed; this necessitates the use of an extra H.F. choke, but in the interests of stability the addition has been found very desirable. The detector is of the leaky grid type, but it will be noticed that when the pick-up is switched on, a cathode bias resistance of the correct value is brought into circuit, thus making the detector into an efficient L.F. amplifier when gramophone reproduction is desired. The L.F. coupling transformer is also parallel fed, as this method of connection prevents the passage of direct current through the primary winding of the transformer, thereby improving response and obviating the possibility of a transformer burn out. The detector anode circuit is effectively decoupled by means of a high resistance and a high-capacity condenser, and therefore the L.F. stage is perfectly stable. A potentiometer control has been connected across the secondary winding of the L.F. transformer in order that volume may be effectively controlled when listening with headphones, or when gramophone records are being reproduced. The pentode output valve has a maximum undistorted output of approximately 2½ watts—quite sufficient to fill a large-sized living-room—and as it is of the directly heated type there is no possibility of a voltage surge occurring when the set is switched on, as would be the case if an indirectly heated valve were used.



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

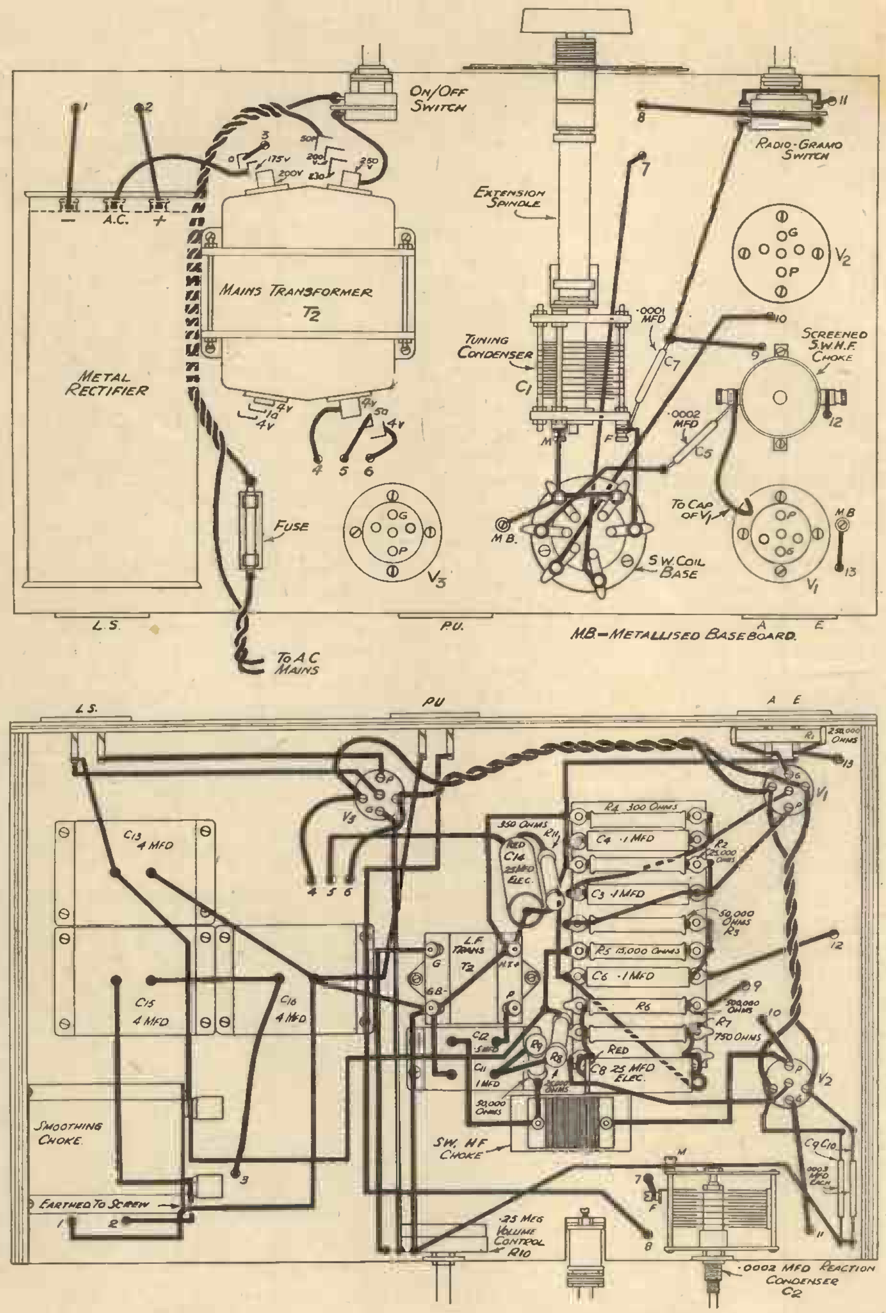
A three-quarter rear view of the receiver.

The Layout

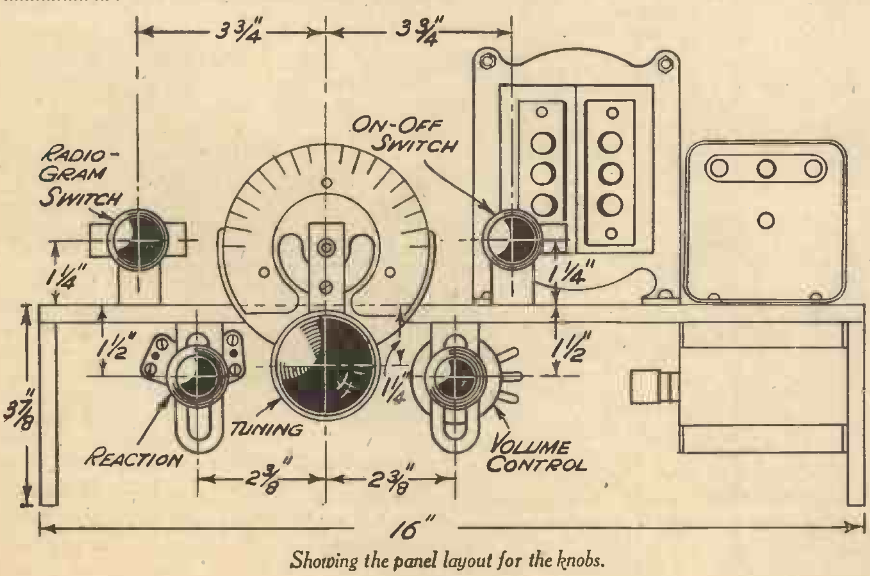
It will be seen that the components have

LIST OF COMPONENTS FOR SHORT-WAVE MAINS THREE.

- Three Short-wave Coils, S.P.A., S.P.C., and S.P.D. (B.T.S.).
- One Short-wave Coil Base, Type S.P.B. (B.T.S.).
- One 0·00016 mfd. Condenser, No. 942, with 3-in. Spindle (Eddystone).
- One 0·0002 mfd. Reaction Condenser, No. 957 (Eddystone).
- One Drive, No. 933W (Eddystone).
- Fourteen Fixed Condensers: 1 mfd. (65), 0·5 mfd. (65), 0·1 mfd. (250), 0·1 mfd. (250), 0·1 mfd. (250), 4 mfd. (84), 4 mfd. (84), 4 mfd. (84), 0·0002 mfd. (M) 0·0001 mfd. (M), 0·0003 mfd. (M), 0·0003 mfd. (M), 25 mfd. 25-volt electrolytic, 25 mfd. 25-volt electrolytic (T.C.C.).
- Ten Fixed Resistances: 500,000 ohms, 1-watt type; 250,000 ohms, 1-watt type; 50,000 ohms, 1-watt type; 50,000 ohms, 1-watt type; 25,000 ohms, 1-watt type; 25,000 ohms, 1-watt type; 15,000 ohms, 1-watt type; 750 ohms, 1-watt type; 350 ohms, 1-watt type; 300 ohms, 1-watt type (Erie).
- One On/off Switch, Type S.91 (Bulgin).
- One Change-over Switch, Type S.92 (Bulgin).
- One Screened H.F. Choke, No. 982 (Eddystone).
- One Short-wave H.F. Choke, H.F.3 (Bulgin).
- One 3 : 1 L.F. Transformer, "Niclet" (Varley).
- One Ten-way Group Board (Bulgin).
- One L.F. Choke, No. L.F.14 (Bulgin).
- One Mains Transformer, Type W.31 (Heayberd).
- One H.T.8 Metal Rectifier (Westinghouse).
- One Fuse (0·5 amp.) with 1034 Holder (Belling & Lee).
- Three Valveholders (5-pin), airsprung type (Clix).
- One Chassis, 16 by 10 by 3½ in. (Peto-Scott).
- Three Terminal Strips, A.E., L.S., and P.U. (Clix).
- One AC/HD Valve (Hivac).
- One AC/HL Valve (Hivac).
- One PT41 (Cossor).
- One Stentorian Loud Speaker (W.B.).
- One 250,000-ohm Potentiometer (Reliance).
- Five Component Brackets (Peto-Scott).



