THE DEPTH CHARGE—*How it Operates*

NEWNES

PRACTICAL MECHANICS

7D.

MAY 1940

SUBSCRIPTION RATES

Inland and Abroad 8s. 6d. per annum.
Canada - - 8s. per annum.

Editorial and Advertisement Office: "Practical Mechanics," George Newnes Ltd.
Tower House, Southampton Street, Strand, W.C.2.
'Phone: Temple Bar 4363.
Telegrams: Newnes, Rand, London.
Registered at the G.P.O. for transmission by Canadian Magazine Post.

PRACTICAL MECHANICS

Editor: F. J. CAMM

VOL. VII. MAY, 1940. No. 80

FAIR COMMENT

By the Editor

Machines, Mahomet and the Mountains

IT is an aphorism that if the mountains will not go to Mahomet, Mahomet must go to the mountains. I was therefore mildly amused the other day when I read the report of a speech by the Minister of Supply in the course of which he said that this country and France were endeavouring to institute a system of exchange of machine tools so that we could loan to France machines for which we had no use, and she would act reciprocally. In other words, machines were to be given return tourists' tickets. It is worthy of note in passing that the Minister of Supply some few weeks earlier had stated that he hoped to find work for every machine tool in this country. I now wonder why it is that there should be any idle machines here, especially as during the later course of his speech he adjured all firms to see that their machine tools were working for 24 hours a day. I do not raise political issues here for it is no part of my policy to criticise Government departments. It may well be that there are other reasons why we should uproot emplaced machinery, transport it abroad for a few months, and then have it returned here. It seems to me, in the absence of an explanation from the Minister to the contrary, that this entails a considerable waste of time, money, and man power. Some machines take months to set and to align, and I therefore make the suggestion that the practicable scheme is that if France lacks a particular machine which we possess, and have idle, France should send the material for us to be machined. In other words, it is the sensible plan to take the work to the machine and not the machine to the work. We do not think that engineering firms will be willing to transplant their machines abroad, because they happen to be idle at the moment. No firm can say that a machine idle to-day may not be put to work to-morrow. A machine which has settled down and has been in operation for years cannot be packed up and transported like a sack of potatoes.

After the War

THE position encourages the thought that after the war the machine tool trades of this country will develop. At present we purchase a high percentage of our machine tools from America. Engineering trades when peace returns will be kept busy making good the lack of production during the war, and there will thus be a steady demand for a number of years for machine tools, as well as excellent opportunities for those who wish to train as engineers. Even as it is necessary for the work to be taken to the machines, so it is for the men to be trained to work them. There should not be any unemployment in engineering for a considerable number of years. And just a reminder that in this connection our new companion weekly *Practical Engineering* (4d. every Thursday), is performing useful work in helping to train engineers. It is described by leading engineers as a most useful contribution to the nation's war effort. If you are engaged in the engineering trade, you should place an order for its regular delivery. Each week there are valuable articles on such modern subjects as plastics, dies and press tools, jigs and fixtures, gear cutting, lathe work, foundry practice, milling, planing, shaping, the drawing office, as well as valuable news features.

Indoor Model Railways—Special Offer

ELSEWHERE in this issue appears a bargain offer of "Indoor Model Railways," by E. W. Twining. This is a standard work on the whole subject of table and indoor railways, and it deals with the history of H0 and 00 Gauge railways, gauges, scales and dimensions, electric traction motors, rotation and reversing, prototype locomotives and modelling them, motor mechanisms and their adaptations to prototype engines, the twin railway, its locomotives and electrical working, electric motor-coaches, carriages, wagons and auto-couplers, track, layout and engineering works, third rail and two-rail systems, control and signalling, and architectural features. Originally published at 5s., a special edition has been produced at the very low price of 2s. 6d. If you are interested in model railways you should obtain a copy of this well-illustrated and nicely-produced handsomely-bound treatise on the subject.

New Books

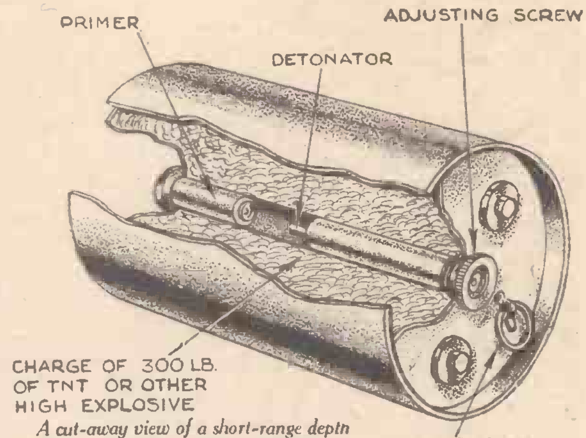
THE second edition of "The Flying Reference Book," which is a factual guide to the history and development of all types of aircraft, has just been published from these offices at 5s. It includes details of most types of modern aircraft, contains valuable tables of records, details of societies, clubs, schools, air routes, and a vast amount of detailed information. Other new books published from this office include "The Dictionary of Metals and their Alloys" (5s.), "Motor Car Principles and Practice" (3s. 6d.), "Model Boat Building" (3s. 6d.), "Short-Wave Manual" (5s.), and "The Engineers' Manual," which latter is offered on presentation terms in connection with our new weekly *Practical Engineering*. Postage is extra in each case.

For those interested in wireless there are also "The Practical Wireless Encyclopædia," "Everyman's Wireless Book," "Practical Wireless Service Manual," "Wireless Transmission for Amateurs," and, of course, *Practical Wireless* every Wednesday.

THE DEPTH CHARGE

How the Dreaded Enemy of the Submarine Works

By Commander Edgar P. Young, R.N. (Ret.)



A cut-away view of a short-range depth charge, showing internal arrangements

THE now familiar depth charge was one of the new weapons introduced into the naval service during the last war, and is, like the mine, handled by the Torpedo Department. It is, in effect, a submarine bomb, and is used for attacking submarines when they are submerged and are invulnerable to most other weapons.

It is of very simple construction, consisting merely of a cylindrical light metal container, filled with a high-explosive charge of T.N.T. This cylinder is dropped or projected into the sea, sinks under the influence of gravity, and is detonated automatically at a predetermined depth below the surface. The depth at which detonation occurs is controlled by a hydrostatic valve, which is adjusted beforehand at a pressure corresponding to that of the water at that depth, the actual adjustment used being varied according to the circumstances and the locality.

Large Amount of Explosive

The amount of explosive used is relatively large, because, since it is exceedingly improbable that the depth charge will be in contact with its target at the moment of detonation, it is desirable that its destructive radius shall be as wide as practicable. Owing, however, to the fact that water is incompressible, its destructive radius is very much wider than might be imagined, and than it would be in the air.

Being of simple and sturdy construction, depth charges require little or no attention, and can be kept ready for use and in position regardless of exposure to the elements. Their exposure to enemy gunfire when in this position represents no danger, since even a direct hit would fail to detonate them. They are firmly secured by wire strops either to a chute, from which they can be dropped over a stern, or to a carrier, loaded into the muzzle of a thrower, from which (together with the carrier) they can be projected. In either case the discharge can be, and usually is, effected from the bridge, where it is under the direct control of the commanding officer who is manœuvring the ship.

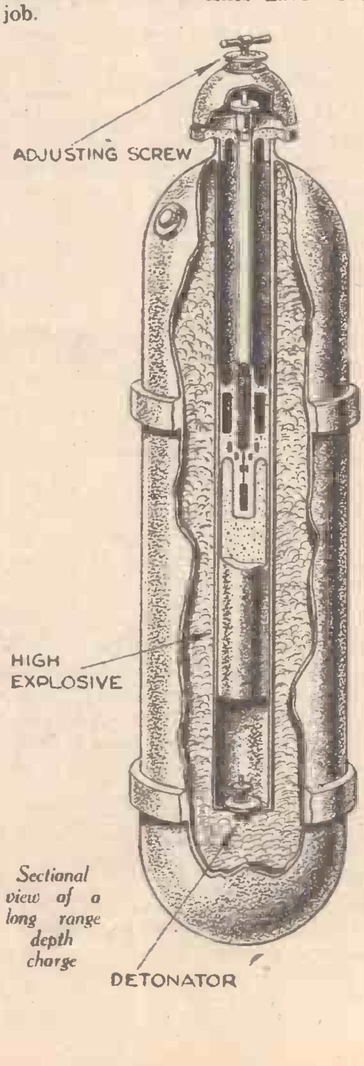
Sinking Rate of Depth Charge

When it is realised that a depth charge sinks at a rate of about ten feet per second, that it is usually set to go off at a considerable depth below the surface, and that its destructive radius is considerably greater than that depth, it becomes obvious that it is a weapon which can be used only by a vessel moving at a high speed. The depth charge is used as a weapon primarily by destroyers and fast patrol vessels, such as are employed specifically on anti-submarine work, which carry a large number of them in their chutes and which are provided with depth-charge throwers.

Method of Attack

The method of attack with depth charges depends, of course, on the circumstances in which the attack is delivered. Thus, for instance, it may be that the presence of a submarine which has not been seen may be detected by destroyers or other patrol vessels fitted with Asdic apparatus. By means of this apparatus the position of the lurking enemy can be located, and once this has been done, since the submarine, with its periscopes submerged, is blind and therefore probably motionless, the remainder is comparatively easy—more especially as the victim is possibly unaware even that the searchers know where she is.

One of the hunting warships steams at high speed over the spot where she lies submerged. As she passes over that spot the attacking vessel releases one or more depth charges, running on in order not to have her own stern blown off by their detonation. In her wake there rises a great mound of water, which is hopefully examined through glasses to see if it contains portions of the submarine as indication of her destruction. If it does not, the attacking vessel steams back again more or less over the same spot, releasing a few more depth charges, and this procedure is repeated until the tell-tale patch of oil reveals that her missiles have done their job.



Sectional view of a long range depth charge

Quick Thinking Necessary

It may happen, however, that the presence of the enemy submarine is detected only when she has discharged her torpedo, and in such a case events move more rapidly and with less certainty of success. The attacking vessel must attempt to guess what evading action has been taken by the submarine. All that is known is that she was once at the spot from which the revealing track of the torpedo originated. She may merely have flooded her tanks still more and submerged herself deeper without moving away; she may have turned in any direction and proceeded at any speed at her disposal under water (which is, of course, not great).

Allowance of Error

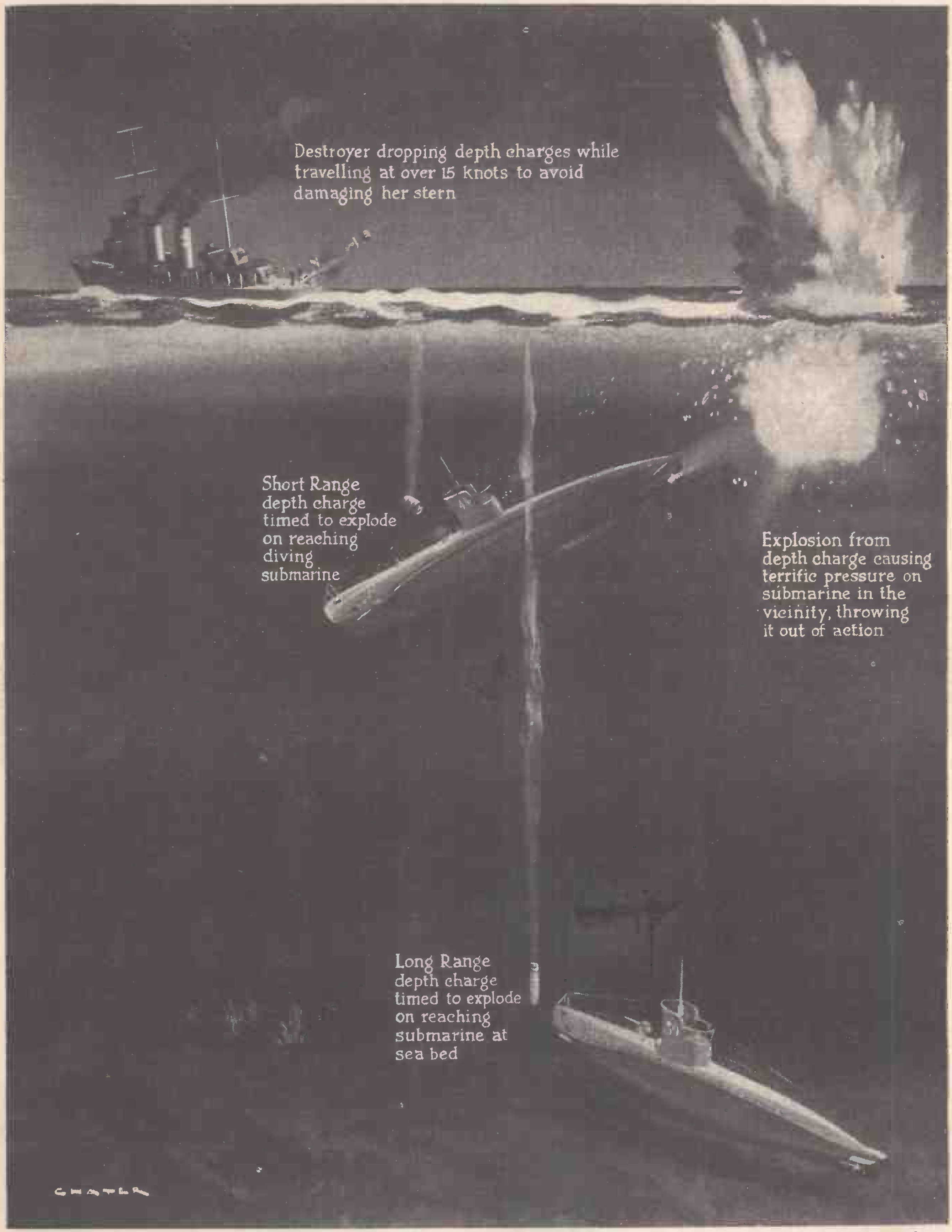
The commanding officer of the attacking vessel can only try to put himself in the place of his adversary and, taking into consideration navigational circumstances, such as the depth of water and perhaps the presence of mines, as well as the tactical disposition, to guess what he has done. Time is of vital importance, for every second's delay increases the effect of any, even slight, miscalculation, of the attacker. Steaming at high speed to the spot where it is reckoned that the submarine will then be, the attacking vessel attempts to make allowance for any error in her reckoning by discharging depth charges.

If the first attack is a failure, it may be repeated again and again, but always with decreasing chances of success, unless, as may happen in clear and shallow water, the attacker is aided by an aeroplane which can see the submarine.

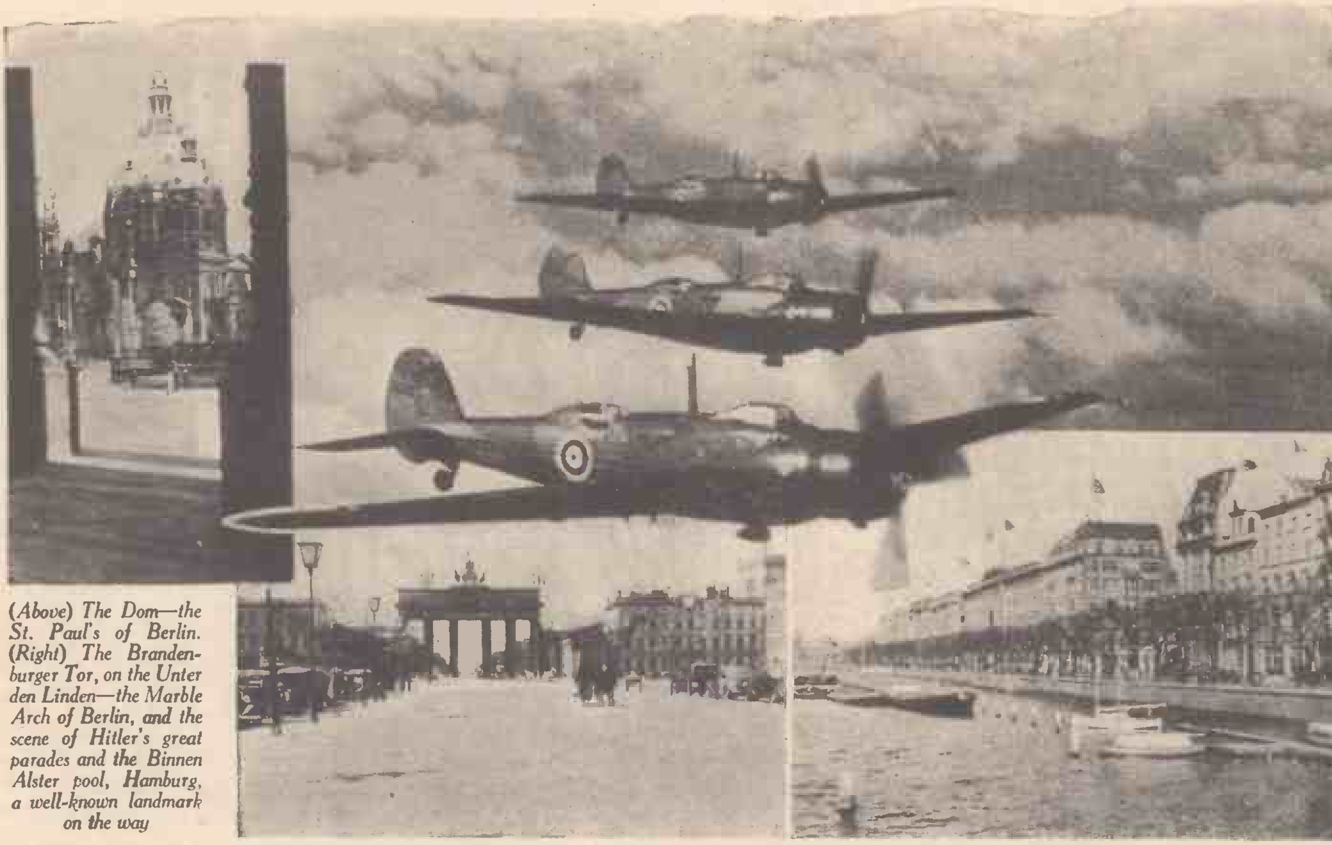
Submarine Has Little Protection

As far as the submarine is concerned, her only protection against the depth charge is to avoid it. If it detonates anywhere near her, it may, even if it does not destroy her, so damage her comparatively thin outer hull (between which and her stout pressure hull are situated the ballast tanks), that she will be unable ever again to rise to the surface. If she is large, and if there is enough water beneath her keel, her best defence is to dive very deep, but if she is small, or in any case if she is in shallow water, she can only manœuvre blindy beneath the surface, hoping to throw her pursuer off her track. The nerve strain imposed on her personnel is very considerable, especially if the depth charges detonate close enough to her to put out the lighting.

A DESTROYER ATTACKS SUBMARINES WITH DEPTH CHARGES



Whether at short range or long range, the depth-charge can reach the submarine by adjustment of the timing. The destroyer must, however, continue at a good speed when discharging her dangerous projectiles in order to avoid damaging her own stern when the inevitable explosion occurs. It will be noticed that there is a difference in the shape of the two charges, this difference is shown in the two illustrations on the previous page



(Above) The Dom—the St. Paul's of Berlin. (Right) The Brandenburger Tor, on the Unter den Linden—the Marble Arch of Berlin, and the scene of Hitler's great parades and the Binnen Alster pool, Hamburg, a well-known landmark on the way

When the R.A.F. Fly to Berlin

Well Known German Landmarks Which Would Guide Our Airmen

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

THIS strange war has been full of surprises, but the most astonishing feature of all is the fact that up to the time of writing—that is after more than seven months of war—no bomb has fallen upon any of our great cities.

This is the more remarkable because in the last war (when air-power was in its infancy), there were more than a hundred raids by the Germans over England, with great loss of life and enormous damage to property. Most of these raids were directed at London, but in spite of this our " Brass Hats " obstinately refused to retaliate in kind upon the enemy's capital, and Berlin was never visited by hostile aircraft.

Berlin's West End

It is most encouraging to see that our High Command has evidently learned something since the last war, for already our gallant airmen have visited all the chief cities of Germany, dropped their leaflets and flares, and returned unharmed. Very splendid was the cool disdain with which they flew low over the Unter den Linden, and the fashionable West End districts of Berlin. No human life was lost as a result of this action, but the moral effect must have been enormous. Every German who finds a leaflet in his back garden, is bound to reflect that it might just as well have been a bomb, and the people in crowded streets who saw the coloured flares fall from our planes would feel the same way.

But if these visits have spread terror in any great city of Germany, they have brought a message of hope to the enslaved populations of Prague, Vienna, and many Polish towns; and have been a main factor in preventing German air attacks on Britain. The logic of this is inescapable. In the last war London was attacked again and again, but no aircraft reached Berlin. We have visited Berlin already half a dozen times, but no German plane has flown over London.

Let us now consider the job which our bill-distributors undertake when they fly to Berlin. In order to avoid giving information to the enemy I shall mention no air-stations by name, and shall only reveal geographical data which he already knows.

Navigational Methods

Our nearest air-stations to Berlin are, of course, in East Anglia, where the Counties of Norfolk and Suffolk bulge out into the North Sea. The distance from the nearest of these bases to Berlin is 480 miles direct flying, but the actual course is somewhat longer because our pilots are not allowed to infringe Dutch neutrality, and must swerve to the north east to enter Hunland beyond the mouth of the River Ems.

How do they find their way? There are two methods, each of which has been used by navigators from time immemorial. The first seamen picked their way from headland to headland, and when they became bolder steered their course over the open sea by means of the stars.

Modern navigation is such an exact science, that a captain can steer his ship across thousands of miles of trackless ocean, and unfailingly pick up a tiny island many times less in area than the great city of Berlin. Our airmen, too, could no doubt reach that city using only navigational methods, but the task is much more difficult than that of sailing a ship, for these reasons.

The much greater speed of the plane makes all calculations more difficult, especially errors due to wind, and such valuable

The 1914-1918 War Memorial at Hamburg

aids as directional wireless are unavailable in war-time. Have you noticed how quickly Lord Haw-Haw fades out when our planes are speeding his way?

The airmen must therefore look out for land-marks to check their course. The first and one of the most conspicuous is the Island of Heligoland, rising steeply from the sea, 31 miles from the mainland. In times of peace its lighthouse sends out a powerful beam, but even when this is extinguished the island can be readily made out by moonlight. The lofty rose-red cliffs, with a great rock-pillar at one end are unmistakable.

Night Flying Guides

The best guide to a night-flying airman is a great river, and during the last war enemy planes were able to reach London on almost dark nights, in the winter months, by following the dark line of the Thames estuary which stood out boldly against the snow-covered countryside.

Nature has provided a similar means of reaching Berlin. After flying over Heligoland, our pilots continue on a south-easternly course till they reach the mouth of the great river Elbe, with the naval base of Cuxhaven guarding the entrance. The harbour is readily recognisable, and is usually crowded with warships.

The route then follows the broad stream of the River Elbe for 73 miles to the great port of Hamburg, second city of Germany. It is doubtful if any black-out can completely hide a city so large as this, with its wide river, its miles of wharves and docks, and the twin lakes of Aussen and Binnen-Alster, surrounded by closely packed streets.

From Hamburg to Berlin is 178 miles, a mere half-hour's flying to a modern plane. The route follows the River Elbe to the point where it is joined by the rival Haval, and the main river turns sharply to the right, leaving our course to Berlin straight on. The river Haval with its chain of lakes can lead the airman as far as Potsdam, which is only 16 miles from the centre of Berlin. Potsdam with its gaudy palaces, is the capital of Prussian militarism, and many think that if we had bombed it in the last war, the arrogant militarism of the war-lords would have cracked up months before it actually did.

The Unter Den Linden

The river is no guide to the pilot in Berlin itself. The Spree is a narrow stream, much built in by houses, and not conspicuous from above. The great central artery of the city is the famous Unter den Linden, a magnificent highway with double carriage-tracks, lime avenues, and wide pedestrian promenades, altogether nearly 200 feet wide, and 11 miles long, though only one mile at the eastern end is actually named the Unter den Linden.

This great arterial road runs from the former Royal Palace—and the Dom—the Buckingham Palace and St. Paul's respectively of Berlin—to Staaken, a distance of over 11 miles. It is said to be the longest, widest, and straightest street in Europe, and just before the war was being actively re-constructed.

R.A.F. "tourists" should look out for the chief landmarks. The upper end of the Unter den Linden answers to our West End and Whitehall. The great gateway of the Brandenburger Tor is the Marble Arch of Berlin, and close by are the chief government offices, and the most expensive hotels. Men wishing to deliver leaflets to Herr Hitler himself, should look out for his official residence in the Wilhelmstrasse, a short distance off the Unter den Linden. The two fine domed buildings close by are the Dom and the Schloss. The streets hereabouts are known as the old West End, but the new and more fashionable pleasure area is centred about the Kurfursterdamstrasse—the Piccadilly of Berlin.

A road through the Tiergarten, Berlin

The Kurfursterdamstrasse, the Piccadilly of Berlin

The Tiergarten

A very prominent landmark in central Berlin is the great park called the Tiergarten, 2½ miles long, and ¾ mile wide.

Surrounding the city proper are vast residential and industrial areas on every side, where nearly five millions of people live and work. The area of Greater Berlin is 339 square miles, that is more than twice as great as the Isle of Wight.

These facts may well make the enemy pause before launching air attacks on London.