The top and underneath chassis wiring plan of the short-wave mains three.

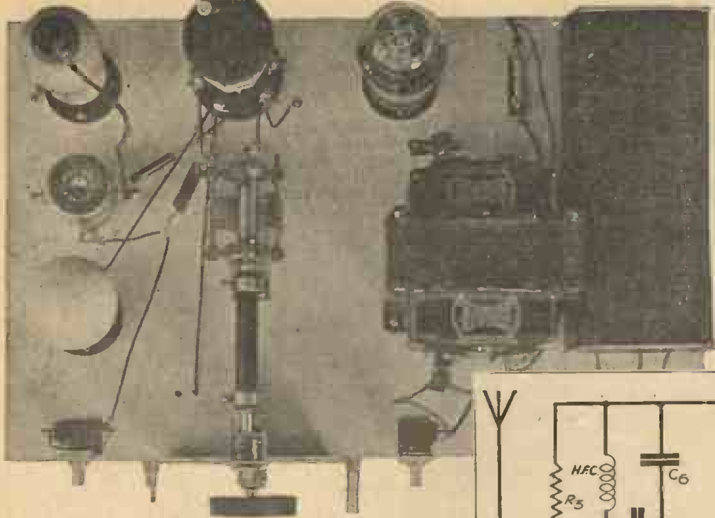


Showing the panel layout for the knobs.

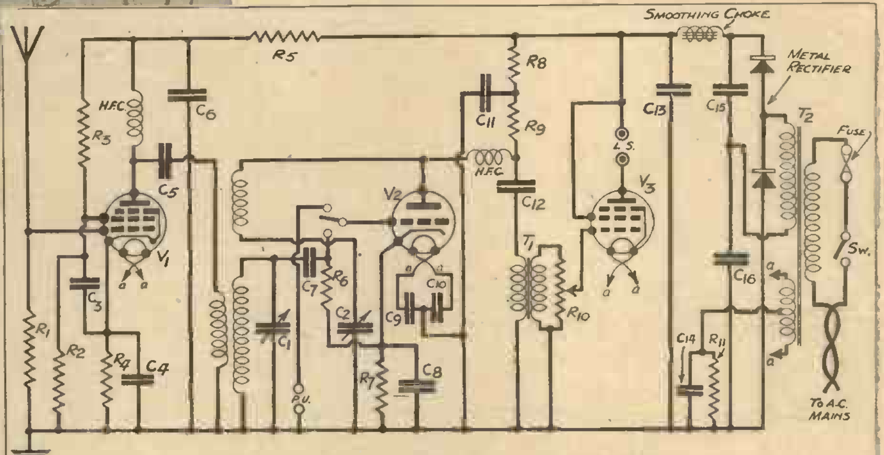
been neatly arranged on the chassis, with the valves and coil in an easily accessible position. An extension spindle has been used in conjunction with the tuning condenser in order to keep this component near the tuning coil. This arrangement has two advantages over the usual method of placing the condenser near the panel; hand capacity effect is obviated, and stray capacities due to the use of long leads in the tuned circuit are reduced to a minimum.

Construction and Wiring

The constructional work is of a very simple nature, but it is probable that beginners will find the following instructions helpful. It is advisable to drill the holes for the valveholders before commencing the mounting of the components, and for this purpose a ⅞-in. drill should be used. The terminal strips may also be mounted at this stage, using a ¼-in. drill for the socket holes. The components on



This photograph shows the neat and compact layout of the components on top of the chassis.



The circuit diagram of the short-wave mains three.

the underside of the chassis may then be mounted and wired, care being taken to separate the resistances and the condensers on the terminal board. After the under-chassis wiring has been completed, the various components on the upper surface may be mounted and wired. As the spindles of the switches are not in contact with the contacts, it is not necessary to insulate the supporting bracket from the metallised surface of the baseboard.

Operating

After the wiring has been carefully checked, the fuse may be inserted in its holder, and the required coil plugged into the coil holder. The receiver is primarily intended for short-wave reception, but medium and long waves may be received if a set of coils covering these wavebands is obtained. It is pointed out, however, that a high degree of selectivity must not be expected on wavelengths of over approximately 150 metres, as the aerial circuit is not tuned. For short-wave reception a 20-ft. length of aerial will be found sufficient, and it is desirable to keep the earth lead as short as possible. After teh mains plug has been inserted into its socket, the receiver may be switched on by means of the switch at the right side of the chassis. The operation of the receiver is very simple, as only one tuning control is employed, and rotation of this in conjunction with the reaction condenser on the left side of the chassis is all that is necessary.

ADAPTING THE TWIN-TRAIN TABLE RAILWAY

(*Continued from page* 414)

Rounding Curves

In this engine the whole of the original boiler casing is done away with and the superstructure must be built up entirely. Besides this another pair of driving wheels must be added, as well as a leading pony truck. In order to facilitate the running around curves it will be advisable to temporarily remove the existing white-metal driving wheels, mount them in the lathe, preferably on their own axle, and reduce the thickness of the flanges, thereby increasing the width of the treads. Those wheels, which have the toothed gear on the inside of them, should have the metal turned away nearly up to the teeth. The additional pair of large wheels can very well be made from hard boxwood as well as the truck wheels.

The important details of construction of this model are given in Fig. 10. Here it will be seen that the frames are extended to the front buffer beam in wood, such wood being made to fit over the cast cross bar in the existing chassis, a wood screw being passed through the hole in the cross bar. The upper drawing is a longitudinal section and the lower one a plan view from underneath. At the front end the wood is cut away on the inside to give clearance for the truck wheels. The bearings for the leading pair of large wheels are formed from two brass plates which are recessed into and screwed to the wood.

The alteration in the wheel arrangement will involve doing away with one of the present current collectors, that is to say the front one which makes contact on the running rail, but as two collectors are necessary for the picking up of current when the engine is going over points a new collector must be made. The simplest form to give this will be that shown in the sketch. It is cut from a piece of spring brass, screwed up through the cross bar in the cast frame and then bent so that it just makes light contact with the rail. Fixing this collector on to the cross bar will ensure its making contact with the frame of the engine. If it were screwed to

some part of the wood, as it might be just behind the cross bar, a wire would have to be run from it to some point on the frame.

Keeping Down the Track Wheels

The reader will notice that in between the up-turned sides of the pony truck frame is shown a block of lead. This will be necessary in order to keep the truck wheels down on the rails, though a light spiral spring can be fitted instead if desired. Such a spring or lead weight will be necessary also in the 2-4-0 model, although I have not shown it in my drawings, Fig. 6 and 7.

The boiler of this 2-6-0 engine will have to be made hollow, of course, to enclose the motor, but the smokebox can very well be turned from a piece of hardwood (beech) perfectly cylindrical and parallel, shouldered down slightly to receive the conical boiler barrel and dowelled or fastened in any other suitable manner to the wooden frame extension. The chimney can then be secured with a single wood screw. The safety valve casing, and the domes in the case of other railway companies' engines will have to be soldered to the boiler. At the front end of the smokebox I have shown a hole into which the smokebox door handles will be fixed. The door hinges can be cut in Bristol board and stuck to the wood. For supporting the footplating the cylinder blocks, which can be made in hardwood, will be carried up and the footplating, if made of wood, glued to them. The elevation Fig. 9 shows also a sandbox which can be made of wood, and these form additional brackets for securing the footplating.

It is impossible in the space available to go into full and complete details of construction, and there are many things which must be left to the reader to devise for himself. The existing connecting rod, however, is transferred to the front motor-driven wheel and additional cranks added to the rear wheel. Between the two, rear coupling rods can be cut from bit of thick tinplate.

(*To be continued*)

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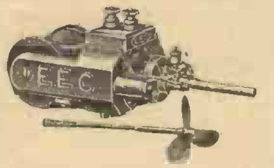

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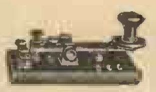

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THE usual method of lighting a room by one lamp suspended from the middle of the ceiling is not the most artistic or even the most convenient. It is comparatively easy for the handyman possessing mechanical and artistic ability to considerably improve on such a scheme. There are two additions that can be made, first standard and table lamps, and secondly, wall lighting.

The former are obviously the most simple, requiring merely a plug in a suitable position to make the connection. The second class need not entail work beyond the average man's ability, and will not cost anything like the amount estimated for by contractors. This class of lighting, however, is best arranged before redecoration, in order to cover up the traces of the wiring required.

It is proposed to give sketch designs for a large standard lamp suitable for the average lounge or drawing-room, and to indicate several methods of adapting candlesticks, vases, etc., as modern and artistic table-lamps. Modern styles of decoration and furniture aim principally at simplicity, and this will be the aim of the present designs, more especially as this simplifies the work.

A Standard Lamp

It is not within the province of the average man to produce turned standards of any great length having a central hole for the cable, although this may be done by the possessor of a lathe if he cares to make the standard in sections of a convenient length for boring. The suggested design shown in Fig. 2, utilises a square section column which is made in two halves lengthways, each half having a ploughed groove, and glued together so that the grooves register, to form a central way for the cable. The lampholder is of the type having a push switch and adapted for conduit fixing. It is fixed to the end of the column by screwing to a short length of suitable conduit which may be easily fitted in the wood by heating to redness, and pushing into the square hole nearly to the depth it is intended to fit, burning a circular tunnel for itself. It is then withdrawn and the lower end filed to a sharp circular edge, which is then re-inserted and tapped home with a hammer.

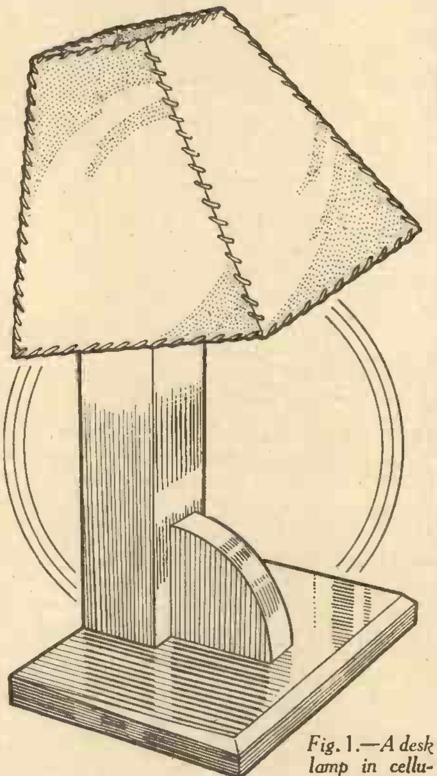
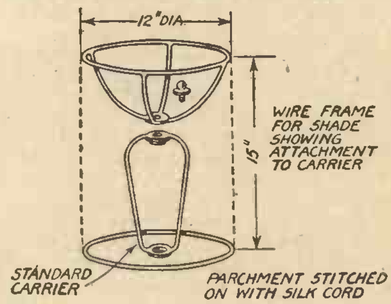


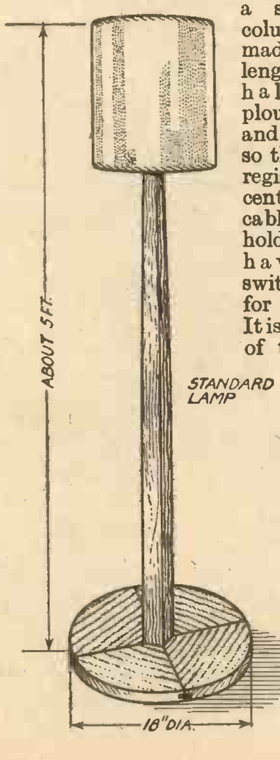
Fig. 1.—A desk lamp in cellulosed wood.

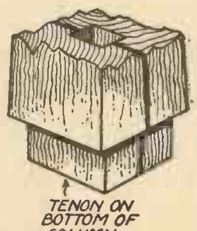
The base, which in the suggested design is circular, may be cut from timber with a bow saw or pad saw, or even with a panel saw, and finished by spoke shaving. A much better job, however, is to make the disc in four right-angled sectors, grooved and glued together with hardwood keys, thus producing the square pattern of the graining. This will look much better and be much less likely to warp than a disc cut from one piece of timber. The bottom end of the column is reduced slightly to form a tenon, and a suitable mortise is made in the centre of the disc to take it. The whole may be made much less likely to capsize by cutting a disc of lead sheet rather less than the size of the base, and screwing this to the underside, a groove being cut in the base to allow the cable to come through between that and the lead. The shade is made by stitching parchment with fine silk cord to a wire frame made from 15 to 18 guage tinned iron wire. The frame in the present design is made in cylindrical form, and this is the easiest to cover, although it may be varied, or a shade may be purchased and fitted with the usual carrier.

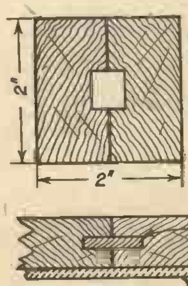
Stained or Polished

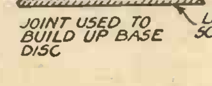
The woodwork may be of red deal stained and polished as indicated in a previous article in our February, 1936, issue, or the whole of the woodwork may be made in mahogany or yellow pine and veneered. The only difficulty is the short-grained veneer round the edge of the base disc, which must be laid by the use of shaped cauls, while the rest of the veneering can be done with a hammer. This will produce a very handsome article in the best modern style. Cellulose paints or enamel may also be used with good effect on a deal standard. The sketch, Fig. 2, gives the main details. Exact dimensions are not given, as it is much preferable for the maker to introduce individual variations. The cable should be threaded up the column when the work is complete with the exception of the lead plate on the base, connection made with the lampholder, the lampholder screwed in position, and the lead plate firmly affixed.











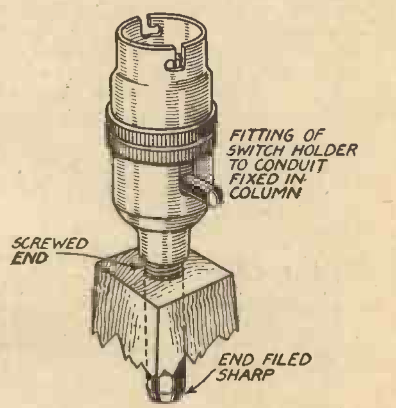
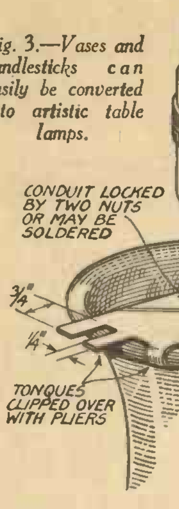


Fig. 2.—Various constructional details for making a standard lamp.

Fig. 3.—Vases and candlesticks can easily be converted into artistic table lamps.