German warships at Cuxhaven

Taking an odd few moments away from the study of new designs in warplanes, tanks and the rest of civilisation's headaches, we show you the invention of Canadian sportsman Edward Rickett, of Toronto—an engine-driven sled, which from a standing start picks up a speed of 60 miles an hour or more in 200 yards. This beetle-shaped power sled can give some thrilling moments to the devotees of ice-boating—a popular winter sport in Canada

THE MONTH IN SCIENCE AND

Highest and Lowest Post Offices

THE only limits to the postal services seems to be the sky and the bed of the ocean. What is claimed to be the highest post office in the world is owned by the Indian Posts and Telegraphs Department. It is at Pharijong, in Tibet, which is situated at an altitude of 15,300 ft. Two other Indian post offices situated at high altitudes are at Gyantse, 13,130 ft., and at Yatung, 10,000 ft.

At the other extreme there is the world's only undersea post office, which is to be opened in May. Details of this have appeared in a previous issue. It is on the floor of the Bahamas Ocean.

Flamingo Air Liner

IN spite of war-time demands, the de Havilland Flamingo air liner is in full production in its commercial form. Improved performance figures are announced. The improvement is due to the fitting of Perseus sleeve-valve engines driving the feathering type of de Havilland controllable-pitch airscrews.

The Flamingo is a high-wing, twin-engined monoplane of 70 ft. wing span. In the new 1940 production model its weight has been brought up to 17,600 lb. This includes an increase in pay load of 500 lb. for a given range. The maximum speed is 239 miles an hour, and the cruising speed 200 miles an hour at 10,000 ft. at 56 per cent. of the maximum take-off power of the engines.

Expressed in air miles per gallon of fuel, the consumption is 3 miles a gallon, and the still air range with full tanks at 50 per cent. power is 1,345 miles. At sea level in a five-mile-an-hour wind the take-off run is 312 yards, and the rate of climb at sea level on take-off power is 1,470 ft. a minute. The absolute ceiling is 22,200 ft. On either port or starboard engine a height of well over 10,000 ft. can be reached. The performance of the starboard engine is slightly better than the other.

Rocket Bomb Fallacy

MATHEMATICAL calculations have shown that there is nothing in the stories of a German rocket bomb that could be fired from Germany and drop on London. The rocket theory is still in an early experimental stage. The problem of controlling the wind and other climatic conditions on such a long distance has not yet been solved.

Superiority of R.A.F. Fighters

COMPARISON between the British Spitfire, the German Messerschmitt 109, and the French Curtiss-Hawk 75A, an American machine, show interesting details. They are all single-engine machines.

The horse-power of the Spitfire is 1,050, the Messerschmitt 109, 1,150, and the Curtiss 900. The maximum speed is 367, 354, and 303 m.p.h. respectively. The armament of the Spitfire consists of 8 machine-guns, the Messerschmitt has 4 guns or 2 shell guns, and 2 machine-guns. The Curtiss has 6 machine-guns. The comparison illustrates the superior performance of the British type with less power than the German. This is due to design refinement.

The Germans also are using the Messerschmitt 110, a twin-engine fighter, which is regarded as one of their most formidable weapons. It has about the same speed as the Spitfire and is armed with 2 shell guns and 4 machine-guns. It lacks the manœuvrability of the Spitfire, however.

North Sea Balloon Barrage

MR. H. O. SHORT, head of the great flying-boat firm, has devised a scheme for a 500-mile line of barrage balloons to guard the East Coast from air raiders. The balloons would be moored to ships specially protected against magnetic mines and equipped with anti-aircraft guns. The ships to which the balloons would be moored would lie far out at sea and heavily armed high-speed motor launches would patrol the line for lurking U-boats.

Mr. Short stated that in order to avoid the balloons enemy bombers would have to fly at over 20,000 ft.

Giant Power Press

MANY huge power presses are used in the production of aircraft components. One of these, stated to be the largest in the world, is a "Clearing" press weighing over 250 tons and capable of a 2,000-ton pressure.

THE WORLD OF INVENITON

It measures 25 ft. between the uprights, and when installed called for an excavation 34 ft. long and 15 ft. wide and 20 ft. deep. It required 300 tons of concrete for the bed.

440 m.p.h. Fighters

THE Bell Airacobra is claimed by America to be the world's finest pursuit plane. It is said to be capable of a speed of 440 miles an hour and costs £20,000. A novel point about these planes is that the engine is behind the pilot. The engine is a 1,100 h.p. V-12 liquid-cooled Allison.

Well Boring

YORKSHIRE manufacturing concerns have sunk artesian wells to ensure a good alternative water supply in case water mains are destroyed during air raids. In Canal Road, Bradford, an artesian well has recently been sunk to a depth of about 700 ft., and this will supply 7,000 gallons an hour. In boring this well, rare fossils of great interest to geologists were found.

New R.A.F. Plane

A NEW type of R.A.F. fighter has been built on to which new parts can be clipped. A damaged tail, for instance, can be detached and a new unit clipped on with metal clips in a few hours. All its details are secret.

New U.S. Bomber

THE U.S. War Department have announced that a new four-engined plane, capable of 300 m.p.h., with a flying range of 3,000 miles and a bomb-carrying load of 4 tons, has completed its first flight. The plane has a wing span of 110 ft. and is 64 ft. long. It is of all-metal construction and weighs about 20 tons. There are four 18-cylinder air-cooled engines of 1,200 h.p. each.

World's Smallest Plane Motor

WHAT is claimed to be the world's smallest aeroplane motor recently completed its first test flight successfully. It weighs only 130 lb., and is without gears and valves. The inventor, Lee Oldfield, former racing motorist, says that the motor generates 50 h.p. and has less than 200 parts.

Internal Combustion Turbine

TESTS have recently been made of a 4,000 K.V.A. turbine of the I.C. type running on fuel oil of 18257 net B.Th.U calorific value per pound. The construction and operation are extremely simple. An axial type rotary compressor delivers air along a streamlined duct at a pressure of from 40 to 60 lb. per square inch. The air stream is divided into two streams by an annular baffle inside the duct. The core of the air stream picks up a spray of oil, which forms the combustible mixture and is accordingly ignited and rushes forward towards the turbine inlet. It mixes with the cold air from the outside of the annulus on its journey, and by this means reducing the temperature of the gas stream from about 2,500 degrees F. to around 1,000 degrees F. At this moderate figure modern heat-resisting alloys used in blading are practically immune from failure or distress.

Aircraft Safety Device

A CURE for "whip-stall" is claimed by American aircraft designers. A whip-stall gives no warning and is usually the failing of heavy monoplanes when attempts are made to fly them very slowly. The Vultee aircraft engineers have fashioned a simple device which they claim causes the whip-stall to become an ordinary stall.

They made a metal cylinder a foot long and half the thickness of an ordinary lead pencil. They sliced it in half, lengthwise. The two halves were fixed on the forward edges of the wings of a monoplane. They prevent the whip-stall starting behind them on the surface of the wings. The device cost 1½d.

"Flying Motor-Cycle"

A SECRETLY developed "flying motor-cycle" has been tested at San Diego, California. It is stated that the machine can take off with great speed from a cramped space and then hover almost motionless in the air. It could rise almost straight up into the air and come down in a landing field of only 50 ft. It has a 420 h.p. engine, and its 50-ft. flaps are so broad that they represented virtually a "retractable wing."

Releasing Bombs From Aircraft

PRESSURE on a press-button control, similar to an ordinary bell-push, instantly releases the bomb load from an aeroplane. A machine carries anything up to 18 cwt. of bombs evenly distributed under the wing on either side of the fuselage. The pilot has to watch a control panel something like a large switch control panel when releasing his bombs. The switches are numbered and are brought into operation to make the bombs ready for release.

Aviation Progress

PILOTS who served in the 1914-18 war realise more clearly than most what remarkable advances have been made in aircraft design. The startling increase in speed, for instance. The S.E.5s, the Camels and the Snipes, doing their 90 to 120 miles an hour, seem slow when pitted against modern fighters, the Vickers Supermarine Spitfires, capable of 367 m.p.h. and the Hawker Hurricanes, whose maximum speed is 360 m.p.h. The medium bombers of those days, the D.H.4's and 9's travelled at only 80 miles an hour. Their modern counterparts, the Bristol Blenheim and the Fairey Battle, have maximum speeds of 295 and 256 respectively.

The power of the engines has been multiplied many times. The D.H.4, for instance, had a 375 h.p. Rolls-Eagle engine. Its modern equivalent, the Battle, has 1,030 h.p. Rolls-Merlin engine.

Making Bayonets

MANY of the operations in the making of bayonets are interesting to watch. The raw material for the blades arrives in the form of flat steel bars, which have to be cut to length. After this the work is nearly all done on automatic milling machines. Many of these are of very ingenious design, some having as many as six tools doing different operations on the sides of the blades. A profile machine shapes the tang, and a grinding tool works out the fullers or recesses on the sides of the blades.

At the controls of the "link-trainer." The pilot carries out all the movements communicated to him by the instructor at the microphone in the background

The torpedo is the submarine's chief weapon. In this illustration is a torpedo being hauled aboard a British warship after it had been fired during practice at sea. A hit from one of these means disaster to a Nazi U-boat

The Principles of the

How electricity is generated and stored in a submarine and the mechanism of a torpedo are herein described

THE very compactness of its design requires from its structure great strength to withstand the continued impacts of the explosions in the combustion chamber, and such strength must be provided by increased thickness and weight of metal. In the last decade, metallurgical research has produced in increasing numbers alloys of aluminium which combine strength with lightness in weight, and many of them are now in use in engines where heavier metals were previously essential, the use of aluminium alloy pistons in submarine diesel engines being one instance of this successful replacement.

A Minor Defect

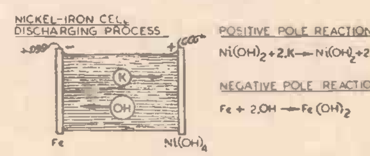
A minor defect possessed by the diesel engine in common with all other types of engine which consume a material fuel is that its operation in a submarine removes fuel oil from the storage tanks at a continuous rate, and tends to upset the buoyancy of the boat, unless steps are taken to readjust the balance at the same rate. Compensation for the consumption of oil is mainly secured by supplying the fuel to the engine under the hydraulic pressure of sea water which is pumped into the fuel tanks. (See Fig. 9.) The sea is admitted into the base of the fuel-filled tank at a pressure which forces the oil through a supply valve in the tank head and delivers it to the engine. The fact that the oil and water are immiscible and that the water has the greater density leaves the fuel in an uncontaminated condition between the supply valve and the piston of sea water in a state of readiness for immediate delivery to the engine. When the tank has been emptied of fuel and filled with water, the oil supply valve is closed and the sea water is blown overboard through the sea valve by the force of compressed air admitted through a valve in the tank head. Compensation by this method is not complete, since the water-filled tank weighs slightly more than the same tank filled with oil, but the discharge of small amounts of water from the trimming tanks during the process of flooding the fuel tank is sufficient to correct the buoyancy of the boat.

When a submarine rises to the surface to breathe, it operates its diesel engines as soon as access is gained to the air of the atmosphere. The engine consumes great quantities of air in combustion with the fuel oil, compresses more for storage in the cylinders used for blowing sea water from the ballast and fuel tanks, and in addition to driving the propeller shaft to promote the boat's propulsion, drives the electric generator to manufacture charge for storage in the batteries.

Under water the submarine is propelled by the power of its electric motors, which are driven by the current supplied by the accumulators. The action of the electric motor depends upon the well-known principle in physics, which states that a conductor carrying an electric current becomes subjected to a mechanical force when placed in a magnetic field. This mechanical force is made continuous and rotary by arranging the conductor in the form of a rectangular coil capable of turning about a fixed axis, and enveloping the coil in a fixed magnetic field directed radially across the axis from pole pieces clustered in a circle whose centre lies in the axis. The passage of current through the coil at once engenders the force which rotates the coil and its shaft, and a continuous supply of mechanical power is provided as long as the current flows. The same apparatus may be converted into a generator of electricity if the coil is mechanically rotated by the power of an external heat engine. In this role its action depends upon the physical principle discovered by Michael Faraday, which states that the movement of a conductor through a magnetic field creates an electro-motive force in the conductor, which supplies a current to the closed circuit of which the conductor forms a part. The submarine is thus an autonomous boat in the sense that the engines responsible for its surface navigation are made to manufacture the electric charge necessary to propel the boat in its submerged condition.

Electricity Stored

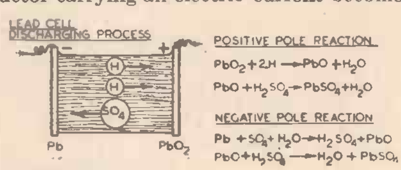
The electricity generated in this way is stored in batteries which are giant editions of the familiar lead accumulator. The relative sizes may be gauged from the fact that each cell in the submarine battery weighs just a little less than half a ton and has a capacity of over 2,000 ampere-hours, as compared with the weight of 10 lb. and capacity of 40 ampere-hours of the portable household and laboratory accumulator. A submarine battery may contain as many as 400 such cells, weighing approximately 160 tons, which is a formidable weight of fixed cargo to be carried by a craft whose dimensions are relatively small, and in fact this excessive weight is considered as a serious defect in the system of under-water propulsion by electric motors driven by charge accumulated in storage batteries.

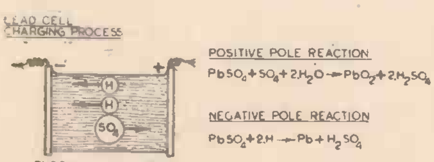


Storage Cells

The electric cell is a device which produces an electric current at the expense of a reaction amongst its chemical contents, and alternatively produces a chemical reaction at the expense of an electric current. In the process of charging with electricity a current is passed through the cell from an external generator to promote a redistribution of its chemical elements. If the cell is then removed from the generator and conducting commuuication is established between its poles, the chemical constituents return to their original arrangement, and in so doing cause the cell to deliver a current.

Two types of storage cells are in use in





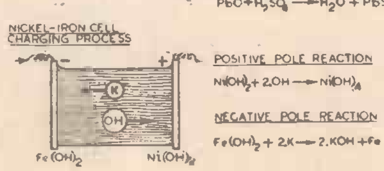


Fig. 10. Diagrams representing the chemical reactions in the charging and discharging processes of the lead and nickel-iron cells

Submarine—Part 4

By R. L. Maughan, M.Sc., A.Inst.P.

submarines and each possesses distinctive merits of its own. They are the lead cell, which was the first type to be tried, and the nickel-iron cell, which has been adopted in later years. In the uncharged state the lead accumulator consists essentially of a pair of lead grills bearing a paste of lead sulphate in the grid spaces immersed in a vessel containing a dilute solution of sulphuric acid. In the process of charging, the current from the external source directs hydrogen ions from the acid solution to the negative plate to reduce the lead sulphate to pure lead, and simultaneously moves sulphate ions from the acid to the positive plate where the lead sulphate paste is converted into lead peroxide. At the end of this process the charged cell contains a positive plate of lead peroxide and a negative plate of lead and is ready to produce current in the effort to convert the compounds of both plates into the original lead sulphate. The nickel-iron cell in its uncharged state contains an aqueous solution of caustic potash, in which are immersed plates of iron and nickel, whose surfaces acquire through contact with the solution films of their respective dihydroxides. The passage of the charging current through the cell carries hydroxyl ions from the solution to the nickel to form a positive plate of nickel tetrahydroxide, and simultaneously takes ions of potassium to the iron to reduce the iron hydroxide to a negative plate of pure iron. In the fully charged condition the cell is in a state of readiness to deliver electric current by restoring its plates to their original dihydroxide nature. The chemical reactions of these two cells are illustrated symbolically in Fig. 10.

The Lead Accumulator

The main claims of the lead accumulator over the nickel-iron cell for adoption in submarines reside in the facts that the nickel-iron battery weighs even more than the lead battery, and that the lead cell has the higher voltage. Against these claims may be set the facts that the iron-nickel cell is more robust mechanically and electrically, since it is capable of being efficiently charged at high speed, does not suffer unduly when short-circuited, and has a high specific output of current, and in addition is free from the danger of generating the asphyxiating chlorine gas which poisons the atmosphere inside the submarine when a leakage of sea water reaches the lead cells. A further disadvantage of the lead cell, which is not encountered in the nickel-iron cell, is its liability to discharge acid into the boat's interior, either as a vapour through the cell vents which gradually corrodes the metal of machinery, or as a liquid through a rupture in the cell wall

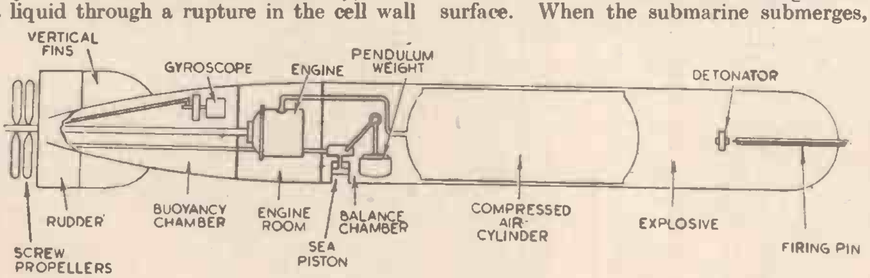


Fig. 12. Longitudinal section through a torpedo, showing the disposition of the compressed-air chamber and engine, etc.

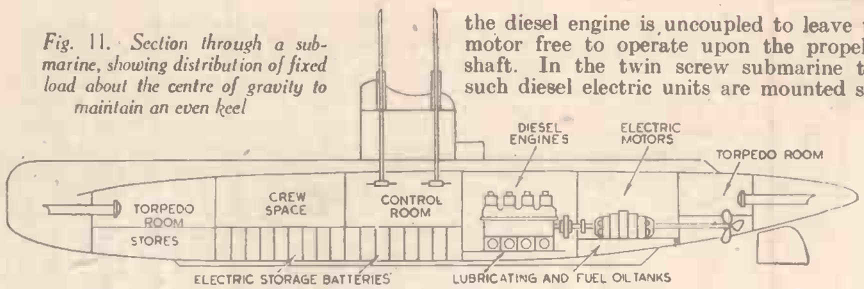


Fig. 11. Section through a submarine, showing distribution of fixed load about the centre of gravity to maintain an even keel

which steadily eats through the hull plates. Both types of cell possess the common fault of evolving gases which are at the same time non-respirable and explosive to a spark, but measures are taken to withdraw them from the submarine's atmosphere by means of fans and ventilation tubes as rapidly as they are produced.

Battery Weight

The defect of battery weight is tolerated in the submarine because of the advantages offered by the electric motor as a means of promoting under-water propulsion. The main merits of the electric motor as compared with a heat engine used for this purpose are contained in its property of operating with comparative silence without the generation of intense heat and without the need of a supply of oxygen, in the facilities it offers for the convenient delivery of power to pumps, air fans, wireless circuits, and other auxiliary apparatus, and in the fact that its absorption of charge from the storage batteries does not require a compensating ballast to preserve the boat's buoyancy as does the withdrawal of fuel oil from the storage tanks for consumption in the heat engine. The disposition of storage batteries, electric motors, and diesel engines in the submarine's interior is illustrated in Fig. 11. These dead weights are distributed along the length of the boat in a manner which brings the centre of gravity of the vessel to a central position in the region of the control room immediately below the conning tower. The majority of the storage batteries are laid forward of the conning tower and low in the hull, in order to keep the loaded hull stable, and the electric motors and diesel engines aft of the conning tower to counterbalance the weight of the batteries. To economise weight and space, the diesel engine and electric motor are coupled in series to the same propeller shaft, and by placing the motor abaft the engine the latter performs the double function of turning the propeller shaft and driving the motor generator which recharges the batteries while the boat is cruising on the surface. When the submarine submerges, the diesel engine is uncoupled to leave the motor free to operate upon the propeller shaft. In the twin screw submarine two such diesel electric units are mounted side by side in the engine room in communication with their respective shafts.

The Torpedo

The torpedo is the submarine's chief instrument of offence, but apart from its sinister character as a deadly weapon, it engages interest wholly on account of the manner in which physical principles are applied in the working of its intricate mechanism. Its outside form roughly resembles that of the submarine hull itself. Its cross section is circular to withstand the crushing pressure of a depth of water, its nose is tapered to minimise the resistance offered by the water to its motion, and its tail is finned and fitted with propellers, hydroplanes, and rudder to promote and control its propulsion. The thin-walled torpedo head carries the charge of high explosive, in which is embedded the detonator, and a firing pin, which protrudes slightly from the head, penetrates the charge to a point immediately in front of the detonator. Impact of the head upon a target drives the pin into contact with the detonator and the charge explodes. Immediately behind the charged head is a thick-walled cylinder, in which is stored the highly compressed air used to drive the engine of the torpedo, communication between air tank and engine being established through a valve which is automatically opened by the release of the torpedo from its firing tube. Between the air cylinder and engine room is the balance chamber, which houses the apparatus for maintaining the discharged torpedo in a straight course at fixed depth below the surface of the water. The main components of this mechanism are a heavy pendulum weight suspended from a fixed pin, and a small piston in a cylinder opening directly to the sea, which are connected to the operating rods of the tail hydroplanes. An upward inclination of the torpedo from a level course at a prearranged depth causes the pendulum weight to swing slowly backwards through an angle equal to the angle of inclination of the torpedo's axis. This motion of the pendulum operates the rods which incline the tail hydroplanes at a corresponding angle to receive the thrust of the oncoming water, which causes the torpedo to descend to its correct course. Conversely, the forward tilt of the pendulum weight caused by a dive of the torpedo rotates the hydroplanes into a position calculated to correct the torpedo's descent.

The Pendulum

The readiness with which the pendulum adapts itself to a change in the torpedo's course is from one point of view an undesirable quality, since the least over-correction due to an excessive forward or backward swing of the pendulum is liable to send the torpedo speeding to the surface in the first case or diving to the sea-bed in the other. To avoid over-correction by a sudden change of course, a sea piston and cylinder are incorporated into the depth-controlling mechanism in such a way that the pendulum weight and sea piston together exert a dual control over the torpedo's course and at the same time exert a restraining influence over each other's movements. The cylinder into which the piston fits opens directly into the sea, so that the position of the piston in the cylinder will be determined by the external pressure of the sea water, which in turn depends upon the depth of the torpedo below the surface. An upward swerve takes the torpedo into regions of lower pressure, causing the piston to move slowly outwards, and a sudden dive takes the torpedo into depths at a greater pressure, which pushes the piston farther into the body of the torpedo. Piston and pendulum operate in conjunction on the hydroplane rods, and the pendulum swing is made more gradual and less liable to an over displacement by the braking effect of the hydrostatic piston.

The Buoyancy Chamber

The space in the torpedo's tail is described as the buoyancy chamber, since it is almost empty of mechanism and provides, together with the compressed air cylinder, that unloaded fraction of the torpedo's total volume which gives the projectile its buoyancy. This chamber contains the gyroscope, its motor and rudder connecting rod, and in addition is traversed by the propeller shaft and hydroplane rods, which pass to the tail from engine room and balance chamber. The gyroscope is a device which prevents the torpedo from veering to the right or left of a straight course in a horizontal plane, just as the pendulum and piston prevent it from ascending or descending from that straight course in a vertical plane. The gyroscope consists essentially of a heavy metal disc, capable of rotation about its axis at a high speed, the motive power for this rotation being provided by the tension in a coiled spring or by a small electric motor. The high momentum of the spinning disc, gathered from its weight and speed, impart to it a marked reluctance to alter the position of its axis in space. Consequently if the disc be pivoted in gimbals held in the body of the torpedo to allow its axis to assume any given direction in space, a departure of the torpedo from a rectilinear course will produce a corresponding change in the angle of inclination between the torpedo's axis and the axis of the gyroscope, since the direction of the latter tends to remain fixed in space on account of the momentum of the spinning disc. The relative motion between these two axes is communicated to a rod which operates the vertical rudders at the tail in such a way that a deviation of the torpedo to the left of its course puts down the rudder to the right to an extent which brings the torpedo back to its straight course. Similarly a deviation to the right would produce a corrective turn of the rudder to the left,

Firing a Torpedo

When the torpedo is projected from its firing tube to pursue its subaqueous path, it is of the utmost importance to make its passage free from any tendency to develop a spin or to heel to one side or the other, for a roll or permanent list would upset the balance of the internal mechanism, in particular of the suspended pendulum weight, making the torpedo's course erratic and its ultimate destination uncertain. The torpedo possesses neither keel nor superstructure, which are the usual agents for correcting a roll, but relies instead for balance upon the action of its screw propellers. A pair of four-bladed propellers are mounted about a common axis at the torpedo's tail in such a manner that both rotate with the same speed but in opposite directions. The cleaving of the curved glades through the water propels the projectile forward, and the equal but opposite angula momenta of the spinning propellers removes any tendency of the torpedo to roll in its course and imparts to it the steadiness and balance necessary for its successful performance.

Remote Control for Television Cameras

CONSIDERATIONS of space often make it difficult to accommodate a large television camera, and an operator, at a point from which a scene has to be viewed.

This difficulty can be overcome by arranging for the camera to move under the control of a view finder observing the scene from a more convenient point at which an operator can be stationed.

The accompanying illustration, Fig. 1, shows an arrangement of this kind. It will be seen that the two mutually perpendicular motions of the camera 1 mounted in the gimbal framework 2 are conveyed to a remote view finder 3, by means of flexible cables or shafts 4 and 5. At the viewfinder the flexible shafts control the positions of two independent cross wires 6, 7, which are within the field of view through the eyepiece 8; their point of intersection indicating the centre of the field of view of the camera.

Alternatively, the flexible shafts may control the direction of the whole viewfinder in which a rectangular framework would indicate the field of view for the lens being used.

A Viewfinder Improvement

An improvement upon the viewfinder is shown in Fig. 2, in which the cross wires are accommodated in a subsidiary optical system 1 and superimposed upon the scene visible through the aperture 2 by means of a half silvered mirror 3. The advantage of this arrangement is that a lens 4 may be included so that both cross wires and object would appear in focus simultaneously.