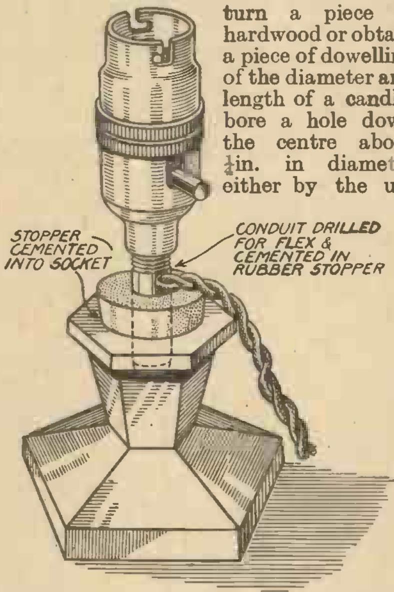
A Table Lamp

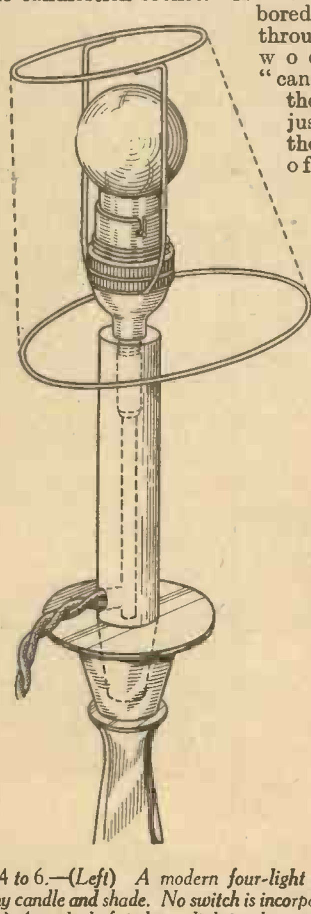
A table lamp can be made in the same way as a standard lamp, and a suggested design is given in Fig. 1. Many modern lamps, however, use glass or earthenware vases, candlesticks, etc., as bases, and they are undoubtedly of much artistic merit. If the reader possesses an old brass candlestick, a modern glass one, or a vase of suitable size and shape either in earthenware, pottery, or laquered metal, he can easily convert it into a most attractive table lamp (Fig. 3). The switch holder with conduit fitting is again used, and in the case of a candlestick, it may be adapted in the following way. A rubber stopper or door stop of suitable size is pared carefully with a wet sharp knife until it fits into the candle socket. The hole in the centre is now made of the correct size by the use of a piece of conduit, one end of which is filed to a cutting edge, and which is then used to bore through the rubber by wetting and twisting it. The conduit is then cut so that it projects from the top of the rubber stopper about ½ in., where it will require to be threaded to take the lamp holder. A ¼ in. hole is drilled square through the side just above the surface of the rubber, to provide an outlet for the flex. To assemble, the conduit is first pushed through the stopper so that its lower end is flush with the rubber, and the end of the flex threaded through the hole into, and out at the top of, the conduit. The connections in the lampholder are now made, the lampholder screwed in position, and the flex pulled back. The lamp is then fitted with a shade, and the rubber cemented into the socket.

To adapt for a vase, a piece of sheet brass about 22 gauge is necessary, 1 in. wide, and about 1½ in. longer than the diameter across the rim of the vase. A hole is drilled in the centre of this to allow passage of the conduit which may be locked in position by the use of two nuts, or alternatively soldered, and no hole is necessary for the flex as it will come through the bottom of the conduit. The brass strip is now cut at the ends into three tongues about ¼ in. wide as shown in the sketch, so as to be easily nipped on to the rim of the vase by the careful use of pliers. The flex must first, however, be threaded up through the conduit, attached to the lampholder, and the lampholder screwed in position. If, as will often be the case, the lamp is now top heavy, the vase may be partially filled with lead shot or sand.

A Dummy Candle

Another useful way of fixing lamps in candlesticks is to turn a piece of hardwood or obtain a piece of dowelling of the diameter and length of a candle, bore a hole down the centre about ¼in. in diameter either by the use of a long pit or more simply with a red hot rod, and pare the lower end to fit tightly in the candlestick socket. A hole must be bored also through the wooden "candle" to the centre just above the level of the socket for the flex. If a metal or wooden candlestick is being used which can also have a hole bored down the centre, the flex can be brought out at the bottom. A lampholder is fitted to the top of the "candle" in the same way as in the standard lamp described above, and the wooden "candle" enamelled to resemble a white or coloured wax candle. A shade is obtained or made similar in size and shape to the shades in vogue some time ago for clipping on to wax candles, and of course a small low-consumption lamp must be fitted. It will usually be found better in all the foregoing examples to arrange the shade to cover entirely, when viewed normally, the electrical fittings, and however small the shade it will be found quite easy to operate the switch with the thumb and finger inside the shade (Fig. 4).



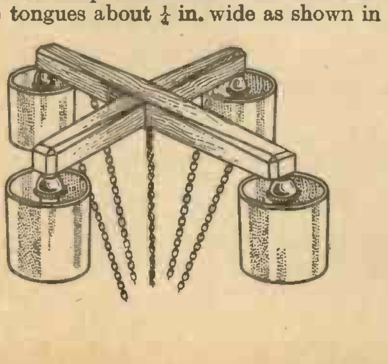


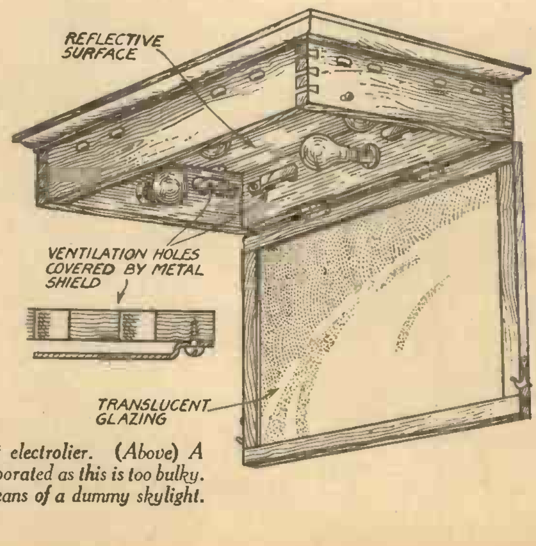
A Four-branch Candelabra

To complete this group of lamps, which entail no alteration to the existing wiring, a sketch design is given for a four-branch candelabra in Fig. 5, which can be suspended from the ceiling rose by chains in the same way as bowl shades, and having four lamps of fairly low power. The arms of the candelabra are fastened together by a half lap joint, and each is ploughed in the upper surface with a ¼-in. groove to accommodate the wire. It will not usually be necessary to take particular care in covering the wire as it will in any case be invisible from below. This type of candelabra may be fitted either with small candle type shades above the frame, or with globes underneath the frame, which will require a special holder to provide ventilation. The woodwork may be, as in the case of the standard lamp, either deal stained, hardwood stained and polished, or mahogany or yellow pine veneered. A very satisfactory modern finish for such small work is to cover with tinfoil carefully glued on to the wood, and use silver chains for suspension. Another method of treatment is to use a Jacobean design for the woodwork, which must be stained dark oak, and to fit candle type electric lamps. These special fittings, candle lamps and globes, increase the cost considerably. The four lamps in the candelabra are wired in parallel from the ceiling rose, and operated from one switch.

A Dummy Skylight

Where the reader is the owner of his house, or possesses a complaisant landlord, and is moreover prepared to go to some trouble, he may reorganise completely the lighting of his rooms, with great artistic benefit. The first suggestion is a method





Figs. 4 to 6.—(Left) A modern four-light electrolier. (Above) A dummy candle and shade. No switch is incorporated as this is too bulky. (Right) A method of indirect lighting by means of a dummy skylight.

of indirect lighting by means of a dummy skylight, housing two or more medium power electric lamps (Fig. 6). The framework is of timber, about 6 in. × 1 in., made into a frame of suitable size to represent a skylight, and may be joined at the corners by dovetailing or by the use of a rebated corner joint according to the skill of the worker. The framework is fastened to the ceiling by the use of brass angles, and screwed to the joists through the plaster,

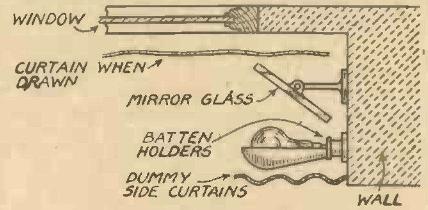


Fig. 7.—How to obtain indirect lighting from deep window embrasures.

being arranged so that the existing lighting point comes within the framework. Reflecting surfaces may be provided in one of several ways. The whole of the inside of the frame and the ceiling enclosed may be enamelled white; the frame and the ceiling within may be covered with tin foil; or several mirrors may be fitted to cover the whole of the ceiling within the frame, the light is provided by fixing batten holders to the inside of the framing, and the lamps wired in parallel with the ceiling rose which is inside. A frame is now made or purchased to fit underneath, glazed with some variety of translucent glass or parchment, and this is hinged and fitted with a catch to permit access to the lamps. Ventilation is provided by several holes in either the ceiling or the frame work. Holes in the ceiling allow no light to escape except through the glazing, but if holes in the frame are preferred, they can be covered by metal shields as shown in the sketch, to reduce the emission of light. It is better to arrange for four 25 watt lamps rather than two of greater power, as this gives a better diffusion of light, and less concentration of heat. This device may also be used in the form of a dummy window instead of a skylight, but the effect of diffusion is not so good, although it may be most attractive. It also has the disadvantage of making it necessary to carry the wiring to the wall, whereas the skylight form takes advantage of the wiring already in place.