Although cross wires have been shown, it is preferable that illuminated slots with a black background should be used in practice, so that the auxiliary optical system will not reduce the contrast of the scene being viewed. Further, as an alternative to two intersecting lines, a gimbal mechanism may be devised which is controlled by the flexible shafts, and which carries a flag (such as a circle of wire) covering the centre of the scene being transmitted.

In the converse arrangement, handles would be attached to the ends of the flexible shafts at the viewfinder, and their manipulation would control both movement of the camera and position of cross wires.

It is obvious that instead of the flexible shafts, alternative methods of communicating the movement of the camera may be employed.

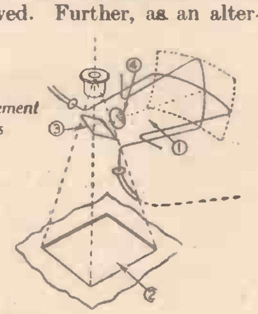


Fig. 2.—(Right). A view-finder improvement incorporating superimposed cross-wires

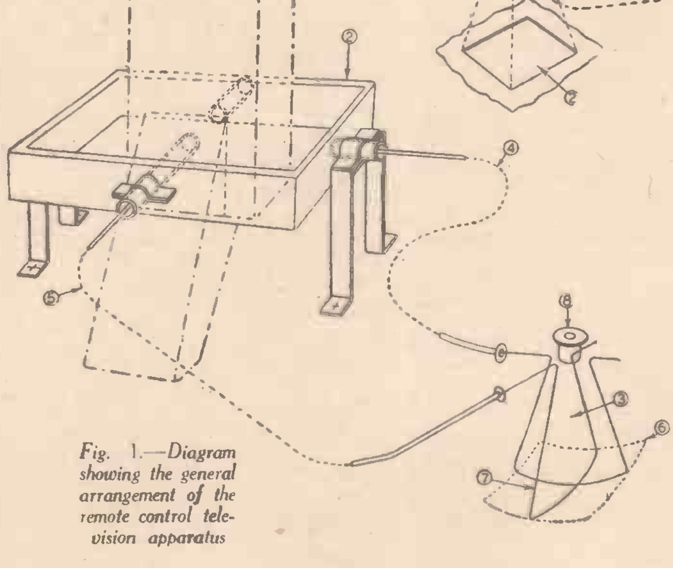


Fig. 1.—Diagram showing the general arrangement of the remote control television apparatus

* * * *

Automatic Telephony

THE distances between automatic exchanges in rural areas are often considerable, and difficulties have existed in controlling electro-mechanically operated switching mechanisms over lengthy junctions by means of dialled impulses. These difficulties have been largely overcome by the development by G.E.C. Telephone works of an impulsing relay known as the H.S.P. (high-speed polarised). It will operate on very small currents, but as it is of particularly strong construction it is capable of resisting distortion of its armature and disturbance of its adjustments when a current of considerably higher value than the normal operating current is applied.

* * * *

Railway Electrification

ELECTRICAL equipment is being constructed for eight 3-car trains to run on the Manchester-Sheffield-Wath section of the London and North Eastern Railway. Many interesting features have had to be considered in the design of this equipment which will be the first in England working on a 1500-volt line in conjunction with locomotives capable of heavy regeneration.

MASTERS OF MECHANICS

No. 56.—HENRY FARMAN

His Fame as an Aeroplane Inventor and Pioneer of Mechanical Flight

TO delve adequately into the early history of Henry Farman, that pioneer of mechanical flight whose name was at one time so sensationally before the public both in England, and on the Continent, we must take ourselves back to the days of old Thomas Farman, an individual who characteristically termed himself an "English Parisian," and who, in his capacity of correspondent for a couple of English newspapers, *The Standard* and *The Tribune*, naturally moved in very informed circles in the city of his adoption.

Old Thomas Farman was, during his heydays, a gentleman of considerable sporting instincts. The cycling boom of the early eighties of the last century claimed him as one of its "victims," as he used facetiously to remark. Additionally, Farman *père* more or less insisted that his sons, Dick, Henry and Maurice, should become adepts in the newly fashionable cycling art. He bought them all brand new bicycles, had them properly tutored in the management of their machines, and then, as he tells us, sat back and awaited results.

The energetic parent had not long to await the coming of fame to his offsprings. At the tender age of eighteen years, Henry, the "middle" son, and the subject of our present article, was a safety-bicycle champion, having a large number of road victories to his credit. In conjunction with his younger brother, Maurice, he became, also, a tandem champion, winning a number of Continental bicycle trials, and events upon a dual machine.

Henry Farman, like his brothers, Dick and Maurice, although of Parisian birth, retained his English nationality. His father saw to it that the education of the boys was made as English as possible. Sports, therefore, and particularly road sports, figured largely in the cultural curriculum of the growing Farman lads. Hence it was that, with such a grounding, Henry Farman—who, incidentally, first saw the light in Paris in May, 1874—rapidly proceeded from the status of bicycle and tandem champion to that of automobile racer.

As a Motor-car Racer

It was not long, indeed, after the introduction of the first commercial cars in Paris that Henry Farman became inseparably associated with these early vehicles. The sporting side of motoring at first appealed to him more than the purely constructive and mechanical aspect of automobilism. At the turn of the century, Henry Farman was a noted motor car racer, the victor of several long-distance runs, and the favourite of an extensive motoring public on the Continent. It is to be noted that in the now celebrated and historic Gordon-Bennett motor race, which was run over on a roughly circular road course in Ireland in 1903, Henry Farman drove a Panhard car and was placed third among the winners.

Exactly in what direction Henry Farman's talents would have led him had not, at a later juncture, the idea of the practicable aeroplane captured his imagination, and chained the whole of his energies, there is no knowing. Farman was at the height of his career as a popular motorist when the embryo aeroplane came along. Initiated by the famous Wright brothers of America, and even at an earlier date (1906), demonstrated to possess an inherent degree of practicality by that brilliant young Brazilian flight pioneer, Alberto Santos-Dumont, the aeroplane was invented by Henry Farman in a form which constituted a forerunner of the present-day type of aircraft.

It seems to have been Gabriel and Charles Voisin, two determined adherents of the art and pastime of kite and glider construction, who first practically interested Henry Farman in the possibilities of mechanical flight. True it is that the exploits of the Wright brothers had taken Europe by surprise, but then, most Europeans were apt to regard the early claims of the Wrights as merely "Americanese," for had not, it was commonly said, other "claims" arisen in the past in the American States?

Henry Farman

Beginning with Kites

It was, therefore, from the brothers Voisin and not from the Wrights that Henry Farman took his cue in his early attempts to solve the problem of human flight. Beginning with the scientific study of kites, both Farman and the Voisins, singly and in combination, worked out a novel variety of kite. It consisted, in its earliest form, merely of a large and peculiarly-shaped wooden frame some two metres square, upon which was stretched strong canvas cloth. The enthusiasts, who were working upon their project in a hut adjacent to a large public ground at Issy-les-Moulineax, near Paris, availed themselves of an extensive piece of excavated ground which was to receive the foundations of a new building. Into this excavated land, which was about a dozen feet in depth, Farman and the Voisins jumped, clutching their "kite" the while. How the intrepid pioneers ever escaped breaking a leg or some other limb, history cannot relate. Nevertheless, it was in this singular and amazing manner that they studied the problems of air-uplift on plane surfaces and, as Henry Farman himself years after put it, "learned how to fly!"

The next plan was to construct a machine having plane and kite-like surfaces and possessing a suitable engine of sufficient power to drive a high-speed propeller. Not a few attempts had been made at such a type of construction, but, despite their close adherence to assumed theoretical principles, all such machines had signally failed to rise even a few inches above the ground.

His First Machine

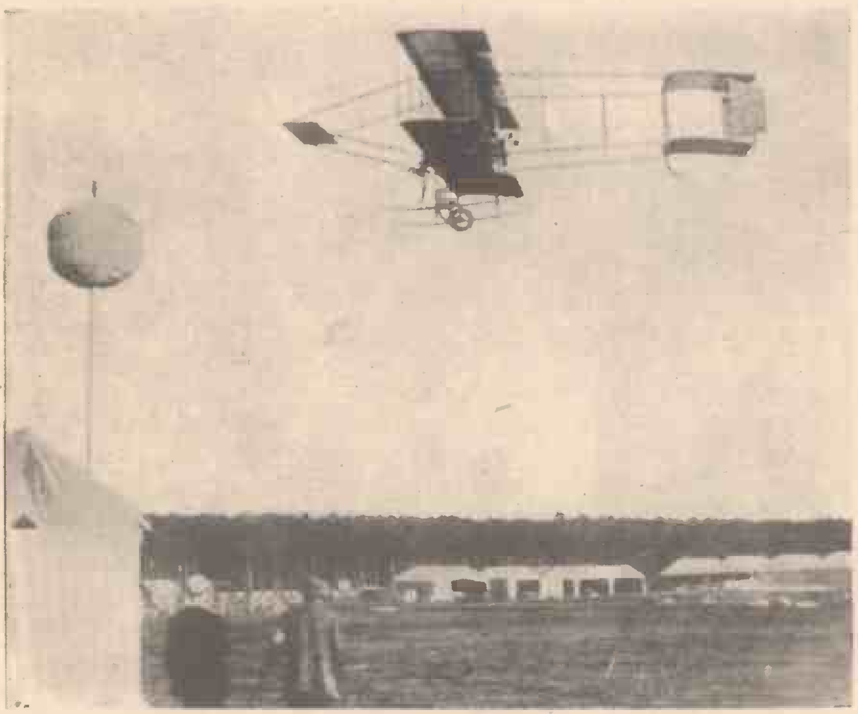
Farman's first machine, which he constructed at Issy-les-Moulineaux towards the end of 1907 had two planes set one above the other and, also, a box-like tail. It was entirely different from anything which had appeared in the past. "Farman's hen-coup" it was quickly nicknamed, at first, perhaps, in a spirit of some derision, but ultimately in admiration. For "Farman's hen-coup," apart from the pioneer plane of the Wright brothers, proved itself to be the first heavier-than-air machine to rise above the ground under its own power, and to undertake controlled and directional flight. Indeed, Henry Farman was the first man in the world to fly successfully a distance of one kilometre around a measured course, a feat which he accomplished on his "hen coup" machine on January 3rd, 1908.

It was not without much tedious trial and experiment that Farman mastered the elementary principles of mechanical flight. During the preliminary trials with his machine, the aeroplane resolutely refused to rise a hair's-breadth above Mother Earth. Weeks and weeks were spent by the inventor in running the plane along the ground and in making a multiplicity of modifications and alterations to its structure. Farman, to a great extent, was working and experimenting entirely in the dark. Practically nothing was known at that time about the principles of aeroplane flight. Indeed, many people, who ought, perhaps, to have known better, still insisted that an aeroplane should be made in the shape and form of a bird, and that it should have flapping wings, in addition to a revolving propeller. The idea of running a "kite-aeroplane," as Farman's type of machine was sometimes termed, along the ground in an endeavour to take-off into the air, seemed preposterous. Even the brothers Voisin at times tried to discourage the enthusiastic and persistent Farman against undertaking useless experiments in his efforts to "run the machine into the air." But Farman was not to be disuaded. His experiments, his ceaseless trials, his almost endless attempts to get himself and his machine into the air went on—often, let it be said, to the disgust of the Voisins—until success came at last.

And success, as is often the case, came very curiously to Henry Farman. He was one day running his machine along the ground, when, lurching suddenly and somewhat violently to one side of his seat, he imagined that the plane had actually lifted itself off the ground for a number of seconds. Attempts to renew the peculiar lifting sensation which Farman had experienced failed, however, until a week or two later, the inventor, in a fit of exasperation, seized hold of two vertical tubes as the machine was running along the ground, and pushed with all his strength on them.

The two vertical tubes were mounted at opposite sides of the pilot's seat, and were connected to a ground or underframe to which were attached the wheels of the plane. During the running of the machine, the two tubes moved somewhat violently up and down, following the unevennesses of the ground.

"To my utter amazement," says Farman, "the machine left the ground and made a flight of about 50 yards! There was naturally a great deal of comment from my friends as to my muscular strength in being able to 'push the aeroplane off the ground into the air a distance of fifty yards,' as they would never believe I had really flown at all. As a matter of fact, the reality was quite another thing. I had simply let the machine do what it liked, and it apparently took a good position in the air and flew!"



Farman's first aeroplane flying around an Exhibition course in France, in 1908

Discovery of the "Flying Angle"

Following upon this discovery, Farman conducted a series of experiments with his machine in which he ran the plane over the ground a successive number of times, the "attitude" or angle of inclination of the front portion of plane to the ground being changed at each trial. At first steep angles were tried and proved failures. Eventually, however, an angle of inclination was found at which the running machine left the ground quite slowly, almost, indeed, imperceptibly, and glided gracefully and confidently into the air in as apparently natural a manner as a fish glides into water. The long-elusive principle of "flying angle" had been discovered and Henry Farman became the world's first individual to indulge in really scientific mechanical flight.

Afterwards, as we have already seen, came Farman's victory at Issy-les-Moulineaux, a couple of days after the New Year's Day of 1908, on which occasion, before a considerable number of spectators, he flew for a kilometre around a measured course. The achievement was carried out with the greatest of ease, and from that time, Farman was proclaimed a Master of Mechanical Flight. The day was, indeed, a red letter one in the annals of aviation.

A prize of 50,000 francs (then about £2,000) had been offered by Henry Deutsche de la Meurthe and Ernest Archdeacon, two great enthusiasts in the cause of mechanical flight, to the first aviator who should successfully fly around a measured course of one kilometre—1,094 yards—and thereafter return to the starting point. Henry Farman naturally captured this, the first of a long series of aviation prizes. In the same year he gave exhibition flights in France, Holland and even in the United States, whilst on October 31st, 1908, he ascended in his aeroplane above the clouds, and so won the world's first altitude prize.

Purely exhibition flying, however, had no great attraction for Farman. During 1909 and afterwards, he concentrated almost solely upon aeroplane design and manufacture. In 1909, in combination with his elder brother, Maurice Farman, he began the manufacture of aeroplanes in a small way at Châlons-sur-Marne. The first Farman workshop comprised a large marquee belonging to a military ground in the district.

First Aeroplane Works

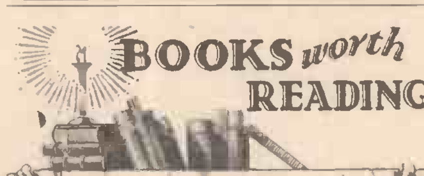
Such was the first commercial aeroplane works in the world. Three years afterwards, the Farmans erected completely new factories for aeroplane production at Billancourt, an industrial suburb of Paris, and here were made the famed Farman planes which served so successfully during the Great War of 1914-18. They were fitted mainly with Renault, Hispano-Suiza and the then very favourite Gnome engines. Subsequently, however, the Farman brothers began the making of their own engines.

At a still later date, Henry Farman established an Air Line service, which received the name of "The General Air Transport Company." It operated between Paris, Brussels, Amsterdam, Hamburg and Copenhagen, and it maintained a regular passenger, postal and goods service.

As a motor-car manufacturer, Henry Farman—who began in that line in 1922—achieved considerable success. Concentrating more upon the luxury class of cars, his first vehicle possessed a six cylinder engine of 40 h.p. rating. The Farman car was, indeed, as it was termed, the "Rolls-Royce of France," and it was upon the inventive and constructive ability of Henry Farman that its success was, in the main, fundamentally based.

Farman, the Pioneer

During the present era of huge aeroplane construction projects, coupled with sensational feats of airmanship, even students of invention's history are apt to lose sight of the fact that it is to Henry Farman, and his close associates, that we owe the first elucidation of the principles of mechanical flight. The name of Henry Farman at the present day suffers an eclipse in consequence of more sensational achievements which have been made subsequent to his pioneering efforts. Perhaps such a fact is only a natural one. Nevertheless, in aeroplane annals, the name of Henry Farman must come very prominently upon the list of pioneers and inventors as the one individual, in particular, who first clearly elucidated for us the fundamental principles of mechanical flight in a heavier-than-air machine, and thereby founded the modern technique of air travel.



"Hardening and Tempering Engineers' Tools." By George Gentry. Published by Percival Marshall & Co., Ltd. 94 pages. Price 1s. 6d. net.

WORKSHOP mechanics, model engineers, and others, will find much useful information in this small handbook, the aim of which is to explain the main points in the various hardening processes used in ordinary workshop practice. There are ten chapters dealing very thoroughly with the subject, from the simple hardening of steel to Case-hardening, and the Heat-Treatment Furnaces. The book is well illustrated in line and half-tone.

"First Year Engineering Science." By G. W. Bird and B. J. Tams. Published by Sir Isaac Pitman & Sons, Ltd. 136 pages. Price 5s. net.

STUDENTS working for National Certificates in Mechanical and Electrical Engineering will find this book specially prepared for their benefit. The subject-matter comprises a course of instruction in elementary engineering science such as teachers declare to be essential to the proper training of engineering students. The presentation of the contents is very lucid, and the book should prove invaluable to students taking courses in engineering at technical schools and colleges, as well as to readers studying privately.

One-Stringed or "Japanese" Fiddles

In This Article Constructional Details of Two One-Stringed Instruments are given

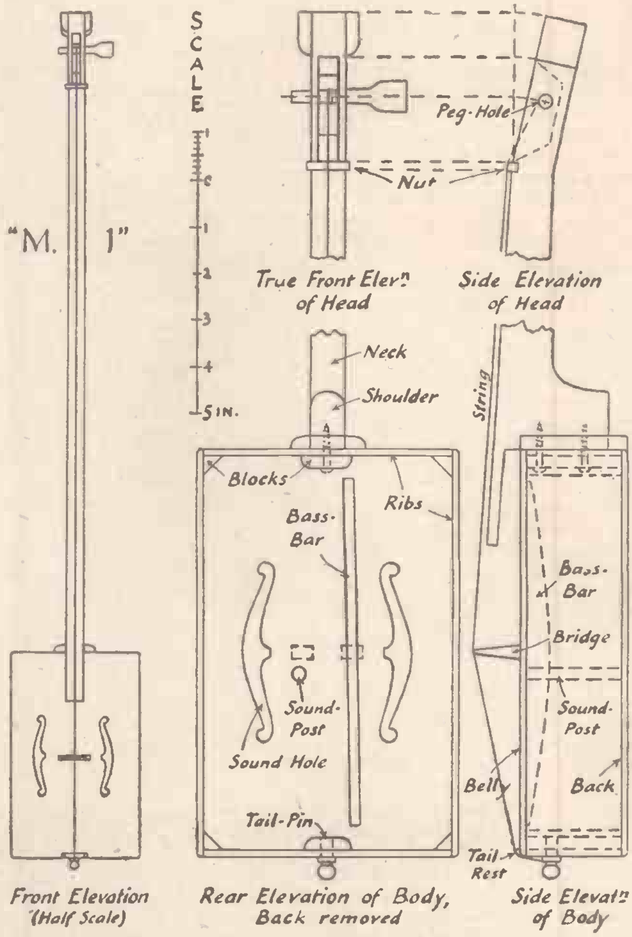


Fig. 1.—Constructional details of a one-stringed fiddle. The body is made of cigar-box wood

THE two simple instruments herein described are easily constructed, and both have a pleasing tone, compared with the cheap commercial fiddles of a similar type.

The body of the instrument shown in Fig. 1 is formed of cigar-box wood (approximately $\frac{1}{8}$ in. thick), but it is not just a cigar-box; it is entirely reconstructed, and reduced in length. The sides or "ribs" are carefully glued together with butt joints, strengthened by a triangular block of soft pine, about $\frac{3}{8}$ in. diameter, the full height of the ribs, glued and rubbed into each angle. A neck- and tail-block, about $\frac{1}{4}$ in. by 1 in. in section, with the exposed angles rounded, is glued centrally on the inside of the top and bottom ribs respectively, also extending their full height. Glued to the inside of the belly, so as to lie exactly under one foot of the bridge, and running nearly but not quite parallel to the long axis of the body, is a *bass-bar*, as in an orthodox violin; and about its own diameter tailwards of the other foot of the bridge a *sound-post* (see article *Sound-post* in Grove's "Dict. of Music") is fitted tightly between the belly and back, and perpendicular to them. The absence or improper fitting of these two members is the cause of much of the poor tone emitted by both commercial and amateur-made one-stringed fiddles, and also of the undeservedly low opinion which many people have of these instruments generally. Both bass-bar and sound-post should be of straight-grained pine. The former should be about 1 in. shorter than the belly, and the edge which is glued thereto $\frac{1}{4}$ in. wide; the depth is graduated from $\frac{1}{2}$ in. in the centre to about $\frac{1}{8}$ in. at the ends, and the free edge should be well rounded from side to side as well as curved from end to end. The sound-post is a wooden rod of $\frac{1}{4}$ in. diameter.

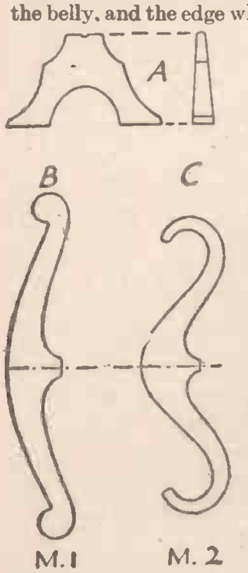


Fig. 2.—The bridge, and shape of the sound holes

The Neck

The neck is sawn out of a piece of $\frac{3}{4}$ in. mahogany (a keyhole saw was used for the curved part of the "shoulder" and as much of the straight part as is necessary). The back of the neck is nicely rounded, and the front, which forms the fingerboard, made truly flat—any convexity in the length is particularly to be avoided, as it may cause jarring of the string in certain stoppings. The *peg-box* is formed like a small violin peg-box (see dotted line on side elevation of head, Fig. 1), being cut out with a chisel; the cheeks are left $\frac{1}{8}$ in. wide at the front, and rather thicker towards the back. The widened part of the head is formed by gluing on two shaped slips of the same wood as the neck, and finishing them off flush at the front, back and top. The *peg-hole* may be bored before the peg-box is cut, at first no larger than the smaller end of the peg. The hole can be tapered with a large rat-tail file, carefully revolved counter-clockwise in the hole; but proper violin peg-borers can be obtained. A home-made peg of rosewood or ebony, something like that shown in the drawing, will look much more in harmony with the rest of the instrument than an ordinary violin peg. If you have a lathe, the forming of the shaft is, of course, a simple matter, but where only one peg is concerned, it will not be a very laborious process to shape it with a file from square to octagonal, and from octagonal to 16-sided, and then to blend the facets, and finish off by turning the peg in a tube of glasspaper formed round it. It is, of course, important to regulate the taper of the peg, and the hole, so that a good bearing is obtained on both sides of the peg-box. The "*nut*" which raises the string $\frac{1}{16}$ in. off the fingerboard at the head end is a slip of rosewood about 1 in. by $\frac{1}{8}$ in. by $\frac{1}{8}$ in., fitted and glued into a shallow groove cut across the neck just below the peg-box, rounded on top, and *very* slightly nicked in the centre for the string.

Tail-Rest and Tail-Pin

The *tail-rest* is another slip of rosewood of about the same dimensions let into the edge of the belly for half its depth where the string passes over to the tail-pin: it should be well rounded above, but needs no centre nick; its object is both to prevent the string cutting into the belly, and to ease the angle through which the string has to bend at this point. The *tail-pin*, like the peg, might be turned; but in our "M.1" (Monolin No. 1) it was made by shaping the end of a stick of rosewood $\frac{3}{8}$ in. in diameter with file and penknife, into the form of a miniature shouldered knob (see Fig. 1) with a shaft about $\frac{1}{4}$ in. in diameter, to be fitted tightly into a hole bored through the bottom rib of the fiddle and the tail-block. When the pin has been satisfactorily shaped, the shaft is cut off about $\frac{3}{8}$ in. long, so that it will go right through the rib and block but no further. It should not be glued in, as the hole provides a view of the interior of the body which may be useful at any time in locating defects or checking the uprightness of the sound-post.

Bridge and String

The *bridge*, in this and nearly all our later monolins, is cut with a fretsaw from a slip of well-seasoned oak. In thickness the bridge is a compromise between an ordinary violin bridge and the shapeless chunks favoured by the "Jap fiddle" manufacturers, which gives it eventually an elevation derived from drawings of Japanese *koto* bridges in "Music and Musical Instruments of Japan" (see Fig. 2 A).

String-Length

The string-length (from nut to bridge) is shown on the drawings as 27 in., the effective string-length of a medium-sized 'cello. As the fingering of a one-stringed fiddle is necessarily related to that of a 'cello, we think the latter might appropriately supply the standard. The *string* with which all our monolins are mounted is that which seems to be consistently adopted for the Jap fiddles of commerce, namely a "banjo third steel," tuned to Middle C. To the violinist or 'cellist the use of wire strings on a bowed instrument may appear barbarous, but we have proved that, with a properly designed body and bridge, the tone produced by their aid can be as pure and soft as anything that could be got out of catgut; and their superiority to gut in durability and indifference to moisture is obvious. The banjo strings have a loop ready made at one end, which can be slipped over the tail-pin; a very small hole is bored in the peg to receive the other end.

Assembly

When the ribs have been put together, it is best, before gluing on the back, to arrange the fitting of the neck. The face of the shoulder which joins on to the body must be quite square transversely, and should make an angle of about 86° with the plane of the fingerboard. Lay the ribs on the bench, with the belly on top, then prop up the neck in contact with the body so that it stands as nearly as possible as it will when fixed. Lay a straight-edge on the fingerboard, overhanging the body, and see how high it stands off the belly at the latter's centre (where the bridge will come): the distance should be just over $\frac{7}{8}$ in. Adjust the neck up or down until you get this right, then mark clearly on the neck where the top edge of the rib comes. Take away the belly, centre the neck to the axis of the body very carefully, then holding or clamping it in the correct position, make two small bradawl holes, on the centre line, through the top block and rib into the neck (see drawings), deep enough to take the two 1 in. or $1\frac{1}{4}$ in. round-headed screws which will secure the body and neck together. Taking these temporarily apart, enlarge the holes in the body so that the screws can be pushed through them right up to the head, slightly grease the screws, bring the parts together, and turn the screws home. It is desirable both for strength and appearance to fit and glue into the angles between the neck and the body (after the back and belly are on) blocks of the same wood as the neck, in section roughly quarter-elliptical, say $\frac{3}{8}$ in. by $\frac{1}{4}$ in. (see Fig. 1). If the wood available allows it, the shoulder of the neck may well finish flush with the body at the back, as in the "M.2"; in "M.1" it does not extend so far, though the strengthening blocks do; the space between their ends is filled in with a kind of packing-piece. The extension of the fingerboard over the body should be about $\frac{1}{4}$ in. thick, and reach to within 3 in. of the bridge, so that the string may be stopped to $\frac{1}{8}$ of its open length ($3\frac{3}{8}$ in.), and thus give the instrument a compass of three octaves.

The back, and then the belly, can now be glued on, and cramped with weights; no nails or pins should be used anywhere. Before the belly is fixed it must, of course, have the sound-holes cut in it and the bass-bar attached. The outline of the former can be enlarged from the illustration in Fig. 2, which is half full size, and cut out with a fretsaw; or the terminal eyes may be bored with a bit and the rest carved out with a knife. When the edges of the back and belly (left intentionally a shade large) have been trimmed quite flush with the ribs, the tail-rest and tail-pin fitted, and the bridge made, the sound-posts may be inserted. Lower it through the sound-hole farthest from the bass-bar by means of a pin stuck in one end, and pare one or both ends until it will just stand vertically inside the body, without any forcing. It must now be slid into the position described in an earlier paragraph, either by means of a piece of bent wire, or a string tied round it with two long ends, one issuing from each sound-hole.

Varnishing

You can now put a string on and get some idea of the tone of the instrument. If it is fairly good, it will be better when the body is varnished. Take the string off, give all surfaces a final glass-papering and slightly round all arrises, then apply *to the body and head only* at least two coats of good quality "dark oak" varnish, with a rub down between. A preliminary sizing with a solution of gamboge in methylated spirit is desirable. The neck is not varnished, but its surface is hardened by several applications of French polish each lightly rubbed down with fine glasspaper or pumice-powder. In commercial one-stringed fiddles it seems to be the rule to "fret" the fingerboard by means of white incised lines, but we strongly urge the amateur maker to leave it quite plain. The varnish on the belly should be scraped away just where the feet of the bridge stand.

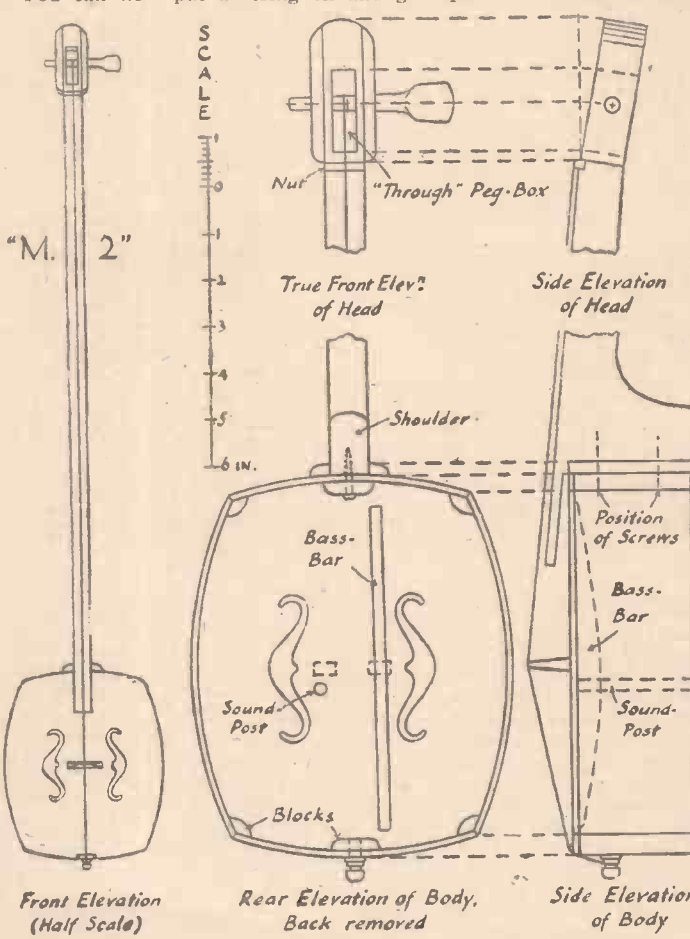


Fig. 3.—Elevation and constructional details of a one-stringed fiddle of alternative design

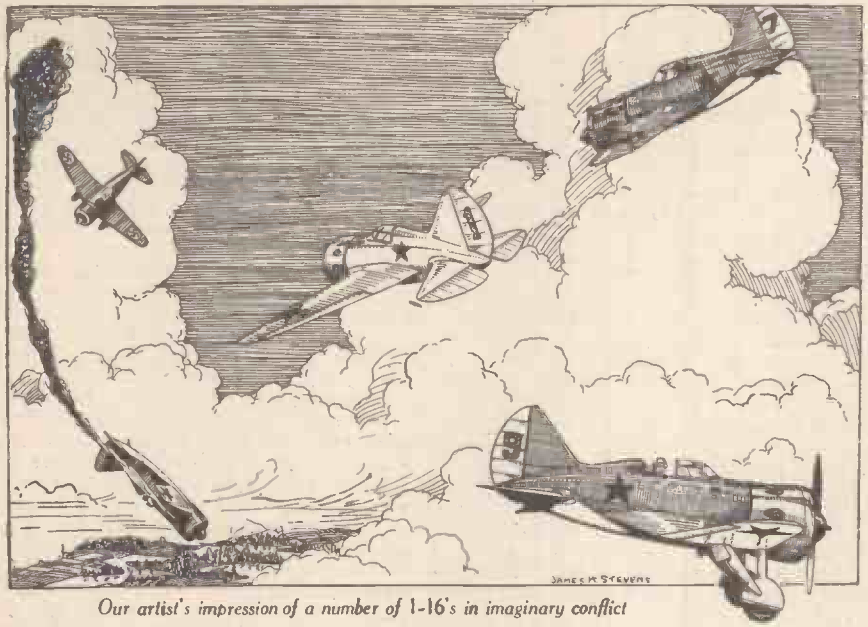
The Second Model

Wishing to make a second monolin for ourselves, we debated the possibility of giving the body the attractive convex outline of the Japanese *kokyu* and *samisen*. We remembered the various decorative uses to which the constructor had formerly put the wood of a Canadian cheese-tub, and "M.2" (see Fig. 3) was the result. The rough stringy birch needs a lot of preparing to get a fair exterior surface for varnishing, but the result pays for the labour. The mitring is done by trial, and the joints depend mainly on the blocks—fitted and glued in while the ribs are secured with string. The back and belly are of $\frac{1}{8}$ in. fretwood—the former "satin walnut" and the latter "silver pine"; the neck being of dark walnut, the colour effect is very good. The head has side additions for its full length, and the peg-box could therefore well be cut right through the head in the Oriental fashion with centre-bit and keyhole saw. The different form of sound-hole (Fig. 2) seems to be demanded by the curves of the body. The tone of this instrument is less brilliant than that of M.1, but is very pleasing.

WATER MAIN ACROSS HARBOUR

BRISTOL WATERWORKS COMPANY'S engineers recently superintended the laying of a new water main pipe across the Floating Harbour at Welsh Back, the pipe is 18 inches in diameter and weighs 10 tons. It was lowered into the harbour bed, a depth of nearly 30 feet. The Stanton Iron Works Co. made the pipe and it is fitted with Stanton-Wilson self-adjusting joints.

SCALE MODEL AIRCRAFT No. 2



Our artist's impression of a number of I-16's in imaginary conflict

THE RUSSIAN I-16 SINGLE SEATER FIGHTER

By James Hay Stevens, A.R.Ae.S.

DURING the time that the Red Air Fleet was so much in the news, owing to the activities of its bombers over the towns of Finland, one would expect that details of Soviet aeroplanes would not be scarce. As a matter of fact, for years past, particulars of modern Russian types have been almost impossible to obtain because of the rigorous censorship which shrouds all the works of that land, except for a few carefully selected tit-bits released in a form calculated to arouse the awe-struck admiration of the capitalist countries. That is why the only photographs of Soviet aeroplanes to be seen outside Russia were those of the ancient four-engined A.N.T. bombers used for dropping parachute troops, until the semi-official German military aviation paper *Luftwehr* published photographs of the I-16, and a medium bomber, the S.B.2, which were being used by the Republicans in Spain.

Unusual Aerodynamic Design

This I-16 is a monoplane of unusual aerodynamic design and, by all ordinary standards, it is extremely daring—the short fat fuselage; the leading edge close to the engine; the deep main-plane chord with large fillets almost to the tail plane and, above all, the small wing area—each of these features is calculated to make it a very difficult aeroplane to fly. Yet it is in use in large numbers, and was successful under active service conditions in Spain, where it was mainly flown by Russian pilots, although a few foreigners were allowed to use it. One of these has put on record ("Some Still Live," by F. G. Tinker; Lovat Dickson, London) that, although the stalling speed is appallingly high—being something between 90 and 100 m.p.h.—and though the machine is not fitted with flaps or brakes, it is fairly easy to land, and is very handy in the air. The handiness is, of course, due to the machine's compactness, and is a virtue which is not by any means inherent in modern fighter designs. It cuts both ways, however, as a handy fast aeroplane is no vehicle for clumsy or badly-trained pilots. In Russia this does not seem to matter very much as there is a large supply of potential pilots, and they are kept under a very rigorous discipline, being made to learn their fighter tactics by wrote, that is, they have to keep rigidly to rules set down for them—one imagines that, with a machine like the I-16, any flagrant disobedience would, in any case, bring an only too prompt punishment.

Used in Spain, 1938

The prototype I-16 is believed to have been flown late in 1934 or early 1935, so that its design is very little earlier than the Hurricane and Spitfire. The type was in service in sufficient quantities for there to be machines to spare for use in Spain by 1938. The American pilot, already cited, spoke well of the I-16 as a fighter and said it was very successful, although, according to an Italian aviation paper—*L'Ala d'Italia*, January, 1939, p. 2-3—277 out of a total of 837 enemy aeroplanes claimed to have been shot down by Italian volunteers with General Franco's forces were I-16's—not a good record for a fighter type which was not used for a long period.

It has been said that the I-16 is an improved copy of the U.S. Air Corps' first monoplane fighter, the Boeing P-26. This statement, however, is absurd; as the Boeing had a differently shaped fuselage, thin parallel-chord wire-braced wing and fixed undercarriage—it was, of course, a low-wing monoplane. The I-16 does somewhat resemble another American type, the Gee Bee racing monoplane, but only because of its smallness, and the large radial engine cowling. It is actually an original design by one of the best Soviet designers, Policarpov.

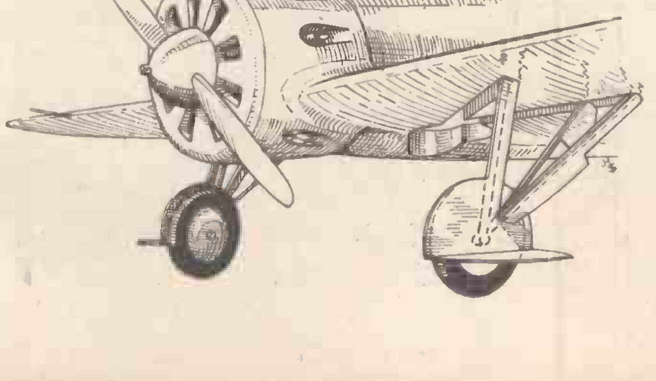
Wooden Construction

The standard I-16 as shown in the drawings on page 354, is of wooden construction. The low-aspect ratio wing consists of two outer panels which are bolted to stub wing roots; the latter being built integrally with the fuselage. There are two wing spars of plywood with solid flanges and Warren-type wooden stiffeners. The main-plane panels have four stout lattice compression ribs with four lighter lattice profile ribs between each, making sixteen in each plane. The chain line in the general-arrangement drawing shows the spars and main ribs of the wing. Only the forward portion of the wing is plywood covered, the greater part having fabric covering. The long narrow ailerons are of aluminium-alloy construction with fabric covering. There are no landing flaps.

The fuselage is a plywood monocoque of an almost circular section. The stub centre section, as has already been mentioned, is built integrally with the fuselage, as also is the fin. Two types of pilot's cockpits are in use; one has the sides cut down to the level of the door shown in the general-arrangement drawing, and a rounded fixed windscreen; the other is the enclosed type, shown in the illustrations, which slides forward to open. The ridges on top of the fuselage are part of the cowlings covering the fuselage guns.

American Engine

The engine in the I-16 is the M-25—that is, it is the American Wright Cyclone built under licence. Although they have several capable aeroplane designers the Russians suffer from a dearth of aero-engine experts, with the result that they have to rely solely upon foreign designs. There have only


Part of the front of the machine, showing details of the undercarriage and exhaust system

been two high-powered Soviet engines, both of them liquid-cooled, one of them unsupercharged, and neither very efficient. The M-25 is a supercharged ungeared nine-cylinder air-cooled radial of 750-800 h.p. It is mounted in front of a fireproof bulkhead. Although the engine may be alien, the cowling is a unique Soviet conception. It is a complete long-chord unit with a front panel in which the cooling air is admitted by individual slots in front of each cylinder. The greatest part of the air escapes through a narrow gap between the trailing edge of the cowling and the side of the fuselage. Exhaust systems totally enclosed in cowlings are inclined to get too hot and, in order to obviate this, the tail pipes from the nine cylinders are led to six chute-like slots where the hot gases are mixed with, and cooled by, escaping cooling air. The large hemispherical spinner serves the double purpose of improving the entry of the nose of the fuselage and of leading air into the cylinder cooling slots. Aerodynamically this cowling must be very good, but it looks as if it would occasion many curses from the hard-worked mechanics. The airscrew is of the American type with detachable metal blades, the pitch of which is adjustable on the ground. An old-fashioned Hucks-starter claw is fitted to the airscrew.

The cantilever tail plane is of light metal construction. Both the elevators and rudder are also of aluminium alloy construction with fabric covering.

Retractable Undercarriage

The retractable undercarriage is made in two units. Each of these is a tripod consisting of a compression leg carrying an inwardly projecting stub axle, on which a medium-pressure tyred wheel is mounted, a rearwardly-sloping drag strut, and an outwardly and rearwardly sloping side strut. The unit retracts inwards, so that the wheel lies partly in the wing root and partly in the bottom of the fuselage. The streamlined tail-skid unit is steerable.

Most of the performance figures quoted for the I-16 in the accompanying table are from a French source (*L'Aviation Sovietique*, published by *Les Ailes*, 77 Boulevard Malsherbes, Paris VIII). and seem to be the most reliable yet published; although *Luftwehr* put the maximum speed as high as 300 m.p.h., and *L'Ala d'Italia* as low as 250 m.p.h.

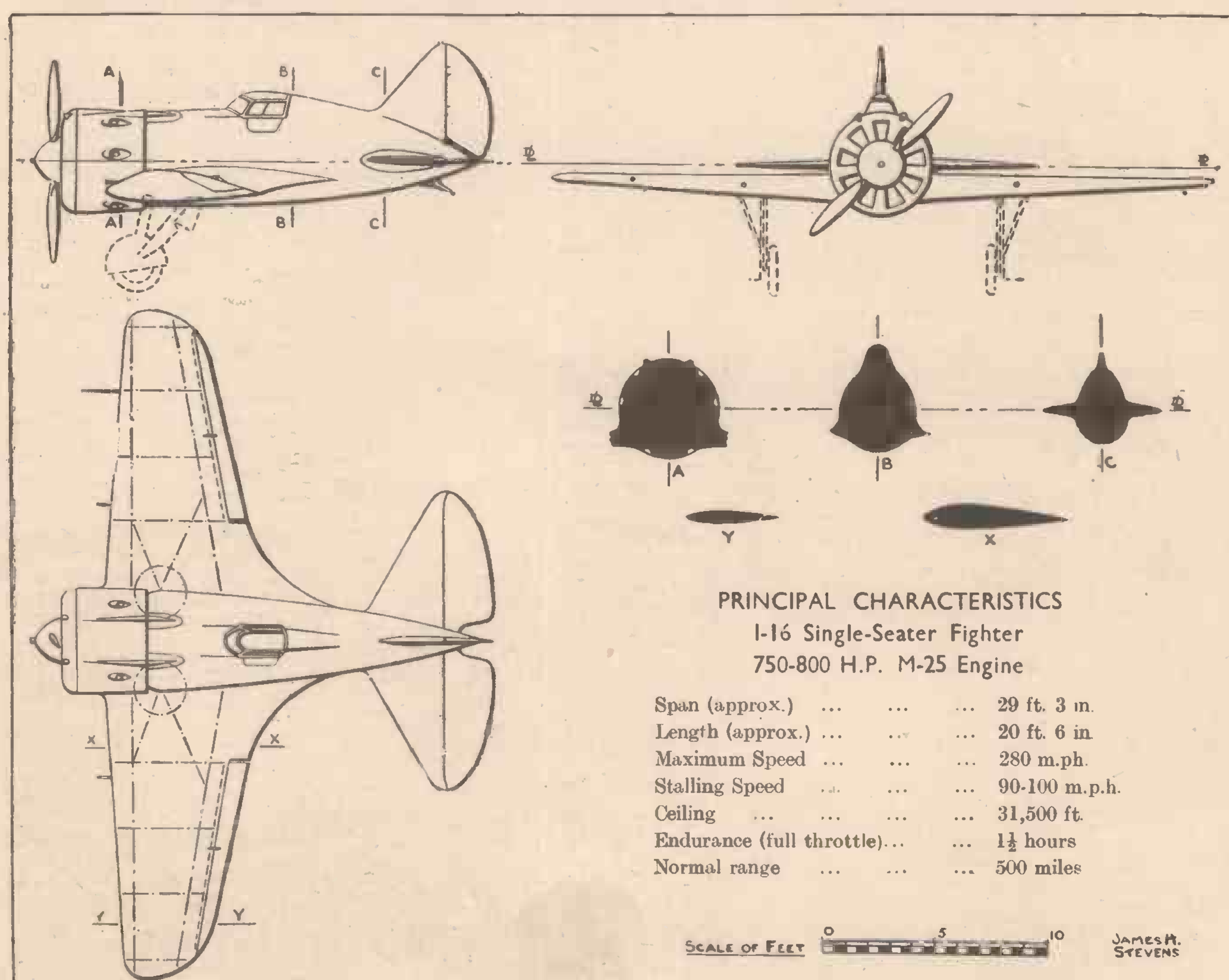
Armament

The standard version of the I-16 is the wooden machine just described, which is armed with four machine guns, two in the wing and two in the top of the fuselage. Variants include a type with only two high-speed machine guns (1,800 rounds per minute as against 1,100-1,200) in the wings; the I-P built of metal and carrying a shell-firing gun in each plane; a ground-attack version which, while retaining the two synchronised guns in the fuselage, carries six further machine guns in the wings; and a two-seater advanced fighter trainer.

Camouflage

The sketch which heads this article shows a number of I-16's in imaginary conflict over Finland, with one supposedly succumbing to a Finnish Fokker. Three of the machines are shown in the usual Soviet colour scheme of dark green with white or silver under surfaces and rudder. One machine is shown in all-white active-service winter paint. The aeroplane in the foreground has had the engine put out of action and the undercarriage dropped in the interests of detail. The red star is carried on wings and fuselage. The rudder usually bears a number but sometimes has a red star instead. The I-16's used by the Republicans in Spain were originally dark green, but the later ones were camouflaged in the effective way now used by the Italians. The whole machine was first painted very light fawn, it was then mottled by uneven patches of grass green (put on "free-hand" with a paint spray) relieved by smaller patches of terracotta—in this colour scheme even the airscrew blades were camouflaged. The insignia consisted of red, yellow and purple cockades on the wings, and the same colour horizontal bands on the rudder.

SIDE, PLAN AND FRONT VIEW OF THE RUSSIAN I-16 SINGLE-SEATER FIGHTER



PRINCIPAL CHARACTERISTICS
I-16 Single-Seater Fighter
750-800 H.P. M-25 Engine

Span (approx.)	29 ft. 3 in.
Length (approx.)	20 ft. 6 in.
Maximum Speed	280 m.ph.
Stalling Speed	90-100 m.p.h.
Ceiling	31,500 ft.
Endurance (full throttle)	1½ hours
Normal range	500 miles

Building a $2\frac{1}{2}$-in. Gauge Model of the "Flying Scotsman"—4

Details of the Tender Frames, Water and Spirit Tanks, Force Pump and Spirit Control Valve

THE tender side frames are of $\frac{1}{16}$ in. planished steel plate, and they are marked out to the dimensions given in Fig. 30. The frames, and slots for the axle boxes are cut out with a hacksaw and cold chisel, and finished by filing.

Fixing the Hornblocks and Springs

There are eight pairs of hornblocks altogether, with four $\frac{1}{16}$ in. holes in each (see Fig. 8). Clamp the hornblocks in position on the tender frames, using a template of the axle box (a piece of $\frac{3}{8}$ in. square brass, or steel, will answer the purpose), and drill through with a No. 51 drill. The hornblocks are fixed with $\frac{1}{16}$ in. copper rivets.

After cleaning up the gunmetal spring castings, lay them on a flat surface and centre-punch the holes for the fixing screws. These holes are drilled and tapped in the "eyes" of the springs which are fixed to the frames, centrally over the axle boxes (Fig. 31), with countersunk screws from the back.

At this stage the axle boxes can be fitted. These are made out of $\frac{5}{8}$ in. by $\frac{1}{2}$ in. brass, and are machined to fit the horn blocks, which are recessed $\frac{1}{4}$ in. at the top to hide the coil spring (see Fig. 17). Each of these springs—there are eight altogether—are $\frac{3}{16}$ in. diameter and $\frac{5}{8}$ in. long (unloaded). On the front of each axle-box is soldered a cover plate cut from $\frac{1}{16}$ in. by $\frac{3}{8}$ in. sheet brass. The keeps, cut off to the lengths required from $\frac{3}{16}$ in. by $\frac{1}{16}$ in. brass strip, are drilled with $\frac{3}{32}$ in. clearing holes, corresponding holes being tapped in the frames for the fixing screws.

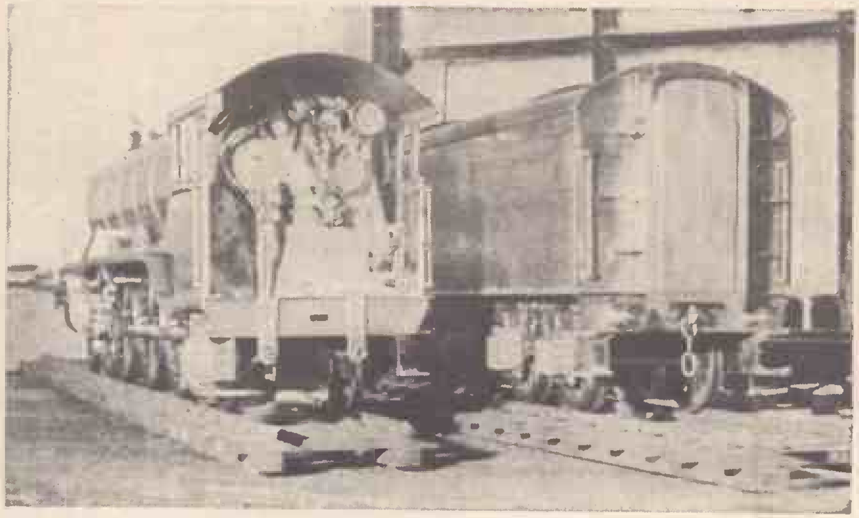


Fig. 34.—Rear views of the completed engine and tender

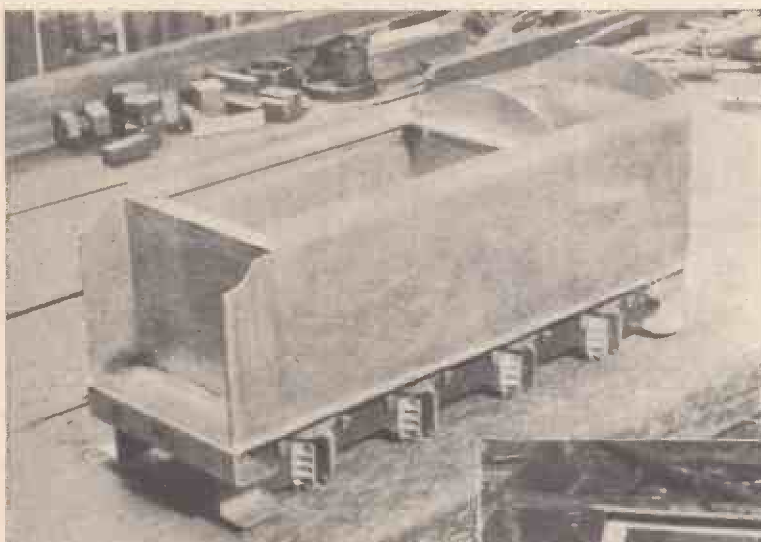
Steps and Buffer Beams

With regard to the fitting of the steps, these are cut out of $\frac{1}{32}$ in. sheet brass, and after being hammered to shape, are riveted in place with $\frac{1}{16}$ in. copper rivets (see Fig. 30). Two lugs, $\frac{3}{4}$ in. long, cut from $\frac{5}{16}$ in. angle brass, are riveted to the frames, on the inside, to support the tender body. These lugs are clearly shown in the drawing.