Window Lights

Another form of lighting which attempts to imitate natural lighting, and which is useful where the house has deep window embrasures, is to fix batten holders to the sides of the window embrasures in such a way that the lamps are hidden by dummy curtains (see Fig. 7). The lamps are protected by shell reflectors on the room side, and their light is diffused into the room by strips of mirror glass in the sides of the window embrasures as shown in the plan. This plan also entails a certain amount of wiring, which will be dealt with later.

Wall lamps can easily be fitted, whether in rooms, halls, or staircases, particularly where panelling or moulding provides a hidden line for the cable, thus obviating the necessity for sinking wiring (see Fig. 8). A most useful position for a lamp is on the finial at the bottom of the stair bannister, and here the wiring may usually be carried under the stairs. A simple modern design is illustrated for a wall lamp, the shade of which is made from coloured glass held together by window lead. Alternatively a wooden frame may be made with glass rebated in.

If the reader is prepared for the work involved he may incorporate wall lighting with panelling in his room, using 3-ply boards, which may now be obtained fairly cheaply faced with rare and beautiful figured woods. The first task is to divide the walls into convenient panels having regard to the size of boards required, and along the divisions battens are fastened to the wall by means of rawl-plugs or plugging. The wiring should now be done on the surface of the wall, using twin lead covered cable, and the special fasteners obtainable to clip it to the wall. The panelling is now fixed to the battens, the joints being covered with prepared moulding in harmony with the scheme of the panelling. If the wall is to be papered the scheme should first be considered with a view to using any existing mouldings, door-framings, skirting, etc., to hide the wiring. Where this is impossible a chase should be cut in the plaster about ½ in. deep from the switch straight to the ceiling and wiring carried between it and the floor above until vertically over the points required, when another chase will be made down to the required height. When wiring is already in existence it will be simpler to find the junction and to commence wiring from there. When the wiring has been completed the hollows will require to be replastered and smoothed off level with the wall. If this is carefully done and the wall paper has no very pronounced design, it is quite feasible to cover the new plaster only with paper, and not necessarily to repaper the room.

Safety Precautions

For the sake of safety, and particularly in damp situations, the lead sheath should be kept continuous, using junction boxes when necessary, and finally a clip is placed on the sheath at some convenient place and connected with wire to a water pipe. If these precautions are taken and British-made bakelite fittings are used throughout there will be no danger of shock. The following precautions must be taken when carrying out the work. First, unless it is definitely known that the existing circuit will carry a heavier load, less than 5 amps should be arranged on any one switch. As this, however, is the equivalent of ten 100 watt lamps, it is not likely that this will be approached. To calculate the current required for a lighting system, add together the number of watts of each of the lamps in the circuit and divide by the voltage of the supply. In this connection bear in mind

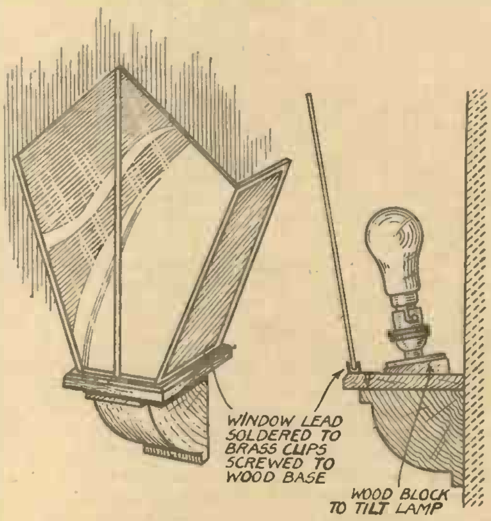


Fig. 8.—A simple and artistic wall lamp.

that powerful lamps are rarely effective for house lighting. Much better effects may be obtained by the use of several low power lamps. Final warning. Make sure that the main switch is off before interfering with any wiring or lamps, preferably also remove the fuses.

SYNCHRONOUS ELECTRIC MOTORS

(*Concluded from page 333 of last month's issue.*)

What happens when the frequency changes? Minute changes are always occurring, but these are due to the varying load thrown on the turbines, and are consequently compensated for by the governors. Any other change is rectified by the engineer, who turns a small switch which operates a reversible motor geared to the governors, and thus the speed is brought back to normal. Several stations can be controlled by one central master meter, just as one master clock will control any number of slave clocks.

From the above it will appear fairly obvious that every house and works supplied from the National Grid will have power at a fixed frequency, which varies through very small limits only. It is these factors which have made the small A.C. clocks so popular. The Warren clock is generally considered to be too expensive for the average householder, so the non-self-starting clocks are more popular. All A.C. clocks have a big disadvantage, and that is that after an interruption of the supply, the correct time is not indicated. In self-starting clocks, a small red window falls to indicate that the clock has stopped, but in finger-starting, the hands remain at the time of interruption. Local interruptions can be reduced to a minimum by installing a correct clock circuit, and wiring this up with suitable fuses from the main bus-bars.

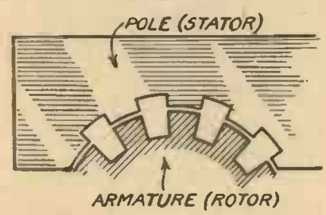


Fig. 3.—Diagram showing the arrangement of the teeth on the rotor and stator of a synchronous motor.

In a modern clock, the speed of the armature is considerably reduced by using a multi-polar armature, similar in every respect to a cog wheel. In the Ferranti clock, this has 36 poles and makes 166·6 revs. per minute. The poles of the magnet are also serrated, so that the same number of poles on the armature are opposite the same number of poles on the field magnet. For simplicity, consider a rotor and stator, each of two poles, connected to a 50-cycle supply. At any instant the field will induce an opposite pole in the rotor, but there will be no tendency for it to move. On bringing the rotor up to synchronous speed, however, the induced poles will change, being alternately repulsed and attracted and hence the rotor will continue to rotate (see Fig. 3).

The LATEST NOVELTIES

The address of the makers of any device described below will be sent on application to the Editor, PRACTICAL MECHANICS, 8-11, Southampton St., Strand, W.C.2. Quote number at end of paragraph, and enclose 1d. stamp for the reply.

An Electric Engraver

THE sketch below shows an electric engraver which can be used by anyone, for quickly and accurately marking any metal and other materials in printed characters or script. Beautifully finished and balanced for fine, accurate work, any type of lettering can be written on tools, instruments, fountain pens, etc. Wherever it is required to put a name, it can be used so accurately that an actual signature is easily recognisable, and it does the work of an expensive machine in a fraction of the time. A powerful internal motor operates the mechanism, which is simple, and all working parts are hardened and tempered. The actual marking is due to the high-frequency beat of a hardened steel point cutting into the metal some 30–40 times per second. The point is reasily renewable. Connected to the nearest lampholder, A.C. or D.C., it is ready for immediate use. The 6-volt battery model costs 70*s.*, mains-driven A.C. or D.C. 105*s.*, and "Powerplus" model 150*s.* [187.]

The electric engraver for quickly and accurately marking out metal and other materials.

An Ingenious Door Light

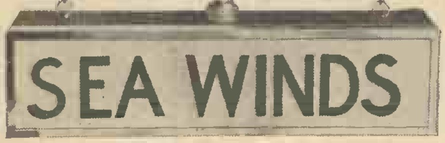
THIS ingenious electrical gadget will be found to have great utility. Open the door—and the light is on; shut the door—and it goes out. It can be used inside the pantry, cupboard, trapdoors, cycle shed, coal house, etc. Simple to fit inside a door, it has no complicated switching mechanism to go wrong. Finished in bright enamel the light has bright plated fittings, and a soft steel lever which can be bent or adjusted to operate on any thickness of door. Supplied complete with lamp and battery, it costs 2*s.* 6*d.* [188.]

This door light, when fitted inside a door, etc., is automatically switched on when the door is opened, and goes out when the door is closed.

An Illuminated Name Sign

WE show on this page an effective house sign, which is suitable for day and night use. It is produced at a price which enables every house to be fitted with one. The all-steel case is finished in an attractive black "crystalline" enamel, and the chains and front surround are bright nickelplated.

A 16-watt lamp (giving over sixty hours light for the cost of one unit of electricity) provides an economical illumination of the sign and also lights the porch through the full-length window in the base of the sign. Black characters against a white frosted background give a clear and distinct reading in light or dark up to forty yards. It is supplied complete with sufficient characters, chains, hooks, lampholder, lamp, and 6 ft. of weatherproof cab-type cable and adapter for 12*s.* 6*d.* [189.]

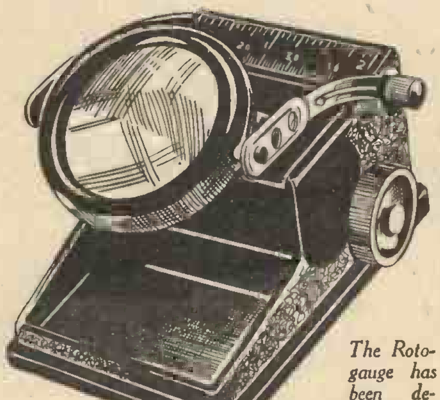


An illuminated house sign.

For Stamp Collectors

THE Roto-gauge shown herewith was developed by three philatelists.

Its most important feature is the new rotating gau e with the oblique lines. To use the device, place the stamp in line with the guide line and turn the gauge until the correct class is indicated, *i.e.* until the all white spaces are covered, leaving only the black. It is fitted with a double gauge for measuring stamps by inch or millimetre, a perforation gauge, a magnifying glass, and a watermark detector. It costs 15*s.* [190.]



The Roto-gauge has been designed for philatelists. It is fitted with a perforation gauge, watermark detector, and magnifying lens and measures stamps by the inch or millimetre.

NEW INVENTIONS

The following information is specially supplied to "Practical Mechanics," by Messrs. Hughes & Young, 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.

Good News for Sightseers

IN these days when huge crowds make desperate efforts to see Royal processions, football matches, and other outdoor events, the late comers and the short people are always at a disadvantage. To help these unfortunate people, the inventor has been busy improving a mirror to enable them to see the passing show at close quarters or from a distance. One of the latest of these devices has a reflector which may be fixed or worked on a swivel, so that the mirror can be adjusted according to requirements. The glass may be plain or magnifying and the handle, made of wood, aluminium, or celluloid, can be constructed to fold or telescope. The mirror, inserted in a case, can be carried with ease and without risk of damage.

Fishing in the Gloaming

IT is a fact well known to anglers that, when the shades of night are falling, there is a better chance of a good catch than at any other time of the day. However, in the falling light, it is difficult for the fisherman to detect the movement of his float. To obviate this disadvantage, an improved electrically illuminated float has been devised. This float comprises an electric bulb and an electric cell. Both are contained in the body of the float, which is composed of two parts forming an air chamber within the body when fitted one on to the other. Contact-strips of conducting material are provided, so that when a fish seizes the bait and pulls the line, one contact touches the other, both contacts being situated on the outside wall of the float. The consequent illumination at once indicates to the angler that he must take immediate action.

Film Fire Extinguisher

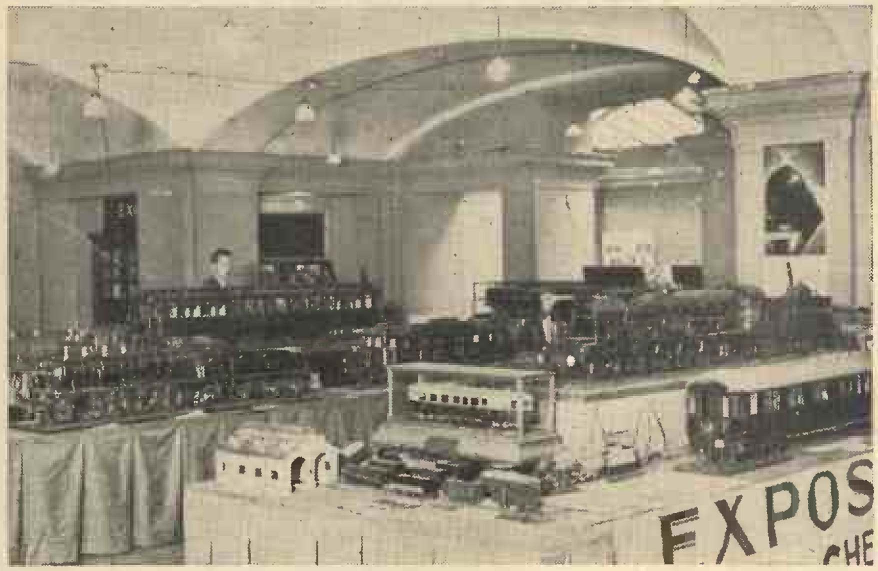
THE greatest danger from which the patrons of the cinema have to be protected is fire. The chief source of this danger is in the cinematograph projector. In case of fire in or near the machine, an invention has recently been devised promptly to cope with the evil. According to this invention, a readily combustible fuse releases a spring-operated knife, which severs the film, and the further feed of the film is immediately stopped, although the motor continues to rotate.

New Use for Silver Paper

AN inventor has discovered a new use for tinfoil, commonly known as silver paper. He calls attention to the fact, which we have all observed, that a lighted cigarette placed upon an ordinary ash tray will usually result in a dark, moist stain on the under side of the cigarette, and that an unpleasant odour is caused. He has found that a lighted cigarette laid upon a sheet of silver paper will continue to burn sweetly and without stain. He concludes that the porous nature of the tinfoil permits a flow of air to the under side of the cigarette and helps its perfect combustion, while it dissipates any heat or moisture which may collect.

DYNAMO.

THE MODEL RAILWAY EXHIBITION



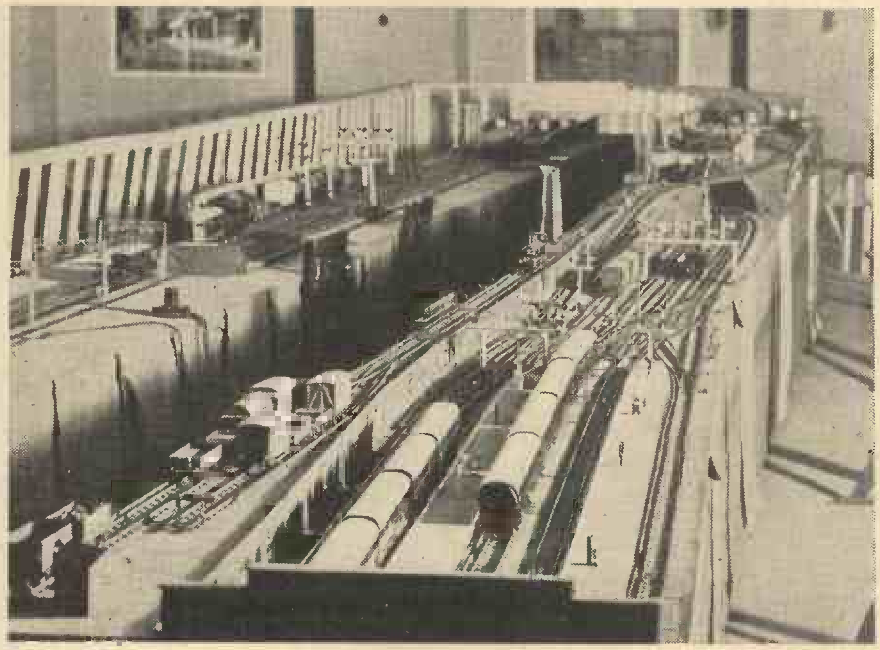
Showing a fine model railway layout which will be on view at the exhibition.

THE Model Railway Club was founded in 1910 for those interested in the making of models of railway prototypes, and in the operation of model railway layouts. The club comprises members of all ages from 14 years, and of all professions and occupations, and they are interested in all types of models of railway subjects, from steam locomotives and rolling stock, running on a gauge of 15 in. down to those running on a gauge of ⅜in.

The interest of members is not solely in the operation of locomotives propelled by steam, but also in those operated by electricity, and in the construction of models of coaches, wagons, signals, tracks, and all line-side buildings and scenery surrounding the railway. Examples of all the varied interests of the model railway enthusiast may be seen at the forthcoming exhibition, to be held in the Central Hall, Westminster, from Tuesday, April 14th next until Saturday, April 18th inclusive.

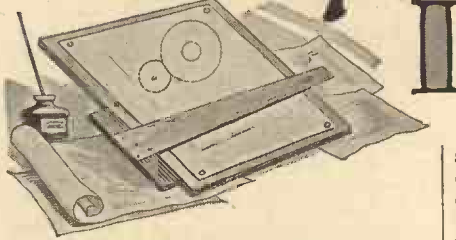
Amongst other exhibits, there will be in operation a multi-gauge passenger-carrying track, upon which the visitor may be hauled by steam locomotives of varying scales, as well as several smaller gauge lines, complete in all detail, and running to a proper time-table, also a layout demonstrating the principles of English signalling. The French Club, as in past years, hopes to send a comprehensive collection of models of locomotives, coaches, wagons, and signals, as used in France.