Clean up the buffer beam castings, and in the rear one set out the buffer centres, using a rule and dividers. In the centre of the front beam drill out and file the slot for the draw-bar which couples the engine and tender. This draw-bar is made from a strip of $\frac{5}{16}$ in. by $\frac{1}{16}$ in. steel, and the dimensions are given in Fig. 21, which also shows one of the draw-bar pins.

The Tender Sides

Mark out the two tender sides on $\frac{1}{32}$ in. sheet brass and cut out with sharp shears. Each side is 13 in. long and 4 in. wide. Finish the edges by filing, and bend the top



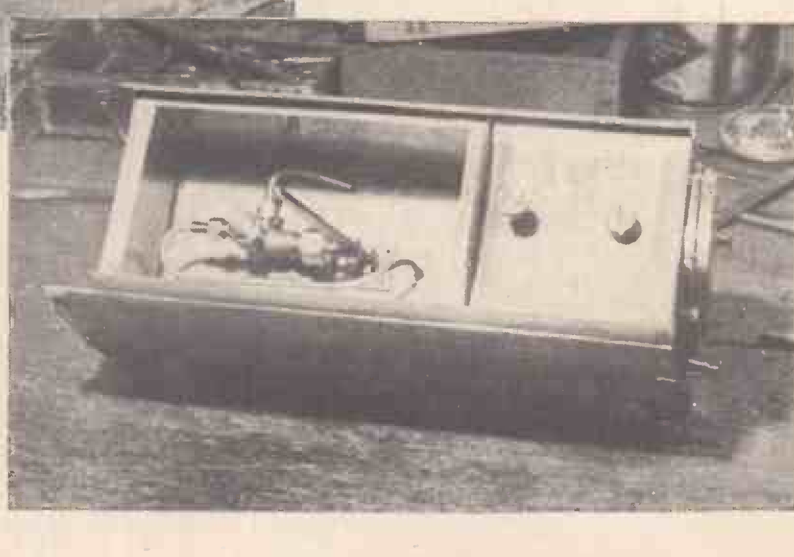


Fig. 31.—(Above) The partly finished tender, with hornblocks and dummy springs in position. Fig. 33.—(Right) Plan view of tender, showing hand force pump, needle valve control, and filler

over in a curve, $\frac{1}{2}$ in. down, and also turn in the front plate of the tender. These can be bent over on $\frac{3}{4}$ in. and $\frac{1}{4}$ in. diameter mandrel respectively. Solder a length of $\frac{3}{8}$ in. angle brass on inside, level with the bottom of the curve. This angle runs the whole length of the tender body to strengthen it (Fig. 31). A partition of $\frac{1}{32}$ in. sheet brass is fitted 4 in. from the back, dividing the spirit reservoir from the water tank (Fig. 30). It has a curved top, as shown in the illustration, and the back of the tender is exactly the same size as the partition.

Angle brass is soldered to the front plate, and along the water partition, keeping in line with the angle brass already fixed to the sides.

Spirit Control Valve

To complete the spirit reservoir, mark out the top plate, of $\frac{1}{32}$ in. brass, and cut out with shears. The positions of the spirit control valve, filler and air pipe to spirit sump are shown in Fig. 30, and holes for these are drilled where indicated. It will be noticed that the needle valve extends through the top and bottom plates of the reservoir, and is soldered in position. The air pipe, the bottom end of which is filed at an angle, as shown, is soldered to the bottom of the reservoir. The dummy corridor connection is cut and filed to shape out of $\frac{1}{32}$ in. sheet brass. It is soldered to the back of the tender. The dummy door is of $\frac{3}{32}$ in. brass plate.

The hand-rail, over the top of the corridor connection consists of $\frac{1}{16}$ in. German silver rod threaded through four hand-rail knobs which are screwed in place. Hand-rails are also fitted on each side of the tender back, and at the front end of the tender side (Fig. 34). This illustration also shows the positions of the six steps, three on either side of the corridor connection. These steps are bent to shape from pieces of $\frac{1}{32}$ in. sheet brass, and are soldered in place. The tender sides are beaded round with $\frac{3}{32}$ in. half round brass, soldered on.

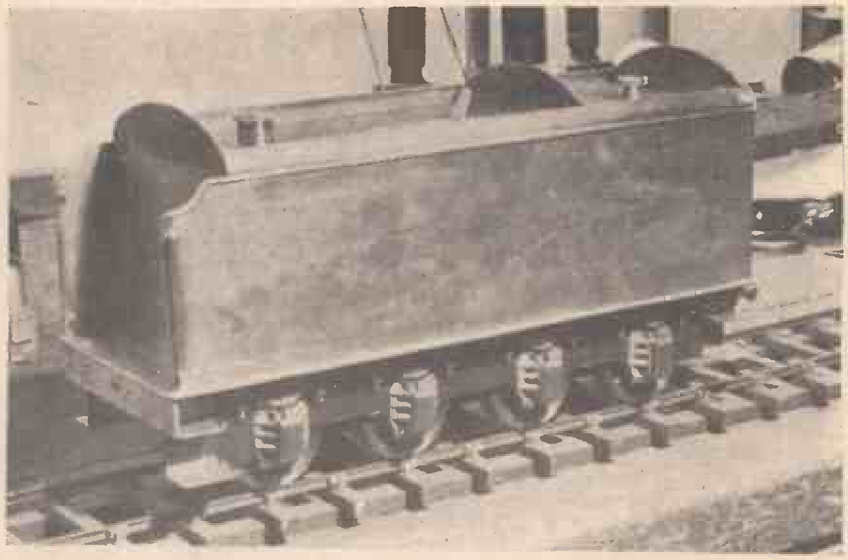


Fig. 32.—Side view of the finished tender, ready for painting

The Spirit Sump

For supporting the spirit sump a stretcher plate, made of $\frac{1}{16}$ in. sheet brass, is fitted between the rear pairs of wheels. The ends of the plate are flanged for securing to the side frames with four $\frac{3}{32}$ in. screws. The plate is cut away to clear the wheels. The spirit sump is made from a piece of mandrel

(Continued on page 372)

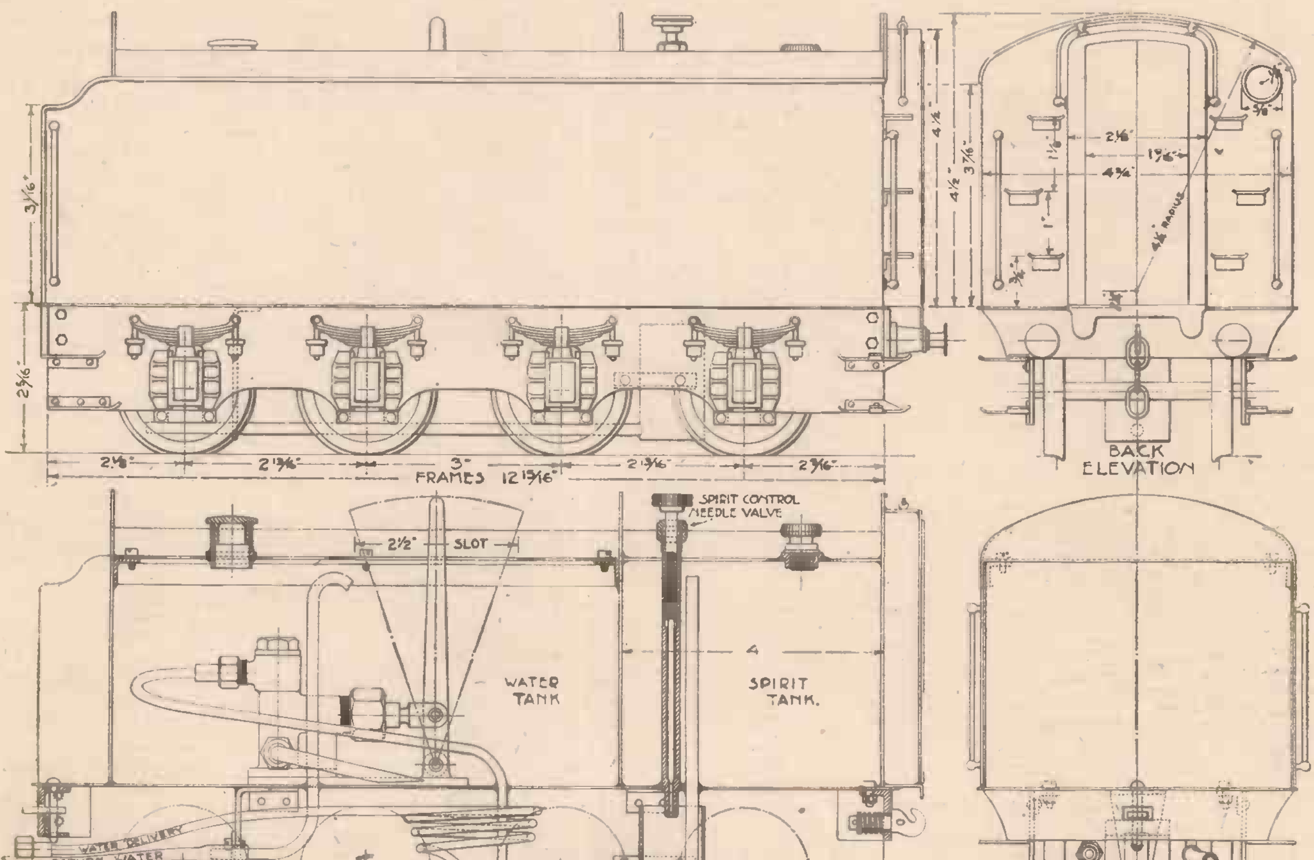


Fig 30.—Side view, section, and end views of the tender

"MOTILUS" PEEPS INTO THE

Some interesting and rare models of famous prototypes are described by Motilus

A fine scale model of the "Revenge," the famous ship on which Sir Richard Grenville sailed. The model is 31 in. long, and 27½ in. high.

HIGH HOLBORN seems to be the happy hunting ground of model hobbyists who are with the Services. A naval man home on leave was in Bassett-Lowke's model shop choosing some parts for his vessel in miniature, when in came a second for a similar reason, and two old friends met. They had been together on the China station four years previously, but had both encircled the globe since last they met. Which reminds me that the men who are carrying on the war are still carrying on with their hobby. An officer in the B.E.F. home on leave came into the Holborn shop, bought a comprehensive layout of the gauge "OO" Twin Trains, and now it is with him "somewhere in France." In the same way a set of parts for building the "Revenge" is helping its owner on some British warship to while away his leisure hours on board ship.

A Rare Model

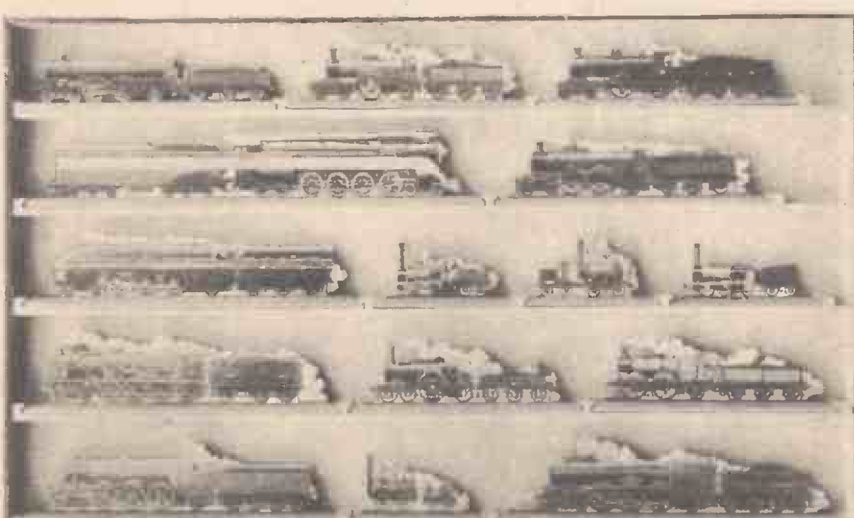
The use of models for public house signs is rare and so it is quite an event to see the very good example recently erected on the rebuilt "Royal George" in Eversholt Street, near Euston Station. As will be seen the model is in flat relief and stands out very well. It is, I take it, of the famous vessel whose fame to most people rests on her having met a tragic end. She was a 100 gun ship—a first rater—laid down at Woolwich in 1746, and she foundered at Spithead in August, 1782, while "being heeled to come at the pipe that leads to the well." You will no doubt remember how she was immortalised in the famous poem, beginning,

"Eight hundred of the brave
Whose courage well was tried
Had made the vessel heel
And laid her on her side."

The practice of heeling a ship over while afloat to make repairs to her bottom, was a common one in those times. The ballast was either shifted or all the guns on one side run out and those on the other hauled in. The lower tier of gun ports would be very close to the level of the water, and little sea-water might enter the ports, though not to any great extent. This is what happened with the "Royal George" but it was not checked in time.

Her tonnage was 2,041, her length 178 feet, and right up to the time of her sinking, she had been on active service, and had been ordered to Spithead for repairs because she was leaking badly. She had been the flagship in turn of Anson, Rodney, Howe and Boscawen. At Quirberon Bay in 1759 she sank the *Superbe*, 70 guns, and fired the *Soleil Royale*, 74 guns.

An interesting model in flat relief, of the "Royal George," used as a sign for a public-house of that name near Euston Station. The original ship, which carried 100 guns, was built in 1746



A case of cut-out models to scale, of various old and new locomotives, representing "Milestones in the Progress of the British Locomotive"

Model Motor Torpedo Boat

The latest developments of the British Navy have been on the lines of small motor torpedo craft, which are most useful for river work and for coastal defence. The illustration shows the hull of a model that is being made. It is being constructed with the co-operation of the British Power Boat Company and is built on the lines of a Hubert Scott Paine motor boat. The hull is of wood painted grey, and the decks will be finished in hard-board. The deck houses are to be all metal grey with machine-gun nests to port and starboard, four torpedo tubes, ventilators, foot rests, ensign staff and the usual fittings and finish of a scale

MODEL WORLD

model. It will be propelled by a marine motor and when finished will show good results besides being most interesting to build.

Cut-out Models

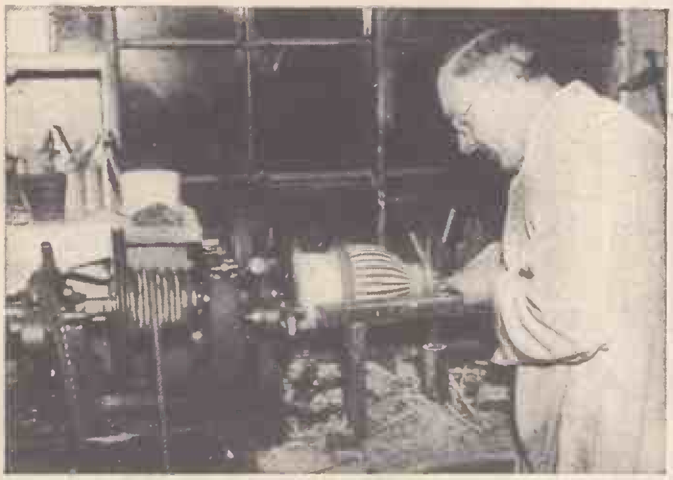
Mr. W. J. Bassett-Lowke was showing me his interesting case of cut-out models the other day. You will remember in "Practical Mechanics" he wrote a series of articles "Milestones in the Progress of the British Locomotive," which appeared in 1938 and the drawings of which were prepared to a scale of 3½ m.m. to the foot by Mr. E. W. Twining. Black line prints are now available and Mr. Bassett-Lowke has had all these mounted on 3 m.m. ply, and they have been carefully coloured by Mr. Twining. The photographs show how handily these can be mounted together in a handy carrying case, and I understand the whole set will be available shortly for model railway clubs in different parts of the country at nominal terms from Bassett-Lowke, Ltd., together with a copy of the lecture.

Pottery Making

Pottery making is one of the oldest crafts in England—in fact in almost every country—and the world-famous firm of Wedgwood, whose line goes back to 1730, is one of the oldest of the potters of England. In their works in the centre of Stoke on Trent is an old lathe made by the famous engineer and steam engine builder, James Watt. It is an ordinary engine lathe and is used for turning pots by hand, and on this lathe have been worked some of the designs of the artist, Keith Murray. The illustration shows Tom Simpson at work on this lathe, polishing up a vase after having obtained the correct outline. This skilled craftsman has worked for Messrs. Wedgwood for 59 years.

All About Owners of Model Railways

That enterprising monthly the *Model Railroader*—published in America—has been sending a questionnaire to all its readers and from their replies has compiled a most interesting survey entitled "The Model Railroad Market, a statistical survey," and here are a few statistics which I am sure will provide food for thought. The "peak" age of the model railroader is between 30 and 35, 23 per cent. of owners being of this age, the next popular being between 35 and 40 and between 20 and 25. The average duration of a model railway owner's hobby is about four years. The highest number of model railroaders earn on an average 2,000 dollars yearly or about £500, and over 50 per cent. of model railway owners spend an average of £10 per annum on their layouts. On the question of occupations, the semi-professional people head the list, and the least enthusiastic owners of model railways are the farmers. Now advancing to the vexed question of gauge. Gauge "O" is by far and away the most popular gauge in America, nearly 50 per cent. of model railway owners operating this size. "HO" and "OO" are next in popularity. Even the question of education is considered and over 50 per cent. have had university or high educations, and half the number of model railway fans in America have workshops.



Tom Simpson is here seen at work on his lathe polishing up a vase with a steel tool after obtaining the correct profile

Lionel Electric Trains

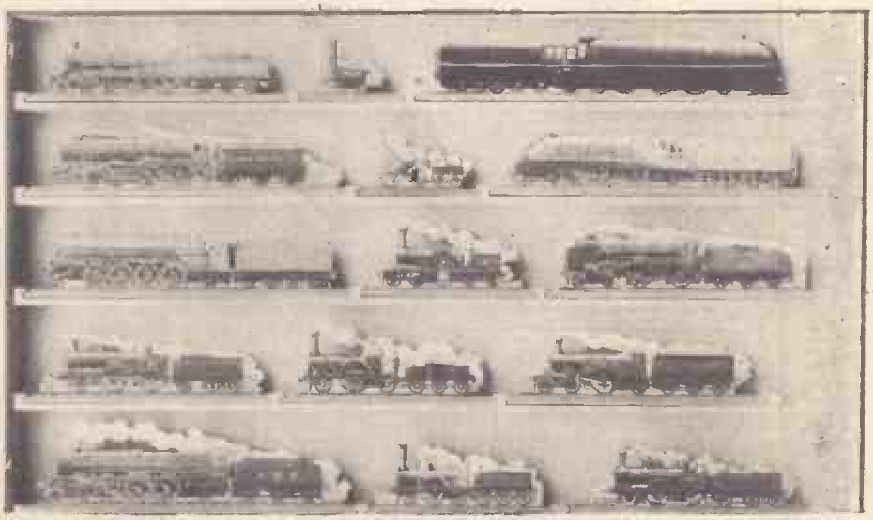
A fine array of Lionel electrically driven train sets is to be seen in the showrooms of S. Guiterman & Co., of 35-36 Aldermanbury, London, E.C.2. Made in "O" gauge, and also to a miniature scale of $\frac{3}{16}$ in. to 1 ft., the locomotives are scale models of well-known American fliers, such as the New York Central Pacifics. There are two systems of working these trains, a 6-8 volt, and a 12-15 volt system, and complete layouts, or separate component parts are available. A start can be made with one train, a transformer, and a few lengths of track, gradually adding new equipment, rolling stock, automatic signalling, etc., till a complete model railway system is installed. These realistic train sets are very reasonable in price; for instance, one outfit consisting of a 9¼ in. streamline Pennsylvania Torpedo locomotive with 8-volt motor, tender, and three passenger coaches, supplied complete with eight pieces of curved track, two pieces of straight track, and a 25 w. transformer for 200/250 volts, costs only 39s. 6d. The train measures 43 inches overall.

This illustration shows the fine lines of the hull of a model of a motor torpedo boat, as now used in the British Navy

Novel Accessories

A novel accessory is a miniature coal elevator, which will actually load model freight trucks by remote control. Imitation coal is conveyed to the top chamber by a series of buckets, and is then released down a chute into an awaiting dump truck. The entire mechanism is electrically operated and is controlled by remote switching.

Other interesting accessories include an illuminated station, a floodlit tower, model power station, and automatic signals and train controls. There is also a large and varied range of "O" gauge model trucks and coaches.



Another group of cut-out models by Bassett Lowke, Ltd., representing the progress made in British locomotive design

A Scale Model Cargo

Constructional Details of a Realistic Model Tramp Steamer

By E.

Illustrated by E. W. Twining

THE model to be described has a rather fine hull, having a block coefficient of .65, that is to say, a comparison of fineness. Average values are .8, an extremely full hull, .7 to .75, an average vessel, and .65, a moderately fine one. The design of the model hull was based on the lower value because of the possibilities of a much more graceful hull than would have been the case had, say, the highest value been chosen. Again, it seems of little use to provide much more displacement than is required to take the weight of the machinery, etc. This applies more to the larger size models, although

per minute. 1½-metre model, 1.5 m.p.h. or about 132 ft. per minute. 1-metre model, 1.2 m.p.h. or about 105 ft. per minute.

Propeller Sizes

To obtain these speeds, suitable propellers must be used. A large propeller is more efficient, theoretically at any rate, but the blades should be as thin as possible. The sizes given below are stock patterns, and for this class of model will be found to give good results. Castings may be obtained from Messrs. Bassett Lowke, Ltd., and are quite reasonable in price. The three-bladed type should be used.

from a brass foundry. The small outside keel, although not usual in this class of ship, will help to protect the hull from possible damage. It may be omitted at the builder's discretion and, if included, should be of square section brass, but in the case of the largest model, could very well be of lead.

"Bread and Butter" Hull Construction

Perhaps the easiest method of hull construction is the "bread and butter" one. Carving the hull from a solid block of timber is better in some respects, as all glued joints are eliminated, but it is rather

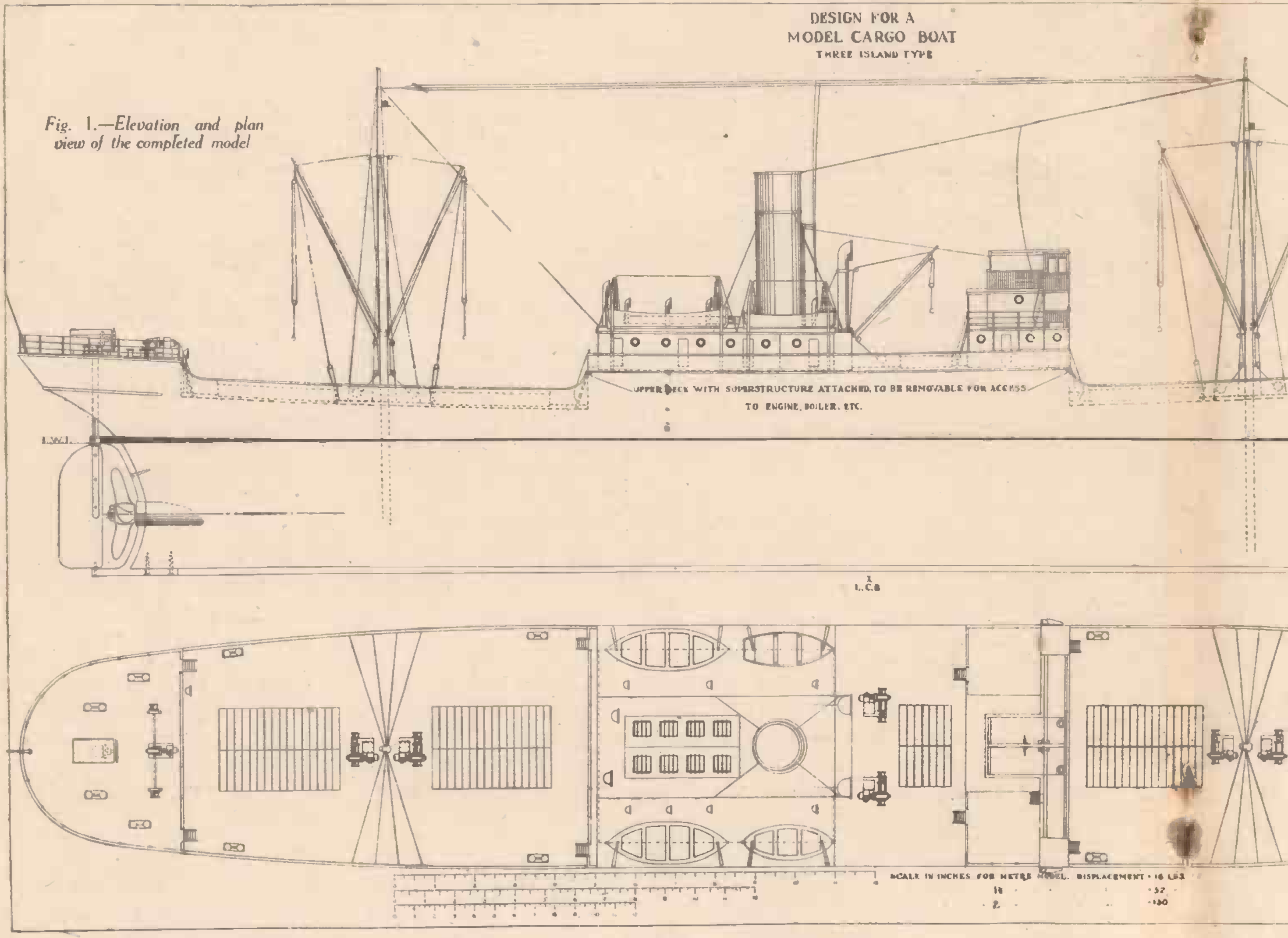


Fig. 1.—Elevation and plan view of the completed model

some extra ballast will be found necessary here, especially so in the case of the 2-metre model.

It would obviously be wrong for a model cargo boat to attain a speed of 5 or 6 knots. To create a correct impression the boat should be run at a scale speed. This, assuming that the prototype has a speed of 10½ knots, or say 12 m.p.h., would be as follows:—

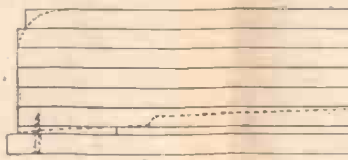
2-metre model, 1.7 m.p.h. or about 150 ft.

	Diam.	Pitch	E.R.P.M.
2 metre	4 in.	4½ in.	500
1½ ,,	3 in.	4 in.	495
1 ,,	2½ in.	4 in.	364

It may be noticed that the E.R.P.M. have been increased by 25 per cent. This is necessary to balance the loss due to propeller slip.

The stern frame should be of brass, and a simple pattern can be cut from 3-ply of correct thickness, and a casting obtained

Fig. 4.—A view of one of the steam winches

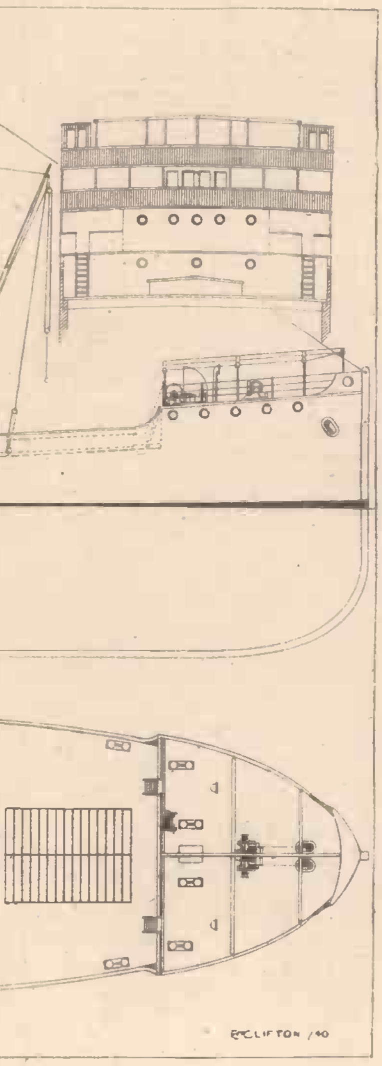


Boat

H. Clifton

difficult to obtain a really sound piece of timber to the size required. Another advantage of the first-named method is that the bulk of the interior shaping is done before gluing together the various planks. It is now possible to purchase waterproof, or water-resisting glue, in powder form, and if the hull is properly jointed and cramped up, there should be little fear of trouble with the joints tending to open when immersed in water.

Yellow pine still holds pride of place for model hulls, but it is not always easy to obtain, and is somewhat expensive. Obeché (or, as it is sometimes named, African



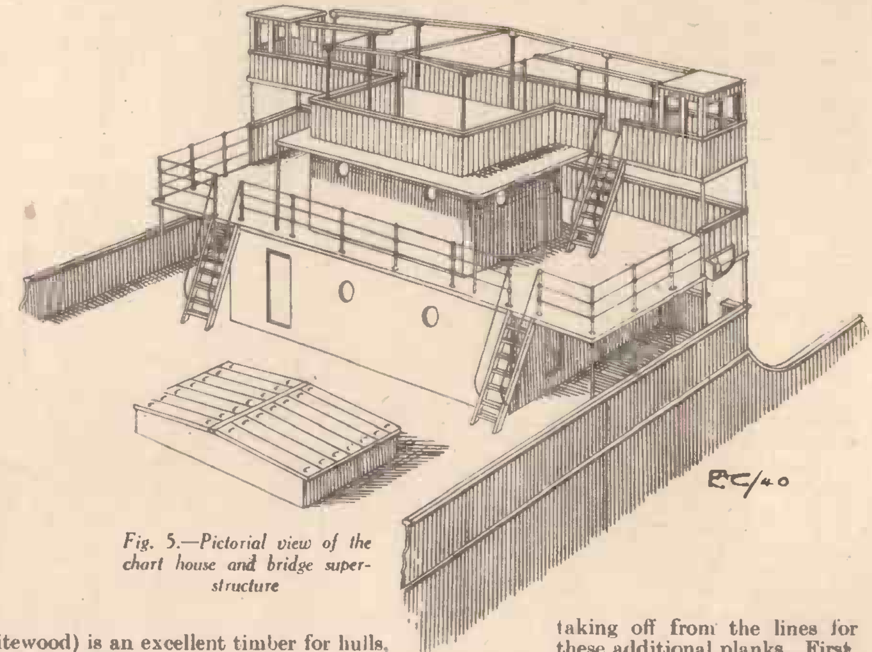


Fig. 5.—Pictorial view of the chart house and bridge superstructure

whitewood) is an excellent timber for hulls, and is even lighter in weight than pine. It possesses a rather open grain, but this slight drawback can be overcome by means of a good wood filler. Western cedar, although not so easy to work owing to its rather spongy nature, is cheap, very light, and is stocked by most timber yards. Really first-class silver spruce is another useful wood for model boat building.

The planks may be of any reasonable thickness, but $\frac{7}{8}$ in. or 1 in. finished is a stock cut in most timber yards.

Marking Out the Planks

The drawing of the hull lines, Fig. 8, shows the number of planks required, and is based on this thickness. For the $1\frac{1}{2}$-metre hull, however, $1\frac{3}{16}$ in. timber will be required, whilst for the 2-metre hull it would be best to subdivide the water planes, and this has been indicated on the body plan in Fig. 8, by dotted lines and lettered A, B, C, etc.; by this means $\frac{5}{8}$ in. timber could also be used for this hull.

No difficulty should be experienced in taking off from the lines for these additional planks. First, draw on each plank at the correct intervals, the section lines, numbers 1 to 13, also a centre line down the length of the wood. The different measurements should now be taken off the body plan with dividers and scale, transferred to the planks, and joined up by means of a thin parallel strip of wood. This must be bent, so as to touch all the points marked. It will probably be found necessary to have a little assistance at this stage; get a friend to run a pencil round the strip whilst it is held firmly down upon the plank. The timber may now be carefully sawn and worked to these pencil lines. Next, place them on top of one another in the correct order (care being taken to see that the centre line registers properly), and draw a pencil line round each of the series of steps. This line will clearly show how close to the outside curves of the hull to cut when bow-sawing out the centres. Do not

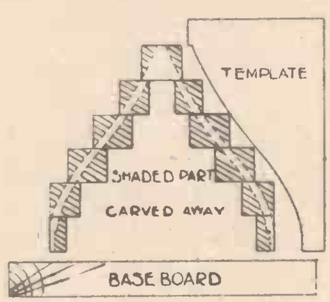


Fig. 2.—Using a template for gauging the lines of the hull body

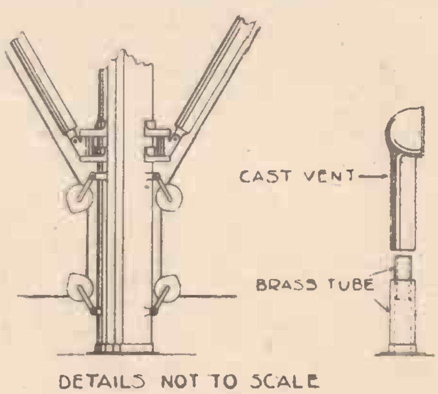


Fig. 6.—Details of derrick fittings and method of lengthening ventilators

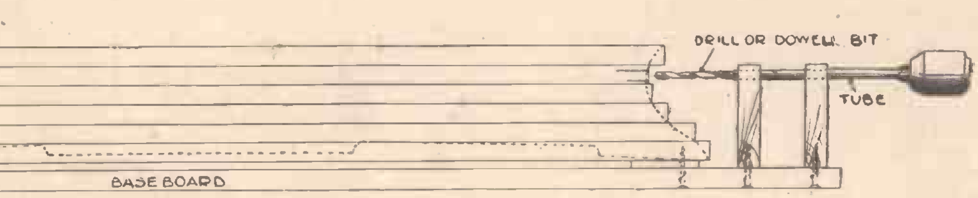


Fig. 3.—Method of drilling the hole for the stern tube

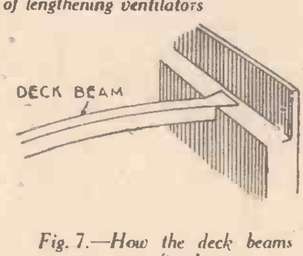


Fig. 7.—How the deck beams are fitted

be tempted to take out too much wood, as there might be a risk of distortion when gluing and cramping up. Leave the hull cramped at least 24 hours for the glue to harden thoroughly. Now make a set of cardboard templates cut to conform exactly to the lines of the body plan. Mark the position of the L.W.L., bulwark and deck on each of these templates. Before commencing the final carving and rounding off of the outside of the hull, the work will be much easier if the roughly formed hull is mounted, deck underneath, upon a plank of wood, packed up where necessary, and temporarily screwed down. This baseboard should also be used when drilling the hole for the stern tube. This must be dead true with the centre line of the boat. A suggestion for overcoming the tendency of the drill to wander is shown in Fig. 3. This consists of two pieces of wood screwed firmly to the baseboard, each piece having a clearance hole drilled in it to take the tubing into which a drill of the right diameter has been tacked with solder. This drilling can, of course, be left until the shaping of the hull is finished.

Work the M.S. section first, and then alternately fore and aft. When the hull has been carved to fit the templates, it should be given a thorough glass-papering. Commence with M.2 grade, then $1\frac{1}{2}$, and finally No. 0 grade. Next apply one or two thin coats of shellac varnish, rubbing down each coat with No. 0 glass-paper.

Carving Out the Hull

The hull may now be removed from the baseboard and the carving of the interior proceeded with. In the writer's opinion, it is unnecessary to carve the hull of the class of model we are dealing with, to extreme thinness; indeed, the writer recently designed and made a metre yacht hull of Western cedar with walls of $\frac{1}{8}$ in., and the whole hull when finished weighed well under 2 lbs. In the case of a high-speed boat, or a small displacement hull, it would, of course, be essential to carve the hull away to extreme fineness. Suggested thicknesses of hull are: for the 1-metre hull, $\frac{3}{16}$ in. to $\frac{1}{4}$ in.; $1\frac{1}{2}$-metre hull, $\frac{5}{16}$ in. to $\frac{3}{8}$ in.; and the 2-metre hull, $\frac{7}{16}$ in. to $\frac{1}{2}$ in. These figures may be increased somewhat if the builder so desires, but a good strong hull should be possible by adhering to these thicknesses. A pair of outside calipers will be of great assistance during this process. Rather more wood should be left at the bow and stern. The bottom plank need not be carved away at all, as a good strong foundation is required for the boiler, etc.

A few deck supports should now be fitted at intervals of 4 in. or 5 in. and should be arranged to leave a clean space over the engine and boiler. The beams should be curved on the upper face to correspond with the camber of the deck. The inside of the hull may now be given a coat of heat-resisting paint; if unobtainable, a mixture of equal parts of gold size, oil varnish and zinc white with a little lamp black added, will be found quite serviceable.

Preparing the Decks

With the exception of the removable portion, all decks should be of $\frac{1}{16}$ in. wood, and American whitewood, yellow pine or satin walnut would be suitable. These decks should be bedded down with white lead paint on to the rebate left after the bulwark has been cut down, and pinned into place with very fine veneer pins. It is suggested that the removable deck amid-

(*Continued on facing page*)

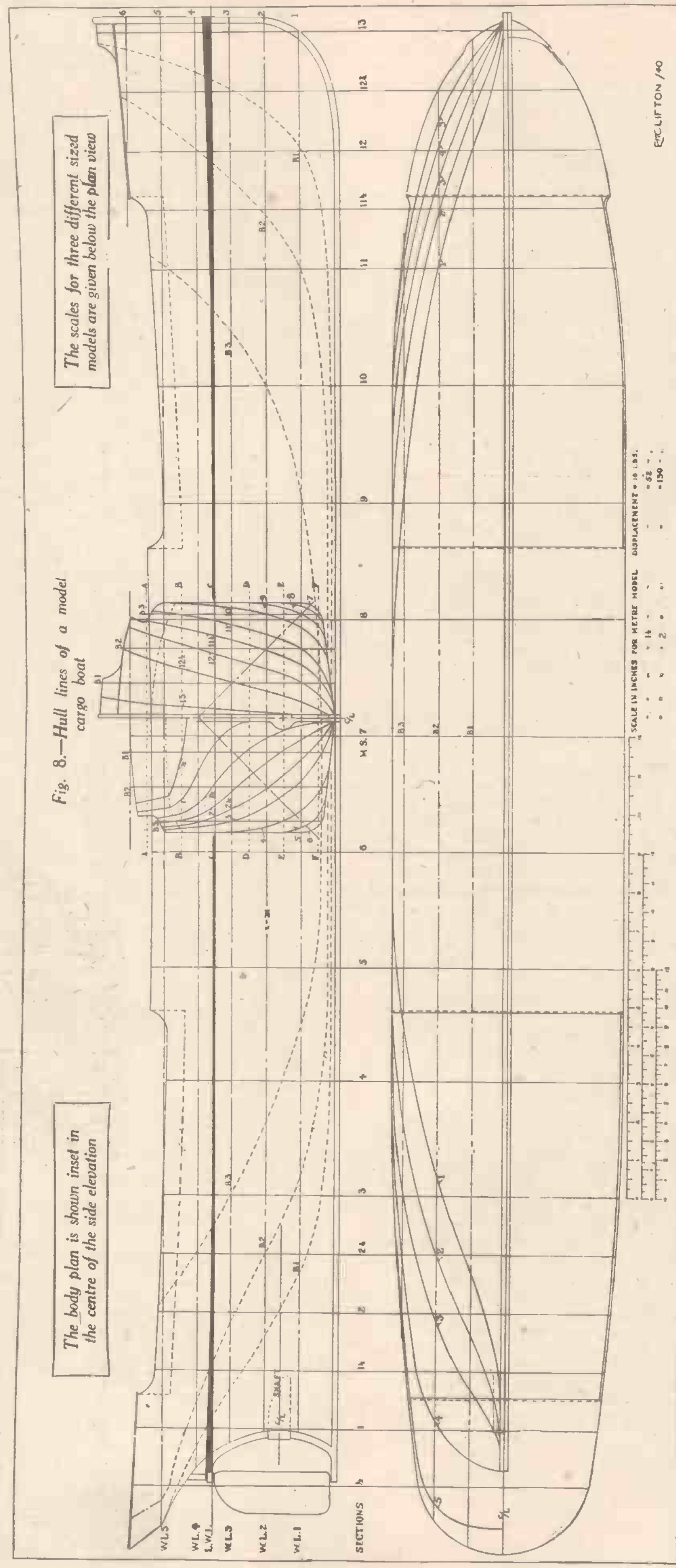


Fig. 8.—Hull lines of a model cargo boat

The scales for three different sized models are given below the plan view

The body plan is shown inset in the centre of the side elevation ships should be of thin brass or sheet tin, of not more than $\frac{1}{32}$ in. in thickness. The deckhouse over the engine room could also be of this thin metal, the boat deck being of wood. The builder must bear in mind that excessive weight of top hamper tends to make the boat cranky, and therefore every effort should be used to cut down weight in this direction. The whole of the bridge, chartroom, etc., should be built in satin walnut, and the "teak" portion should be scribed and finally finished bright. The decks of the bridge should follow the camber of the main deck, as shown on the front view of the bridge (Fig. 1), also it must be noted that all doors and windows should be at right angles with the loadwater line. This is most important on any model of a ship.

Deck Fittings

Sufficient details of fittings have been included in the drawings to make the model representative of its type, but the actual amount of detail incorporated in the model can best be left to the discretion of the builder. If fittings are purchased ready made, do not be tempted to use exhibition type fittings; these, besides being fairly expensive, are rather out of place on a working model.

Messrs. Bassett Lowke, among other firms, stock a useful range of the cheaper type, many of which could be adapted for any of these models. For instance, cast white metal ventilators can be bought for a few pence each, but will require lengthening to agree with the height shown on the drawings. This is quite a simple matter (see Fig. 6), although some care is necessary when soldering the brass tubing to the casting. Before finally fitting these vents to the decking, a hole should be drilled under each one to allow a current of air to find its way to the "engine room." Ventilation is rather important in a steam-driven model, as the heat generated after a few minutes' run is considerable.

Unless the builder has the use of a lathe, and the necessary patience and skill, it would be best to purchase the handrail stanchions. These articles are really a most important fitting, and many an otherwise good model has been spoilt by some makeshift.

Clarke, Chapman winches are shown in the illustration, Fig. 4, but as the model is not an exact copy of any particular ship, any other type of winch of correct scale could of course be used. The masts should be of wood, and birch dowelling of suitable diameter is quite good for this purpose. The taper of the masts, and booms, it should be noted, is not a straight one, being a very flat curve.

The stern tube for any of the models dealt with should have packing glands. Many of the very cheap ones do not possess this refinement. A few extra shillings spent, or a little extra work expended in this direction is well worth while.

Painting and Finishing

Before painting or finishing off the vessel, it will be advisable to fit all the parts to the model and take them off again. It is much easier to line decks, etc., when there is nothing standing in the way. The forecastle, bridge and after decks could be lined with Indian ink to represent planking, and should then be given two thin coats of copal varnish. The well decks should be painted a dark red oxide or purple brown colour, as these decks on a real ship are almost always of steel, and are not sheathed with planking.

Deckhouses should be finished white, two coats flatting, and a final coat of white enamel. The hull may be black or lead colour, although black is most common for this type of boat. Boat topping or water line, vermilion or green, and the underwater part of the hull, Venetian red or red lead colour. Boats and ventilators, white or pale buff; winches, bollard and warping winch on after deck, black. Engine-room skylight varnished satin walnut. Hatches, white painted sides with varnished satin walnut tops. Funnel may be painted to builder's requirements, but very brilliant colour schemes here would be rather out of place on a model tramp steamer.

For the smaller fittings a good brand of cellulose lacquer is to be preferred, as it does not clog the detail work to the same extent as enamel.

Finally, it may be of interest to give the scale of the three sizes dealt with; these are $\frac{1}{8}$ in., $\frac{3}{16}$ in. and $\frac{1}{4}$ in. to 1 ft. respectively.

RECORDING AND PLAY-BACK EQUIPMENT

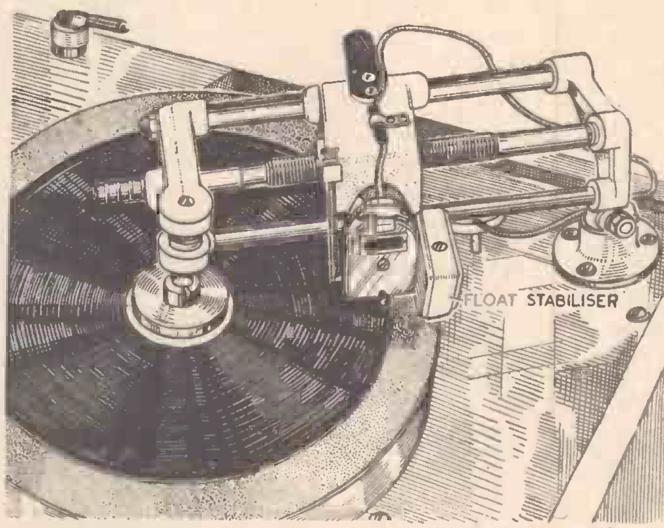
THE process of home-recording is a fascinating one, and many amateurs have already made up recorders which give very good results. There is, however, a market for records made at dances and other public functions, where individuals may make records to keep as souvenirs, and for this purpose something more elaborate is required. One of the main features is constancy of turntable speed, and the cutting head must be really well designed if the results are to be worth while. We have reviewed several types of apparatus for this purpose from time to time, and it would appear that in America this type of equipment has reached some rather high levels. One such is illustrated on this page and is an R.C.A. Victor unit.

Self-contained Unit

It is complete in itself, containing in the unit all the components necessary for making recordings of professional quality and playing them back immediately after completion. The turntable may be set for either 78 or 33 r.p.m. The cutting head is provided with a float stabiliser which acts as a shock absorber on the cutting head and thereby assures utmost smoothness and freedom from surface noise in recording. Other features in the equipment are a high-fidelity ribbon-type microphone with floor stand, motor and turntable assembly, together with amplifier for the recording function. A high-fidelity speaker, reproducing pick-up and tone arm are also incorporated within the cabinet. A visual volume indicator assists control and regulation of the recording level, and a jack is provided, so that headphones or a remote speaker may be used for monitoring.

Other Models

There are several similar pieces of apparatus available in the U.S.A., and they all appear to make use of the micrometer rod which guides the recording head along the disc. This is the most critical part of the apparatus and absolute smoothness of movement is essential. Furthermore, the recording head must also be free from shake or the effects of vibration and yet at the same time should be capable of being lifted at any part of the record where it may be necessary to interrupt the recording. In an instrument produced by the Federal Recorder Company, two buttons are mounted on the head, and by pressing these the drive mechanism is released and the head may be slid back and forth to any desired point. In this particular model also smoothness of running the turntable is assured by using a steel turntable weighing 35 lbs. Another idea for turntable reliability is the provision of a rim drive, enabling a really sound pivotal system to be used in the centre of the disc and at the same time providing a high-speed motor with a very small disc drive bearing on the wide rim of the turntable, without the introduction of a series of gears which might give rise to shake.



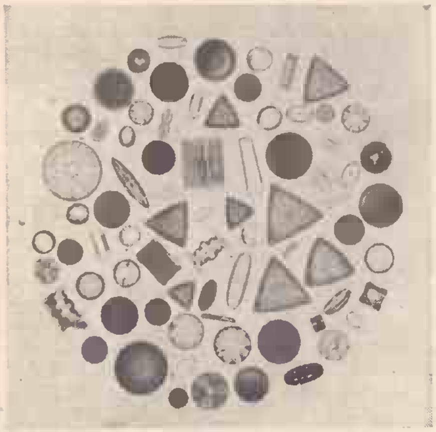
A general view of the R.C.A.-Victor Recorder, showing the float stabiliser

AN ELECTRIC FURNACE

A LARGE furnace in one of the works of Leyland Motors, Ltd., for stabilising and nitriding heavy crankshafts is now in full commercial operation. It is the first installation of its kind. The crankshafts are suspended and both the stabilising and nitriding are achieved with negligible distortion. The furnaces are of the vertical cylindrical type and the cylindrical pots which take the place of the ordinary nitriding boxes, have a very simple, quick and effective method of closure.

Chemistry for Beginners

No. 14—Silicon, the Sand Element. Engrossing Experiments in a More Unusual Field of Practical Chemistry



"Diatoms" or perfectly formed skeletons of minute living organisms as seen through the microscope. Each one is about one quarter the size of a pin's head, and consists of pure silica, or silicon dioxide

OWING to the fact that sand is insoluble in nearly all liquids and remains unaffected by most laboratory chemicals, few experimenters pay much attention to this greatly abundant material. Yet sand is a very important commodity, not only in the strictly economic sense, but also in respect of its status in the chemical world. For sand, as most chemical enthusiasts will be aware, is the oxide of silicon, being composed of one atom of the element silicon combined with two atoms of oxygen. Having the chemical formula SiO_2, it is, therefore, termed silicon dioxide, or, perhaps, more frequently, *silica*.

Now silicon is a very interesting element in many different respects. In the first place, it is, with the one exception of oxygen, the most plentiful material in the world. Sand is composed mainly of silica. So, also, is a large proportion of the earth's rocks and minerals. Mountain ranges weighing in the aggregate millions upon millions of tons are composed for the most part of the element silicon existing in combination with other bodies. All clays contain silicon, and even tiny living organisms called "diatoms" possess skeletons composed of pure silicon dioxide (silica), which, when viewed through the microscope, exhibit many varied and astonishingly beautiful geometrical patterns.

Silicon, indeed, is to be found everywhere on the earth's surface. As an element, it comprises about one-quarter of the total weight of the earth's solid crust, although, in the uncombined state it never occurs. So great is the affinity of silicon for oxygen, that it is most difficult to separate the two elements from each other. Hence, in most instances the element silicon (whose name, incidentally, is derived from the Latin, *silex*, meaning flint or granite) is found in the form of its dioxide, nowadays universally known as "silica."

Common Sand

The best known form of silica is sand. In reality, common sand consists of nothing more nor less than tiny grains of silica, which comprise the debris of huge masses of rocks and granites which once formed cliffs, bays, and headlands. The ceaseless action of water upon these rocks has, during the course of countless years, washed away the more easily soluble constituents, leaving the hard, insoluble silica grains as a fine, gritty mass on the shore.

Sand, therefore, is one of the most abundant sources of silicon, and although almost any type of flint, quartz, granite, and sandstone will serve as a satisfactory source of silica, we shall confine ourself in our description of the present experiments mainly to the use of sand, since this material is everywhere and cheaply obtainable.