A cinema (entrance free) will show films of railway interest, and any visitor to the exhibition interested in model railways who has any problem or who requires any information concerning his hobby, is invited to consult the stewards. Refreshments will be obtainable in the hall.



In the scale model train section.

Money Making IDEAS



Advice by our Patents Expert

A SELF-ADJUSTABLE GEAR

" I ENCLOSE a design for a ' self-adjustable ' gear for motor cars, which I would be pleased for you to criticise, giving me information as to the practical value and novelty of the design." (R. J., Birkdale, Southport.)

THE improved variable speed gear, if novel, forms fit subject matter for protection by Patent. It is, however, not thought to be broadly novel to combine a sun-and-planet gear with a hydraulic coupling, it may, however, be possible to obtain a Patent for a specific construction. The inventor is, however, advised to make a search amongst prior Patent Specifications dealing with the subject before incurring any expense in experimenting or protecting the invention. The commercial value of an invention is dependent on novelty, utility, cost of production, and probably the most important factor is the way the invention is marketed.

THE CLARIFICATION OF COAL WASHERY WATER

" MAY I take the opportunity of asking you a few queries with regard to the above?

" As I am an engineer and work on one of the above plants owned by a private firm, I am naturally interested in this subject.

" A few months ago I designed and made a model for the clarification of coal washery water, which, with the aid of chemicals, was quite a success.

" I did not think it fit to be patented because of the expense of the chemicals involved. Quite recently, the firm have had a new patent installed which has a vacuum process and has also to use chemicals, but of a cheaper kind.

" Now I have redesigned these two devices into one, making, in my opinion, a much better device (on paper). I cannot afford to make a large-sized model, therefore it cannot be put to a practical test by myself.

" 1. As a servant of the firm, is it possible for me to obtain a patent for the device I have redesigned?

" 2. Would there be any infringement of the patent the firm has bought?

" 3. Providing that my device is a better one than the one patented, do you know of any other reason why I cannot obtain a patent?

" 4. If I am able to apply for one which is the best and cheapest way of doing so?

" And lastly, what would you do if you were in my position?" (J. B., Newton-le-Willows.)

1. AN employee is entitled to patent an invention, which he has invented, in his own name and to reap the reward, provided (*a*) he has no agreement with the firm to give them the benefit of any inventions he may make during his employment with the firm, (*b*) the invention was not the result of research work for which he was employed, and (*c*) the invention (or experiments in connection with the invention) was not carried out during his employer's time.

2. The manufacture, use, or sale of the invention might possibly be an infringement of an existing Patent, although an improvement on the invention covered by said Patent. It is not possible to give an opinion without having *full* particulars of both inventions, in any case it is a matter for professional advice, and the inventor is advised to consult a Patent Agent. The Editor will be pleased to recommend a reliable Patent Agent.

3. If the invention is novel and better, *i.e.* more useful either by reason of less expensive construction, or less expensive working, than an invention covered by existing Patents, there is no reason why a valid Patent could not be obtained for the improvement.

4. An Application for Patent may be filed with either a Provisional Specification or a Complete Specification. In the former case, protection is obtained for about twelve months before the expiry of which period a Complete Specification must be lodged if a full Patent is desired. Filing an Application for Patent with a Provisional Specification is the least expensive way of obtaining protection for an invention.

In reply to the final question, the inventor is advised to place the matter in the hands of a reliable Patent Agent for advice, because it is obvious that without a full disclosure of all relevant matters it is not possible to give an opinion of any value.

A GARDEN SEED-BAG CLIP

" I AM enclosing for your perusal a rough sample of a garden seed-bag clip, which I am prepared to patent. Before doing so, I have been anxious to obtain information regarding the spring operating this clip, as to whether it has already been patented, and whether the clip itself is of a design already governed by patent rights." (H. N., Mon.)

THE improved garden seed-bag clip forms fit subject matter for protection by Letters Patent and should you desire professional assistance in doing so, the Editor will be pleased to put you in touch with a reliable Patent Agent.

The clip, provided with an integral stem for inserting in the ground, is thought to be novel from personal knowledge. It is not, however, possible to give a definite opinion as to novelty without first making a search amongst prior Patent Specifications and publications relating to the subject matter. The inventor, however, may rest assured that there cannot be any Patent at this time covering either the clip *per se* or the particular type of spring employed, as such spring clips have been freely marketed for very many years, particularly for use as clothes-line clips.

A STANDARD WORK

Newnes Home Mechanic Encyclopædia, by F. J. Camm. 5/- or 5/6 by post from Geo. Newnes Ltd., 8/11 Southampton Street, Strand, W.C.2.

Non-slipping Drawing Instruments

By "Handyman"

WHEN drawing on good quality card with a polished surface, and more particularly if the drawing board is canted up at an angle, the tee-square and other straight-edged instruments are liable to slide down the board. The same thing is experienced sometimes when two or more flat instruments are used in combination with each other, and difficulty is met through the inability of the draughtsman to spread his fingers over a wide area and thus get sufficient and individual pressure on each of the instruments. This trouble can be easily overcome, however, by attaching, with a spot of glue, small discs of sandpaper to the underside of the instruments. These discs may be about ¼-in. diameter, cut from medium grain sandpaper.

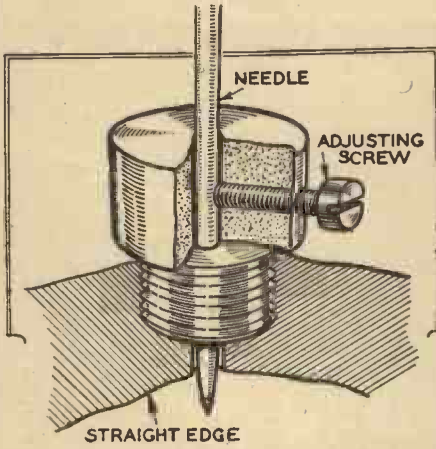


Fig. 1.—Long steel straight edges can be fitted with points as shown.

For Tracing Paper

It might be thought that when using instruments so treated, the face of the drawings might be scratched, but in practice it will be found that this is not so. They should not, however, be used on tracing paper, because with this material the surface is not integral with the body, and being more or less soft, scratch lines are sure to be made, which will show up on the prints made subsequently from the tracing. However, the smallest circular rubber patches used in cycle inner tube repairs can be used instead of sandpaper. If you make these patches too thick, the colour may drag off on the paper.

Fig. 2 shows a selection of drawing instruments fitted with discs, in the positions in which they will be found most effective.

Straight Edges

Sliding is also experienced in using long straight edges, not only on the drawing board, but on any other kind of job. The following dodge may be found useful. Two or more thin panel pins should be driven through the wood from the upper-side, until the points just protrude through the under-side. Straight edges so treated, are self-supporting even on a vertical surface, providing the pins protrude sufficiently to obtain a grip on the material.

Long steel straight edges can be fitted with points in a similar manner, the most satisfactory way of doing this being shown in Fig. 2. The straight edge is drilled and tapped to take the brass insert. A fine needle should be used for the point. The set-screw at the side of the brass insert, allows the depth of the needle to be adjusted to suit different materials and surfaces, or the complete removal of the needle if required.

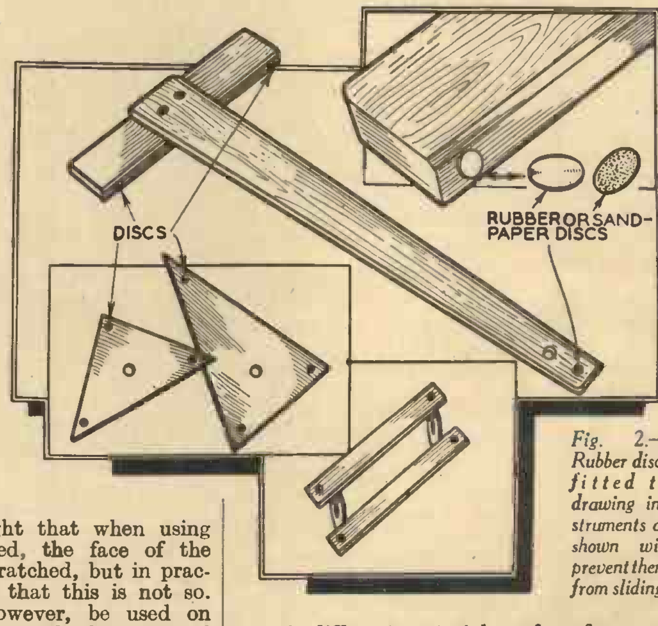


Fig. 2.—Rubber discs fitted to drawing instruments as shown will prevent them from sliding.