For chemical experiments dealing with the subject of silicon and its compounds, it is best to use the finest white sand. If the only grade of sand which is available is strongly coloured, it is best to boil it up several times with strong hydrochloric acid in order to get rid of the iron and other soluble metallic constituents. This type of treatment, combined with several good intermediary washings, will clean up any reasonably good grade of sand and will end by converting it into "fine white sand," which, as we have already pointed out, consists almost solely of silicon dioxide (*silica*), SiO_2.

Now, although silica is insoluble in all acids (except hydrofluoric, and, to a lesser extent, phosphoric acid), it is easily converted into a soluble condition by fusion with ordinary sodium carbonate or washing soda. The soda should have previously been heated up to rid it of its contained "water of crystallisation." It should then have been finely powdered, and only in this state should it be intimately mixed with an equal quantity of fine white sand.

Natures silica crystalline masses of quartz, or silica dioxide, which exists in enormous quantities in the earth's crust

This latter mixture should be placed into an ordinary clean tin can (a disused cocoa tin, for instance, will suit admirably), in which receptacle it should then be heated to a bright red heat in the middle of a hot, smokeless fire. A quarter of an hour of this heating will suffice to convert a portion of the silica into sodium silicate, which is soluble in water. This sodium silicate may be extracted from the residue of silica by boiling water, after which the solution may be gently concentrated by heating to a thick syrup, the well-known "soluble glass" or "waterglass," which consists of almost pure sodium silicate.

"Waterglass"

This sodium silicate or waterglass is, as its name implies, an actual glass which happens to be soluble in water. Potassium silicate is also water-soluble, but all or most of the other metallic silicates are insoluble in water under ordinary conditions. Thus, by fusing up to bright red heat a mixture of silver sand, limestone, soda, and red lead, we get ordinary glass, which is a very complex mixture of different metallic silicates. Window glass is chiefly a soda-lime (or sodium-calcium) silicate. By fusing up read lead or litharge with sand we get a lead silicate, which is an easily fusible glass of brilliant lustre, much used nowadays for making artificial "paste" jewellery.

Making Glass

It is, of course, actually possible for the amateur to prepare small quantities of these different glasses at home, provided he can heat his "mixes" up to bright red heat, but, of course, to prepare such materials in any quantity is out of the question in view of the difficult fusible nature of these glasses when heated in large bulk.

As we have already noted, it is not easy to separate the element silicon from its combined oxygen in silica or silicon dioxide. The best way of doing it, perhaps, on a small scale is to make a mixture of 2 parts of fine white sand and 3 parts of magnesium powder, and to heat this mixture to a bright red heat in a closed crucible. Under these conditions, the magnesium, having itself a powerful affinity for oxygen, abstracts the oxygen from the silicon dioxide (silica), becoming converted into white magnesium oxide, which may subsequently be dissolved away in hydrochloric acid, leaving the freed element silicon as a dark brown amorphous powder.

It is also possible, as we shall see later, to obtain pure silicon in a brilliantly crystalline condition, in which state the element appears as a steel-like material, brittle, but exceedingly hard.

Apart from the fact that it burns in air, silicon, which is essentially non-metallic in nature, is a comparatively inert element. It is insoluble in acids (except hydrofluoric), but when heated in chlorine gas, it takes fire and burns with the formation of silicon tetrachloride. Crystalline silicon is hard enough to scratch glass, and, indeed, a good piece of this material (which is nowadays a commercial commodity) may be employed as a very useful glass-cutter.

In most of its properties, silicon very greatly resembles the element carbon. Hence, chemists place silicon in the carbon family of elements, with carbon on one side of it and the metal germanium on the other.

Silicon Hydride

Just as carbon combines with hydrogen to form the gas methane, CH_4, so, also, silicon forms an analagous compound known as silicane, or silicon hydride, SiH_4. It is almost impossible for the ordinary amateur to make this gas in its pure state. Nevertheless, it may be prepared, admixed with some hydrogen, by acting upon magnesium silicide with hydrochloric acid. Magnesium silicide for this purpose may be made by strongly heating in intimate mixture of 1 part of sand and 4 parts of magnesium powder.

Silicane is a colourless gas. As ordinarily prepared, it is spontaneously inflammable, bursting into flame immediately it comes into contact with air. This inflammability is conferred upon the gas in consequence of the presence of traces of another hydride of silicon which is inherently spontaneously inflammable, and which is generated in small quantities along with the normal silicon hydride or silicane. The perfectly pure silicane is not spontaneously inflammable, yet it possesses the curious property of bursting into flame when a jet of it is made to impinge upon a flask filled with merely warm water.

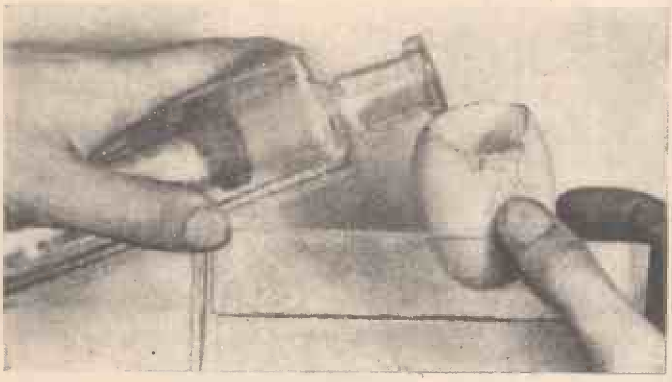
Silicon Tetrafluoride

Perhaps the gaseous compound of silicon which is easiest for the amateur to prepare is silicon tetrafluoride, SiF_4. This, incidentally, comprises one of the few fluorine compounds which are available for the amateur's preparation.

To make silicon tetrafluoride, all we have to do is to place in a capacious flask fitted with a delivery tube a mixture of equal quantities of powdered fluorspar (calcium fluoride) and fine sand. The mixture in the flask is then covered over with concentrated sulphuric acid and gently warmed. Immediately silicon fluoride is evolved, and it appears as a colourless, fuming, noninflammable gas, having a sharp, pungent odour akin to hydrochloric acid gas.

When the gas is led into water a rather remarkable effect occurs. In contact with the water, it is immediately decomposed into hydrofluosilicic acid and silicic acid :

$$\underset{\text{Silicon tetrafluoride}}{3SiF_4} + \underset{\text{Water}}{3H_2O} = \underset{\text{Hydrofluosilicic acid}}{2H_2SiF_6} + \underset{\text{Silicic acid}}{H_2SiO_3}$$

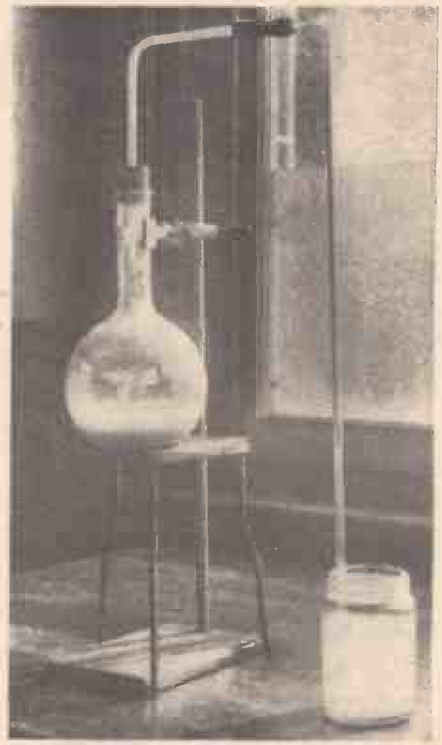


A useful dodge for filtering solutions in the laboratory; it comprises an empty eggshell, pierced with a hole in the bottom and filled one-third with cotton wool. It makes quite an effective and useful filter for rough work

Each bubble of silicon tetrafluoride gas, as it comes into contact with the water, is immediately decomposed. Silicic acid is precipitated as a gelatinous mass around each bubble, and the hydrofluosilicic acid passes into solution. On filtering the liquid, the solid silicic acid is obtained as a white powder, whilst the hydrofluosilicic acid is obtained in clear solution form. This solution, however, cannot very well be concentrated by heating, since it decomposes into silicon tetrafluoride and hydrogen fluoride. It can, however, be neutralised by metallic hydroxides, forming fluosilicates. In this way, by carefully neutralising the solution of hydrofluosilicic acid with a solution of caustic potash, potassium fluosilicate may be obtained, and this, when heated with an excess of aluminium powder, produces crystalline silicon. The excess of aluminium is thereafter dissolved away by acid, leaving the crystalline silicon behind.

Pure Silica

Reverting now to the gelatinous precipitate of silicic acid which is formed in the water when silicon tetrafluoride gas is passed through the latter liquid, this material is soluble in a solution of sodium carbonate with the formation of sodium silicate. It also combines with other soluble carbonates to form metallic silicates. When heated strongly, the silicic acid is converted into pure silica, thereby providing a convenient means of obtaining absolutely pure silicon dioxide. Care must be taken in preparing silicic acid not to let the gelatinous precipitate block up the gas-delivery tube.

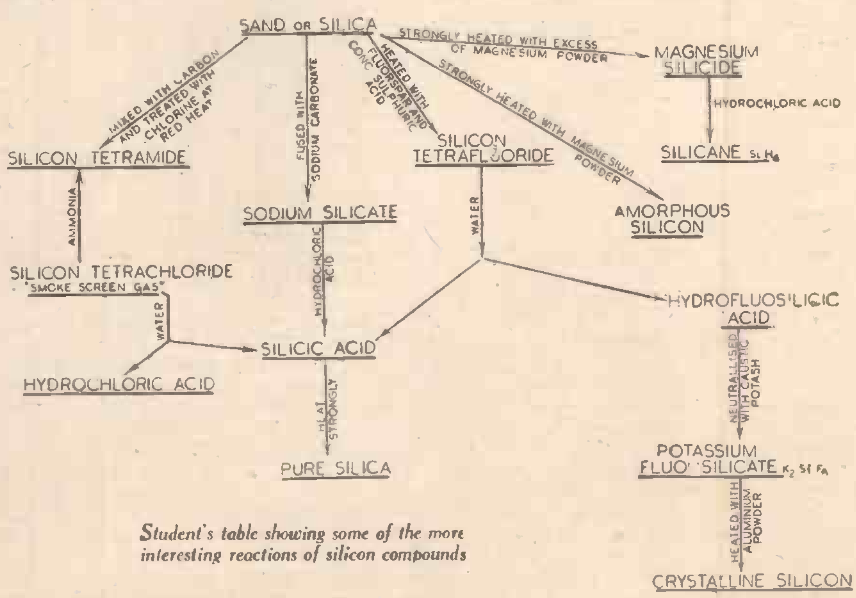


Making Silicon Tetrafluoride and also Hydrofluosilicic acid by the action of warm concentrated sulphuric acid on a mixture of powdered fluorspar and sand

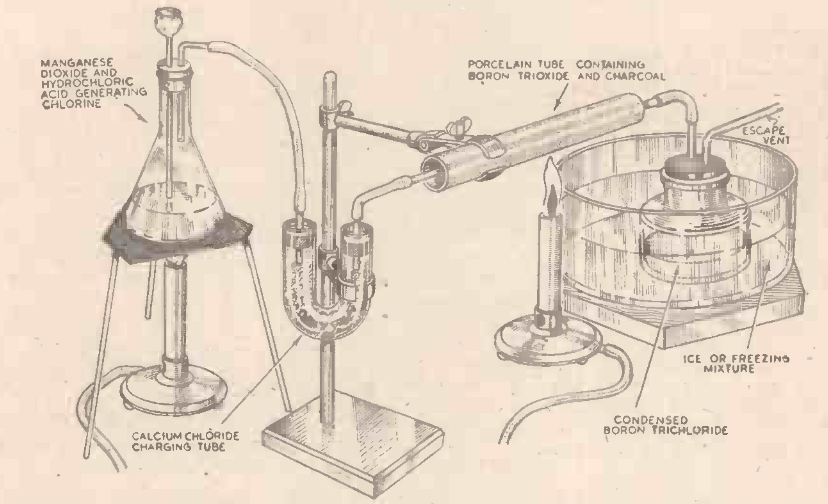
The exact composition of silicic acid is still a matter of dispute among chemists. In all probability it is a much more complex material than it would at first appear to be, and it is almost certainly a mixture of several different silicic acids.

A gelatinous mass of similar properties, and usually known as "silicic acid," is very readily prepared by adding hydrochloric acid to a solution of sodium silicate. Under different conditions of formation, this "silicic acid" may vary considerably in properties.

When wood is soaked in a bath of lime water and then transferred to a solution of hydrofluosilicic acid, prepared as above, the timber becomes coated with a stone-like film. Paper and cardboard can similarly



Student's table showing some of the more interesting reactions of silicon compounds



Sketch showing the apparatus for the production of boron trichloride, as described in last month's article

be impregnated, and thus rendered highly fireproof.

Silicon Tetrachloride

Coming now to a matter of topical interest, it may be noted that silicon tetrachloride, $SiCl_4$, which is without difficulty prepared by passing dry chlorine gas over silicon heated in an iron tube, and by condensing the evolved fumes in a cooled U-tube, has been much used as an aircraft smoke-producer, since it comprises a liquid which fumes strongly in air. The dense white clouds which it produces in contact with moist air are due to its being decomposed by water into a mixture of silicic and hydrochloric acids :

$$\underset{\text{Silicon tetrachloride}}{SiCl_4} + \underset{\text{Water}}{4H_2O} = \underset{\text{Silicic acid}}{Si(OH)_4} + \underset{\text{Hydrochloric acid}}{4HCl}$$

This useful compound may also be prepared on a small scale by passing chlorine gas over a strongly heated mixture of finely powdered silica and carbon.

Silicon tetrachloride, when brought into contact with ammonia vapour, produces still denser white fumes, owing to the formation of ammonium chloride and silicon tetramide, $Si(NH_2)_4$.

"Silicate Garden"

One final experiment in connection with silicon and the silicates is that of the "silicate garden." When a solution of a metallic salt, such as copper sulphate, is added to a solution of sodium silicate (waterglass) a precipitate of the insoluble metallic silicate is formed, which, in the case of copper silicate, is a bright green in hue. Acting upon this principle, if now we take a beakerful of waterglass and drop into it gently single crystals of various metallic salts, as, for instance, copper sulphate, iron chloride, cobalt chloride, manganese sulphate, etc., there will in time, arise from the crystals as they rest on the bottom of the beaker peculiar thread-like branches and "streamers" composed of the highly coloured silicates of the several metals whose salts have been dropped into the waterglass solution. If the solution is allowed to remain undisturbed for some time, these filaments will spread slowly through the liquid, growing upwards and outwards from each crystal like the branches of some curiously shaped underwater plant.

The whole effect is, of course, entirely dependent upon the precipitation of the insoluble silicate of the metal contained in each salt crystal which has been dropped into the waterglass solution. When the variously coloured "streamers" intermingle, some very pretty and curious effects may be seen.

New Dive-Bombers

DELIVERY to the U.S. Navy of the first of a large production order of the new Curtiss SBC-4 Dive-Bombers for service aboard the aircraft carriers of America's scouting and battle fleets, has been announced by the Curtiss-Wright Corporation.

Designed for scouting and dive-bombing, the new SBC-4 is an all-metal, two-seater biplane of monocoque construction, powered with a 1,000-h.p. Wright Cyclone engine, equipped with completely retractable landing gear and tail wheel, and an automatically-functioning, hydraulic system which operates both landing gear and flaps.

Split type flaps on the trailing edge of the lower wing, provided for use during dive-bombing operations, limit its vertical diving speed, thereby assuring greater bombing accuracy, greater ease of pilot control, and reduced strain on the pilot and plane during diving and pull-out.

The new Curtis SBC-4 dive bomber

A German Mine-Laying Seaplane, Heinkel 115

ONE of the aircraft types popular with the Nazis for laying mines from the air is the Heinkel 115. Operating from bases on the islands of Sylt and Borkum, these large, two-motor seaplanes have frequently flown over the waters round Britain's coasts, attempting to lay mines in the paths of British and Neutral shipping.

The Heinkel 115 is a twin-float, mid-wing monoplane with an all-up weight of about 9 tons. The wing span is 72 feet 10 inches, and its length is 56 feet 9 inches. It carries a crew of three and it has an effective range of about 1,300 miles.

Two B.M.W. radial motors, each rated at about 850 h.p., are fitted, and they give a cruising speed of 180 m.p.h. The maximum speed claimed is 220 m.p.h. The service ceiling, or maximum operating height, is said to be 21,300 feet, or about four miles. The load it is reputed to carry, in the form of mines, torpedoes, or bombs, is about a ton.

The fuselage is a strong, monocoque structure, of a design intended to avoid breaking up in the event of a crash on the sea. The aircraft carries a collapsible rubber dinghy.

The performance figures of the Heinkel 115 show it to be a fairly fast, relatively lightly armed aircraft which can be used for a variety of purposes. Against British defence fighters such as the Vickers Spitfire, which has a speed of over 360 m.p.h., the Heinkel 115 has had to rely on evasion to avoid destruction. Nevertheless, several have been shot down in action by British aircraft.

Baird Bomb Detector

BAIRD TELEVISION have been turning their scientific abilities to wartime use and it is announced that they have succeeded in developing a sensitive photo-electric detector for indicating the presence of incendiary bombs and fires. The apparatus is so sensitive that it will operate from the flare from 10 grains of magnesium flash powder ignited 260 ft. distant.

Low-Wing Design and Construction

The Pros and Cons of this type of Design for Model Aircraft

ASK the average constructor why, in common with about 99 per cent. of his fellows, he builds nothing but high-wing monoplanes, and he cannot tell you. He has simply followed a fashion. As to why such machines are so popular, vaguely he supposes that inherent superiority must have something to do with it. Besides, hasn't so-and-so, winner of the Wakefield and everything else, declared that low-wing models are difficult and unsatisfactory?

That is about as far as the subject is usually pursued, except for an occasional half-hearted experiment, and so an interesting and potentially useful type of model is libelled and neglected.

That High-Wing Complex

It will help us to view this question of wing-placing in true perspective if we briefly examine the origins of high-wing popularity. They are two-fold. In the first place, the high-wing lay-out is the simplest and most obvious way of building, and so comes naturally to the hand of most beginners. Then, when they essay competitive flying, they receive a second impulse towards the high-wing lay-out. For, until comparatively recently, the royal road to "big durations" which, for reasons which need not concern us here, are what matter in practically every contest, was to build the model as lightly as possible.

This meant the use of ultra-light materials, and simplification of structure. The one-piece wing, coupled by rubber-strip to the top of a slab-sided fuselage, fitted the case perfectly, any other type being under at least a small handicap. Few modellers seem prepared to consider the subject apart from the cup-winning aspect, and so for most the high-wing monoplane remained for years the most logical type to build.

Hence, although the weight and wing-area formula now imposed in major contests eliminates the need for ultra-light construction, and so makes various lay-outs practicable, modellers generally continue with the highly-developed high-wing type. Few are prepared to turn to the low-wing type, and build up a new technique because meanwhile the cups would go elsewhere!

And all too frequently the few who do essay a low-wing design, proceed by the high-wing methods with which they are so familiar, with the result that one hears complaints of "hedge-hopping," indifferent stability, and poor glide.

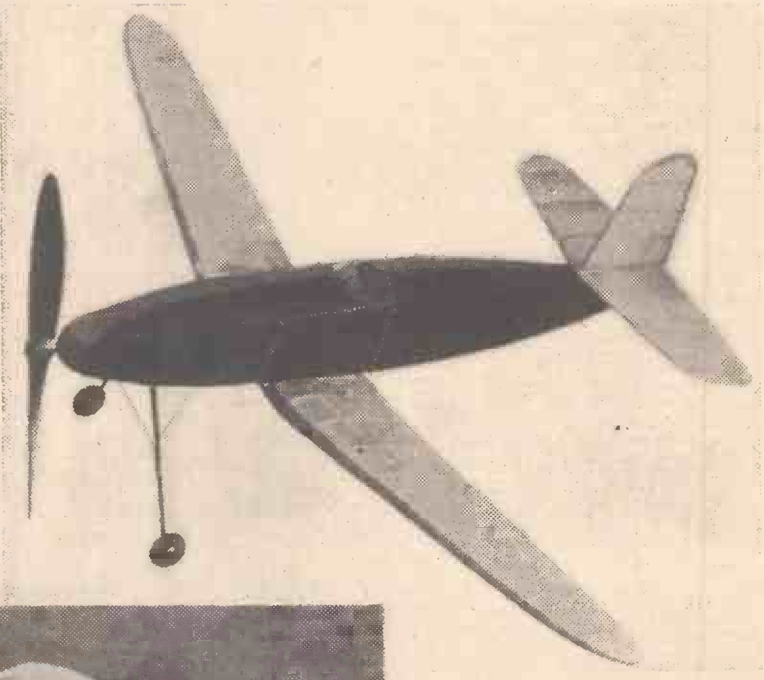
Let it be remembered that in pre-feather-weight days, a low-wing model won the Wakefield Cup. And the "Kinglet" beginners' model, despite its birch and steel wire construction, and the crudity of the single-surfaced wing which it sported, on a number of occasions achieved "out-of-sight" flights. It certainly was not done on long motor run.

But, the reader may ask, why bother about a low-wing model, since the high-wing type is so satisfactory?

Low-Wing Pros. and Cons.

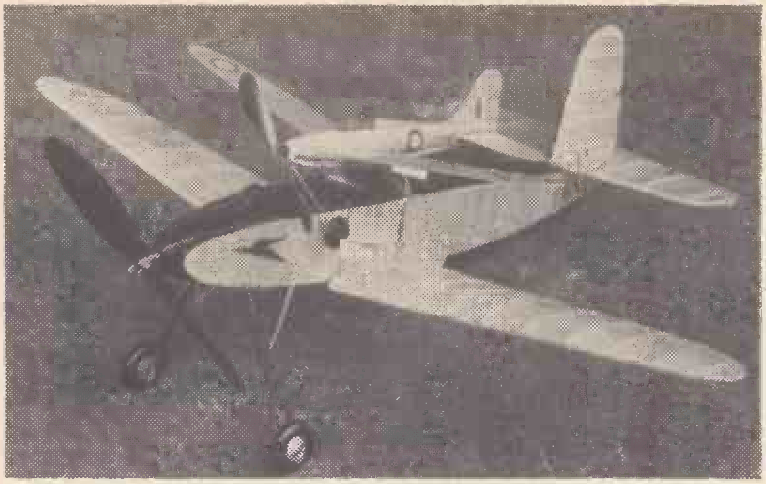
After all, wind-tunnel research has indicated that of the various possible lay-outs,

A low-wing composite model. A 2 oz. model carried by a Wakefield type



(Above) Mr. Knight's low-wing model "Kestrel"

(Left) Mr. John Coxall's Magister-type low-wing model, winner of the Bowden Trophy in the last pre-war S.M.A.E. contest



Mr. Knight's low-wing composite model "Kenna"

the low-wing is the least efficient. But that is not the whole of the story. Experienced modellers will be well aware that structural considerations may outweigh advantages or disadvantages of aerodynamic design. And there is a third, and very important factor to take into account, namely, thrust-line placing. For if power is misapplied, the potential merits of a design will not be realised. It is in this third connection that the low-wing machine scores.

The type has its little snags, in common with others, but in the writer's judgment, these and the alleged inefficiency of the wing-position, are more than counter-balanced by the possibility of perfect thrust-line placing.

Let me enlarge on this theme. The varying power-output of a rubber motor is probably the model designer's biggest bug-bear. That first terrific burst has to be prevented from stalling the machine, without ruining the climb. The problem is eased if the thrust-line can be placed dead on the model's centre of resistance.

With the high-wing machine this is only possible by employing motor gearing, with the propeller turned by an idling shaft. For the centre of resistance is usually in the region of the top longerons, where the rubber-skein cannot possibly fail to foul the structure. Lowering the thrust-line to overcome this difficulty imparts to the model an over-climbing tendency which, though it can be checked, leaves the machine somewhat sensitive to small changes of longitudinal trim. At the take-off board, one frequently sees a high-wing model stall badly on full turns, and subsequently fail to climb through slight over-correction.

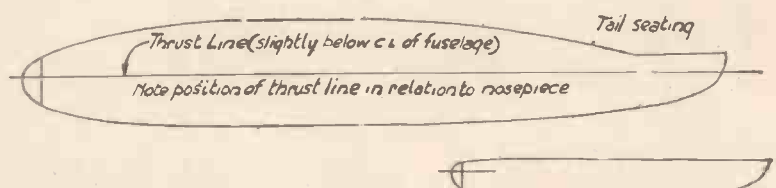
With the low-wing lay-out the thrust-line can be placed on the centre of resistance, for this is usually just below the centre-line of the fuselage. The advantages accruing, some of which benefit the beginner, and some the contest flier, are that trim, launching, rubber-bunching, and variation in the weight of different skeins, have to be really serious before they will cause a bad stall, also abundant power can be applied and the model made to climb steeply with perfect safety.

I admit that certain modellers, so far from deploring the over-climbing tendency of a high-wing model, exploit it in the interests of maximum climb. But they could apply the same technique to a low-wing model with less risk, for there is with the high-wing type a very thin dividing-line between meteoric climb and a bad stall. Skill and experience are called for, and this system is not for everybody.

There are quite enough things to go wrong at the take-off board, and surely the knowledge that the high power employed on the modern Wakefield model is safely harnessed in the case of a low-wing type should make for peace of mind and calmer judgment.

Design Characteristics

But can this happy state of affairs be achieved without sacrificing the efficient performance obtained with the high-wing model? One's personal conviction, based on an extensive all-weather experience with low-wing models, is that a reasonable amount of the development work by modellers with competition experience, would prove the low-wing machine as capable of high performance as it is pleasant to fly.