A POCKET BRAIN

THERE are still many busy people, whose work involves frequent calculations, who do not use a slide rule. Engineers, builders, architects, and surveyors have used this great time saver for generations, but there are other practical men who still make their calculations by slow and tedious methods. Commercial men particularly seem to be afraid of the slide rule, and some have an idea that the instrument is difficult to use. Learning to use a slide rule takes the average man about half an hour.

Expense cannot be urged as a deterrent, since reliable and accurate slide rules are available at the cost of a few shillings. "Unique" slide rules are famous and are used in all parts of the world.

The study of the slide rule is diverting and pleasurable and the short time required to become proficient is time well spent. No one who has learned to use this invaluable time saver would ever be without it.

PRACTICAL MECHANICS Replies to Queries and Enquiries

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

PRODUCING A SMOKE SCREEN

"CAN you give me particulars of a formula for producing a dense smoke screen from safe chemicals; the denser the smoke screen the better." (R. N., Wilts.)

RED phosphorus is undoubtedly the safest and the most convenient means of producing a smoke screen. It has the advantage of being non-poisonous, convenient to carry, and there is no danger of accidentally igniting the substance by friction.

The red phosphorus should be scattered on the ground in a thin line (about an inch wide), the direction of the line depending, of course, upon the direction of the wind and the course which the smoke screen is required to proceed in. Ignition of the phosphorus is best carried out by means of a lighted taper tied to the end of a long stick, although ordinary touch-paper can be used for this purpose. Red phosphorus, when burning, emits clouds of dense white "smoke." The material costs about 6*s.* per lb.

Yellow phosphorus is considerably cheaper and it burns with the same effect. Unfortunately, yellow phosphorus is extremely poisonous and, owing to its liability to be ignited by slight friction, it is unsafe to carry about.

Any firms of manufacturing chemists, such as the British Drughouses, Ltd., London, N.1, will supply you with either of the above varieties of phosphorus.

MERCURY FULMINATE

"COULD you please inform me on the following:

"1. What is mercury fulminate?

"2. What is its composition, how is it made, and for what is it used?

"3. Is it possible to make a small oxy-acetylene welder from a cycle lamp by generating oxygen from hydrogen peroxide in the generator of the lamp together with calcium carbide?" (W. C., co. Sligo.)

MERCURY FULMINATE is the mercury salt of an organic acid known as fulminic acid. It possesses the chemical formula $Hg(O.CH)_2$, which indicates its composition. It can be made in several ways, the most common being to heat mercury in a flask with moderately concentrated nitric acid and to add pure alcohol bit by bit. A violent action sets in, and after the contents of the flask have cooled, mercury fulminate crystallises out. Mercury fulminate is ONE OF THE MOST DANGEROUS AND EXPLOSIVE CHEMICALS KNOWN and *on no account whatever* should its preparation be attempted since, unless special precautions are taken, it is liable to explode with extreme violence. Mercury fulminate is used in the making of cartridge percussion caps, dynamite fuses, and for other detonating purposes.

It is quite impracticable to generate acetylene and oxygen in the same generator at the same time. Even if it were possible, the two gases would form an explosive mixture when ignited. We have heard of experimenters rigging up a crude oxy-acetylene apparatus by generating acetylene from calcium carbide and water in a cycle lamp generator and by deriving their oxygen supply from a gasbag previously filled with oxygen prepared by heating a mixture of potassium chlorate and manganese dioxide. Such a method is unsatisfactory, however, and it is only really practicable to employ oxy-acetylene welding methods when the gases are derived from storage cylinders.

A HARD AND GLOSSY SUBSTANCE

"I AM trying to produce a hard and glossy substance with which I could make ornaments for indoor or outdoor use. I am using glue, resin, and shellac in colours, but I fail to get it to set off as hard and glossy as I desire.

"Could you tell me if there is a known chemical reagent that would set off exceptionally hard and glossy, either glue, resin, or shellac, after being dissolved in methylated spirits?" (F. P., Staffs.)

TO make a hard and glossy compound such as you require, take 4 oz. of ordinary shellac and 1½ oz. of powdered resin. Dissolve these ingredients in about 4 oz. warm turpentine. Filter the solution through cotton-wool and then add about ½ or ¾ oz. of the finely powdered colour which you intend to incorporate into the compound, the exact proportion of the colour, of course, being determined by the exact shade required. If this product sets to a paste, heat it until the unwanted turpentine is driven off. The compound can be softened, for moulding purposes, either by heat or by turpentine, and it will acquire a glossy surface.

We feel bound to point out the fact, however, that compositions such as the above cannot possibly compete, so far as strength and durability are concerned, with the modern bakelite and other synthetic resin compounds. Unfortunately, however, the preparation of bakelite and similar articles necessitates the use of a powerful hydraulic press, which requirement puts the use of such compounds beyond the reach of the average home worker.

If you add a little powdered magnesia or powdered chalk to the bottle in which the methylated spirit solution of resin or shellac is contained and shake it up frequently at intervals for two or three days, afterwards filtering the product through muslin, a better gloss will be obtained, the chalk or magnesia retaining the impurities in the resin or shellac which inhibit the formation of a high gloss.

REPLIES in BRIEF

C. D. (Uttoxeter).—You could not have obtained all of the issues of PRACTICAL MECHANICS which described the construction of the "Flying Flea." We suggest that you obtain a book published by Messrs. Sampson Low, Ltd., 100 Southwark Street, S.E.1, which costs 7*s.* 6*d.* The issues which dealt with the "Flying Flea" were October, November, December, January. You did not enclose a stamped addressed envelope.

P. S. (Cornwall).—Use American Whitewood, Silver Spruce, and Birch.

O. B. (Nottingham).—There are no engines for 3-ft. span monoplanes. The span and length of a model are decided by the total weight. The minimum span for a petrol-driven model would be about 6 ft. You are apparently endeavouring to design the thing the wrong way round. We recomment you to study *Power Driven Model Aircraft* and *Model Aeroplanes and Airships*, copies of which can be sent to you for 1*s.* 2*d.* each by post.

B. C. J. (Cornwall).—A suitable rust remover may be made as follows: 100 parts of stannic chloride are dissolved in 1,000 parts of water; this solution is added to one containing 2 parts tartaric acid dissolved in 1,000 parts of water, and finally 20 cubic centimetres indigo solution to act upon the stain for a few seconds; it is rubbed clean, first with a moist cloth; to restore the polish use is made of silver sand and jewellers' rouge. (Henley's Book of Recipes.)

A SIMPLE MILLING TOOL

(*Continued from page* 395)

ensure the taper bearing bedding. Another way of ensuring this is to use a taper-reamer of a more acute angle of taper, and just ream off the corner at the end of the taper in the hole. Either method will be effective, but only the slightest amount should be taken off.

Details of the Spindle

Then turn the parallel part at the end of the spindle to take a ½-in. hole milling cutter, and cut a screw thread to take a standard fine thread hexagon nut—12 threads per inch. Also fit a $\frac{3}{32}$-in. driving pin.

The other end of the spindle is cut with a fine thread to take a collar and lock-nut or two lock-nuts *J* and *K*, Fig. 1. The extreme end is turned parallel to ½ in. diameter and a radius slot is cut with a round file to take the $\frac{5}{16}$-in. bolt shown in Fig. 4. The lever is made of $\frac{3}{16}$ in. × ¾ in. flat steel bar. At one end it is turned over on itself to make a thickness of ⅜ in. into which the turned handle *M* is riveted as shown by dotted lines. The other end is curved round a $\frac{5}{16}$-in. bar so as to make a bearing for the pinch-bolt and nut shown in Fig. 4. A hole, ½-in. in diameter, is drilled through both parts of the bent over portion so as to take the top end of the milling spindle and a slot is cut at the end as shown, so that the pinch-bolt tightens everything, and also keys the handle to the spindle by reason of the pinch-bolt passing through the curved slot in the spindle. Washers should be placed under the head and the nut of the pinch-bolt.

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