Diagrams showing the advantages of a low-wing model

Unsatisfactory behaviour is generally due to the centre of gravity being too high, and attempts to overcome this by increasing the dihedral cause the model to lose height easily. It is of fundamental importance to secure a low centre of gravity and this will be facilitated by the following procedure.

First reduce the maximum depth of the fuselage, retaining the correct cross-sectional area by adding to the width. Now dispose this depth with rather more than half of it above a horizontal datum-line representing the thrust-line. Place the bulk of the nose-piece below the thrust-line. The top longerons can now be swept downwards from the point of maximum depth to meet the nose. Similarly they can be swept downwards behind the maximum depth, until the tail-plane leading-edge and the top longerons on which it rests just comfortably clear the rubber-skein.

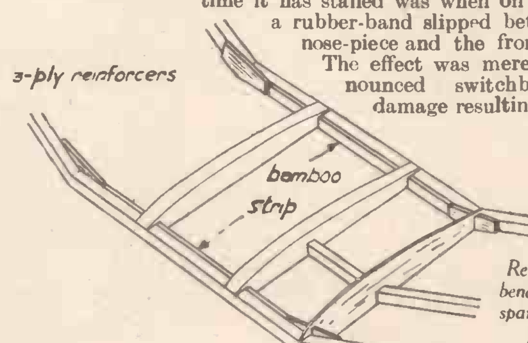
Thus a considerable proportion of the structure-weight, represented by the nose-piece, the entire tail-unit, and all but the central parts of the longerons, is lowered, resulting in a low centre of gravity. The side elevation now appears almost symmetrical, but slightly humped, almost the reverse of the straight back and deep belly of many high-wing models.

Rather more dihedral is needed than for a high-wing model, on account of the blanketing effect of the fuselage, but if the latter has been shaped as suggested, not more than 10 degrees of dihedral should be needed, and 8 degrees may well suffice.

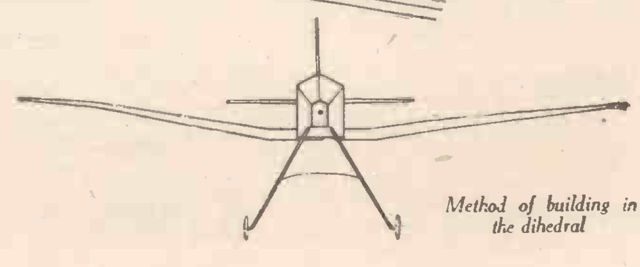
Low-Wing Line-Up

Finally, be prepared to scrap that well-proved positive-tail line-up! A low-wing model functions much better with the tail negative to the thrust-line. When a flat or symmetrical section tail-plane is employed, try it first at 1 to 1½ degrees negative to the thrust-line, with the wing at 1 to 1½ degrees positive to the thrust-line. When using a tail of lifting-section, increase the negative tail incidence to 2 or 2½ degrees.

Carry out the first tests with the centre of gravity about 40 per cent. across the wing-chord. Gradually move your trimming weight rearwards until best climb is attained. As an indication of low-wing docility, it may be mentioned that the writer's latest Wakefield type will fly with the C.G. anywhere between 40 and 70 per cent. across the wing-chord. Apart from certain composite experiments, the only time it has stalled was when on 800 turns a rubber-band slipped between the nose-piece and the front-former. The effect was merely a pronounced switchback, no damage resulting.



Reinforcing the bends on the spars with hard plywood



Method of building in the dihedral

MAKING A SPOT WELDER

By "Home Mechanic"

Constructional Details of a Small Machine for Model Work and Light Shop Use

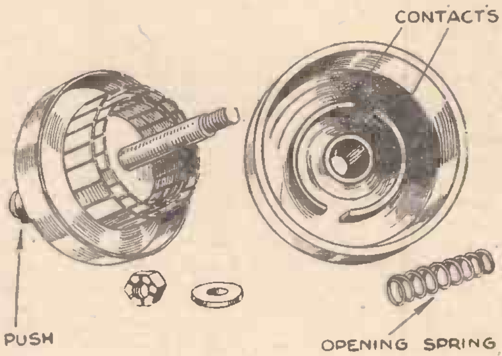


Fig 1.—Details of the contact switch

MOST readers can soft solder and some can braze and weld, because these processes require little apparatus. Spot welding is entirely electrical, the two metals to be joined being brought to fusing temperature over a very small area, hence the term "spot." Briefly, the work is placed between two pointed electrodes which are brought together with as much pressure as possible, and the current is then switched on for a fraction of a second. On examination, the metal is just joined over a pin spot. At the point of contact, the resistance is so high and the current so strong that the heat produced, C_2R, is enough to melt the metal. In practice, several spots can be placed side by side, but never one spot over another. Currents vary from 100 amps. upwards, and the voltages from 1.25 to 7.5 or slightly more. It must be understood that if these large currents are to flow at the low voltages mentioned, the resistance of the circuit must be very low. Hence all leads are as short and as fat as possible, and the only material to use is copper of the best quality.

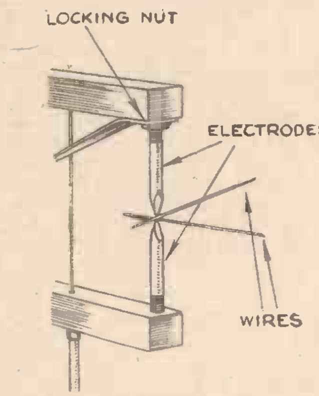


Fig 2.—Electrodes welding two wires at right angles

For Model Work

In this article we only deal with a small machine for model work and light shop use. A spot welder can be used in almost any job that requires the quick, clean and sure joining of metals. Of course, a spot welder cannot make a water-tight seam, and for this a special machine is required with revolving electrodes, etc. Since the advent of stainless steel, the welder has been very prominent in dentistry and other professions where fine wires require joining.

We cannot enumerate all the uses of the welder, but after one has been made and installed in the shop, it will be found as useful as the machine vice.

The two types of welder to be described are actually identical in detail, but the power supplies are different. The first is battery-operated and the second draws its power from the mains through a transformer. Details for making a transformer will be given later. To supply the necessary current a six-volt high-capacity battery will be required. A car battery of the lead-acid type is quite good, especially if it can be trickle charged from the mains. It must be a multi-plated cell of very low resistance and fitted with suitable and large terminal posts. The voltage to the electrodes is varied by changing the tappings on the battery. A suitable battery is one of the nickel-iron type. The big advantage of these cells is that they can be left for long periods without deteriorating in any way.

Simple Construction

The actual construction of the welder is very simple and can be followed from the illustrations (Figs. 2 and 3) on this page First obtain a good supply of copper rod, ½ in. square; about 18 in. will be required. The first welder is battery operated and is actually mounted on one terminal post of the battery so as to do away with one lead. The lower limb of the welder is 8 in. long and is bolted to one terminal of the contact maker or switch. The pillar is 5 in. long and is fixed to the limb by a ¼-in. copper bolt tapped into it. The two surfaces must be filled dead flat and the pillar must be at right angles to the limb. Screw up as tightly as possible, but remember copper is soft and will strip easily. When tight, soft solder must be flushed all round the pillar to make a good join, and, if possible, get it to run between the metals. The top arm is movable and hinged over the pillar. In order to make this arm free to move and yet obviate side play, i.e., so that the electrodes will meet when they are closed, the suspension bracket is made as wide as possible; in this case about 4 in. The top arm is a little larger than the bottom and is drilled with a 3/16 in. hole 2 in. from one end. Through this hole a rod has to pass and is secured so that it does not make electrical contact with the arm. Reamer out the hole to a little over 3/16 in. The supporting rod is of brass and ¼ in. diameter threaded any suitable number per inch. Study the various sketches to get a good idea of the general layout of the machine. Slip a length of thin-walled rubber tubing on to the rod and then push this into the arm. It should be a tight fit. Screw up the nut tightly, so that the arm is rigid (Fig. 5). Test on six volts and then on 230 volts, just to make certain.

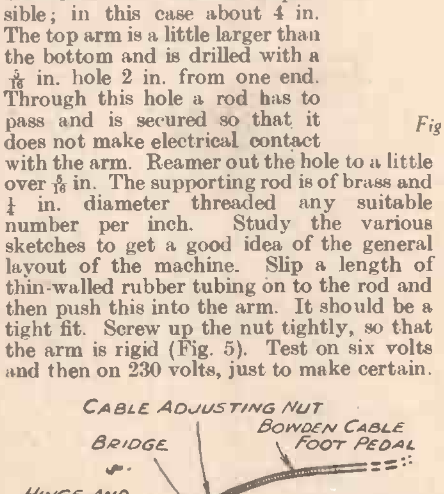


Fig. 4.—The foot control

The bracket is of brass strip ½ in. by ½ in., bent to shape and fixed to the pillar with one screw and soft solder. It will be observed that the arm is insulated from the remainder of the machine. The upper arm is centred over the lower and held in place by two nuts on either end of the threaded rod.

Electrodes

These are made from 3/16 in. or ¼ in. diameter hard copper rod to any shape desired. It is essential that the welding current, in order to get a spot, be concentrated to or over a small area, and therefore the electrodes are pointed. Not to a point, but to a flat point of approximately 1/32 in. diameter, depending, of course, on the material to be welded and the capacity of the machine. For thin steel plate of tin-plate gauge, a diameter less than 1/16 in. should be used; the point to be quite flat and kept in this condition by an occasional touch with a fine file. The pointing of the electrodes can be easily accomplished with a file. Make the points fairly blunt, but do not have a long taper to them like a needle. The heat of the weld will soon soften the end, causing mushrooming, and faulty welding will result. The upper and the lower electrodes are both the same for simple plate welding and should be about 2 in. in length. Each one is screwed into its respective arm and adjusted so that the points meet.

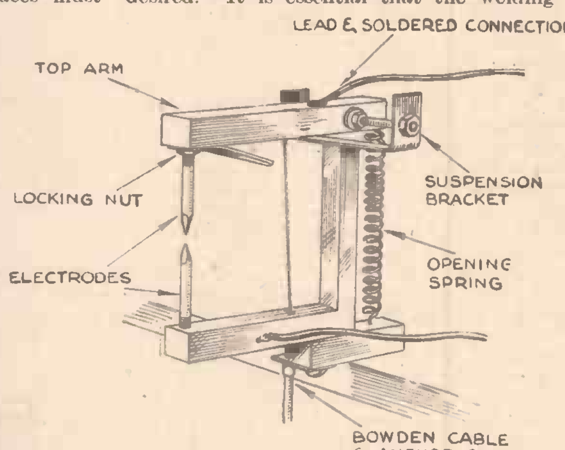


Fig 3.—The complete welder

A Useful Tip

A good plan is to make some electrodes larger than others so that the gap is not in the centre, but can be made higher or lower according to the electrodes used.

This is an advantage when awkward slopes are being welded. The electrodes are threaded any convenient size and then fixed in holes in the arms. In order to lock them in the arms, make small adjusting bolts from strips of copper and tap them to fit the electrodes. A pair should be made for each pair of electrodes and must be fitted to them; this will save a lot of time when the pairs have to be changed. We will deal with the types of electrode required before going on to discuss the method of using them for welding. In some cases it is necessary to weld on the outside of a cylinder, like the handle attachments on a tin can or "billy can." A straight lower electrode cannot be used and a special swan-necked one is required. Make this from similar material as before, and turn up the end to just touch the upper one. The depth of the neck will depend on the distance along the tube that is required to weld, but if this is greater than 1 in. or so, make the electrode from stouter material. A swan-neck is required for all work where the article is said to be under cut, such as rings and tubes of no great length, etc. (Fig. 6). Wires have frequently to be welded together at right angles and at a simple tap joint. But welding cannot be done with this machine. In these cases, straight electrodes must be used with grooves in them to accommodate the wire. The depth of the groove must be just under half the diameter of the wire, as its function is to firmly hold the wire and get as big a current density as possible. For right-angle welding, the grooves are at right angles and in the same line for top joints (Figs. 2 and 7). Of course, they can be in any other intermediate position.

The Contact Switch

In the original machine this was very successful and was a starting switch from a motor-car. We advise readers to obtain a switch rather than to make one. The cost from a "breaker's yard" is anything from 6d., depending on the "breaker" and not the switch. Dismantle the switch and clean it, trim the contacts and make them true, and remove the powerful spring that normally works the switch and fit a light one. If your switch is foot-operated, this is essential because it is hand-operated on the welder. It should be possible to make contact with one finger and yet the switch must open quickly (Fig. 1).

Oil the sliding mechanical parts but not the electrical ones. The switch is bolted directly to the bottom arm of the welder by the contact screw on it. It is a good plan to make this contact to the frame of the switch so that both are firm mechanically and a good electrical join results. The other switch contact is connected to one pillar of the battery. To keep all leads as short as possible, it is necessary to have this contact welded to a battery terminal clamp; the usual battery clamp is ideal but the weld must be a good heavy job. If the battery is filled with screwed terminal posts as in traction batteries and crane batteries of the nickel-iron type, the switch is fixed directly on to the pillar by the terminal nut. This gives a good electrical contact.

Bringing the Electrodes Together

Some device must be fitted to the machine for bringing the electrodes together, and the simplest is a coil spring between the arms. This must, of course, be insulated from the top arm, and if a spring is fitted a means for opening the contacts is required. The best way of doing this is to fit a spring to keep the arms open and close to them to suit your own needs.

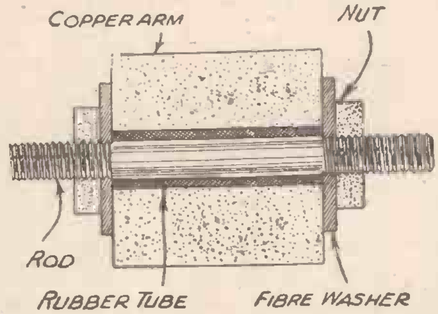


Fig. 5.—How the top arm is insulated from the supporting rod

This is done by using a Bowden cable and foot pedal. A length of Bowden cable such as used on cycles is ideal. The method of connecting up is very simple. First make a small arm about 1 in. long and fix this on the upper electrode arm supporting-rod, using lock nuts, etc. The arm is made from sheet brass and is soldered or brazed to a nut to screw on the rod. The arm must not turn on the rod, it has to be well made and quite strong as considerable pressure can be brought on it by the foot pedal. A small catch is fixed on the lower arm or pillar to which is anchored the outer cable.

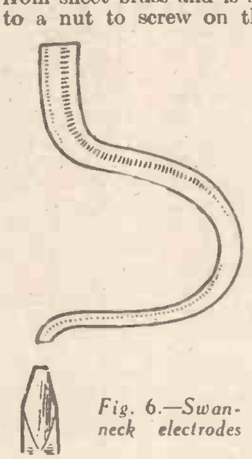


Fig. 6.—Swan-neck electrodes

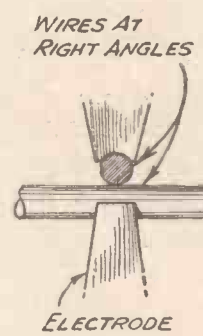


Fig. 7.—Position of electrodes for wire welding

The Foot Pedal

The foot pedal is very simple to make, and can be just a board hinged to a fairly heavy base, the cable being anchored in the usual manner. The simple foot control shown is more robust, and is very simple to make and easy to handle (Fig. 4). It consists of a mild steel strip, $\frac{1}{2}$ in. by $\frac{1}{4}$ in., with a treadle, $1\frac{1}{2}$ in. by 2 in., welded on one end. The other end is welded to a simple wood hinge which is screwed to the baseboard. A bridge piece from $\frac{1}{2}$ in. by $\frac{1}{2}$ in. strip is bent over the arm and screwed into the base. A fine hole is drilled through the bridge to take the wire which passes through a hole in the pedal. At one end, the wire should be easily adjustable so that when necessary any slack can be taken up. Grease the wire well so that the arm opens quickly when the foot is removed from the pedal. A connection made from a short length of cable as flexible as possible must be fitted to the top arm. For this make up your own sample, having first determined the minimum quantity required, by trial with a length of stiff wire. Take about $\frac{1}{2}$ lb. of No. 20 wire, anneal it dead soft and clean and straighten it out. Cut into lengths as required and twist them all together to give a firm yet flexible cable. Solder one end to the top arm, and to the other end fix a large spade terminal to make good contact to the battery.

Connect everything up. Place the battery and welder on a bench of suitable height, and connect the flexible lead to the lowest voltage, say, 2 or 1.25. Place two thin bits of steel plate between the electrodes and bring them together with moderate pressure. Close the circuit for 1/25 second (this may sound impossible but it only requires a touch on the switch). The metal between the electrodes should not flow, because if it does so the weld has been too long. A little practice will soon produce good results.

BUILDING A $2\frac{1}{2}$ in. GAUGE MODEL OF THE "FLYING SCOTSMAN"

(Continued from page 356.)

drawn brass tube, 1 in. diameter and $1\frac{3}{4}$ in. long, with a brass disc soldered in for the base. The stretcher plate is cut away in the middle to receive the sump which is silver-soldered to it, in the position shown in the illustration. A hole is drilled in the sump, just above the base, to take one end of a piece of $\frac{3}{16}$ in. brass tubing, 8 in. long, which carries the spirit to the burners. A bracket, made out of $\frac{1}{16}$ in. brass, $\frac{1}{2}$ in. wide, supports the spirit supply pipe just behind the front pair of wheels.

Force Pump

The hand force pump (Fig. 33) is fixed to the base of the water tank by four $\frac{3}{32}$ in. screws. A flexible coil, of $\frac{1}{8}$ in. copper tube, has a $\frac{3}{32}$ in. union fitted at its outlet end, as shown. This couples up with another pipe on the engine, which is connected to the check valve on the boiler.

The water-container top, of $\frac{1}{32}$ in. sheet brass, has a narrow slot cut in it for the pump handle. (Fig. 30). This top plate is attached to the angle brass by six $\frac{3}{32}$ in. screws. A large size filler is fitted for filling the tank (through a funnel), and is soldered in. A $\frac{3}{8}$ in. diameter ring is soldered on the right-hand top side of the tender back, to form the window for the corridor.

Standard $\frac{1}{2}$ in. scale buffers are fitted, and also a steel hook, with spring and split pin, and three German silver links.

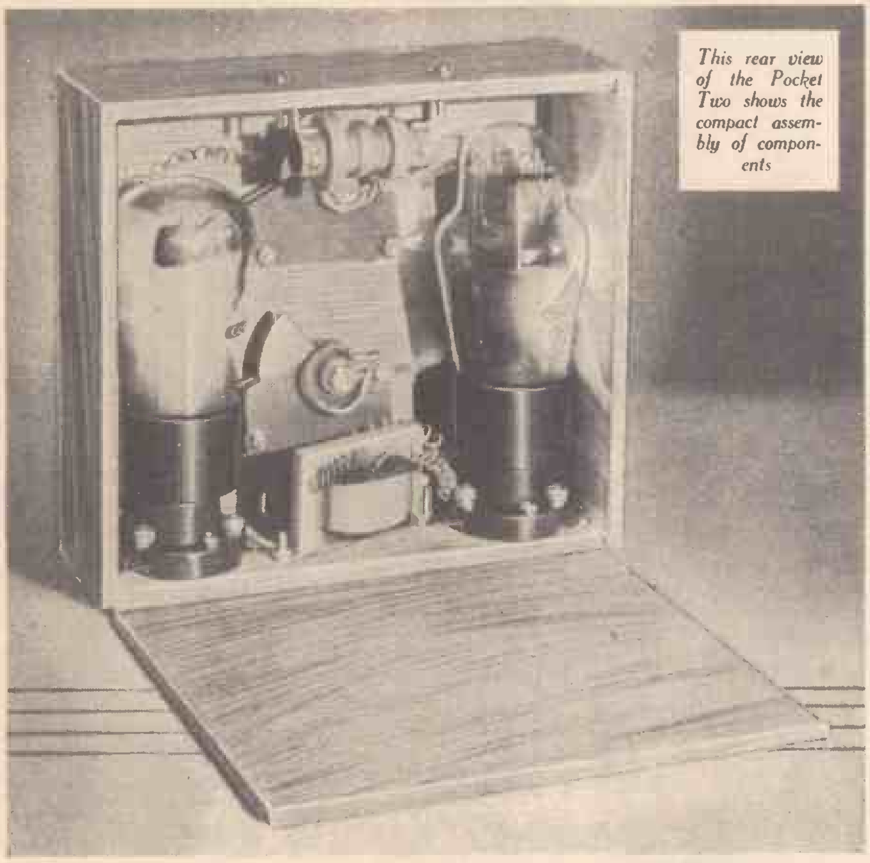
Testing Under Steam

To give the engine its first test under steam, first well lubricate all the working parts, and then fill the boiler three parts full of water through the safety valve opening under the dome. See that the connections between the engine and tender are made. The central one is for the spirit supply. Turn the spirit on slightly, wait for about two minutes for the burner wicks to soak, and then light them. A small mirror laid flat under the burners will help you to see that all the burners are working properly. If no auxiliary blower is available, steam should be raised with the smoke-box door open, as this prevents the flames baffling back. When the gauge shows 5 to 10 lbs. pressure, shut the smoke-box and open the blower valve, just sufficient to keep the burners bright. Do not attempt to run the locomotive until the pressure reaches 80 lbs. When that pressure has been reached, shut the blower, open the regulator, and move the engine up and down a few times to remove all condensed water from the cylinders. After that, the locomotive is ready for its trial run

"PRACTICAL MECHANICS" WIRELESS SUPPLEMENT

The Pocket Two

Constructional Details of a Simple Two-Valve Receiver Built into a Cigar Box



This rear view of the Pocket Two shows the compact assembly of components

THE design of pocket receivers can embody many novel features, but generally speaking, the true pocket set is only possible when midget valves and special parts are employed. Even so, the accommodation of suitable batteries then brings the total dimensions rather beyond anything but a large coat pocket or similar receptacle. If, however, the batteries can be separately accommodated then quite reasonable pocket sets may be made up, even using standard parts. In an endeavour to see just what could be accomplished in this direction we carried out one or two experiments, and the interesting two-valver, shown in the accompanying illustrations, is the result.

The Cabinet

Standard parts were to be used, and a selection of standard cigar boxes was obtained. These varied considerably in shape, but a very useful size was that used for 25's, and this measured 5 in. by 5⅝ in. by 1⅞ in. deep. This just enables two valves to be accommodated comfortably in standard baseboard-mounting valveholders at each end of the box, with sufficient room between them to take a small transformer, and the two variable condensers. The question of a coil was solved by using the Bulgin Midget coil, and this was bolted to the top of the box—the relative positions of these parts all being indicated in Fig. 1.

This, therefore, only leaves the problem of the batteries, and one easy way of overcoming this is to have a similar box in which may be placed a small jelly-type accumulator for L.T., with three or four G.B. batteries connected in series for the H.T. supply. If the receiver is only required as a novelty, then standard batteries could be used in the ordinary way. Leads for the batteries are brought out from the case through a suitable hole, and two-socket strips are mounted on each side for aerial and earth, and for 'phones. The cigar-box wood is generally of cedar, and although very thin is easy to cut, and when cleaned down will take a very good polish, or may be left in its natural state. The labels are usually well fixed but a damp cloth pressed on them will enable them to be cleaned off without warping the wood. Do not use too much water, and do not use coarse sandpaper to clean down, as this will scratch the soft wood and spoil the surface. Be careful not to damage the cloth hinge, as this is also attached with glue, and will not stand up to misuse. When cleaned, drill the two holes in the front (which is actually the bottom of the box in question), using a twist drill to avoid tearing the wood. At the sides drill accommodating holes for the socket strips, and then attach valveholders, coil, transformer and socket strips with short bolts. The wood is too thin to permit of satisfactory screwing. If desired, the valveholders may be wired up —from the filament point of view, before attachment, although it is possible to get at the various terminals if the position which we adopted is followed. This is shown in the wiring diagram, Fig. 1. Wiring may be carried out with insulated solid wire, or ordinary flex, and is quite a simple matter.

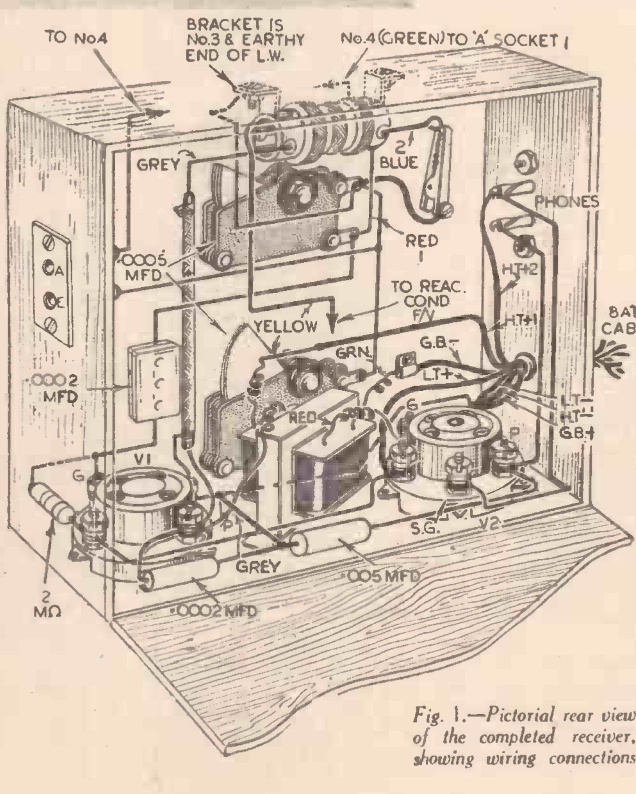
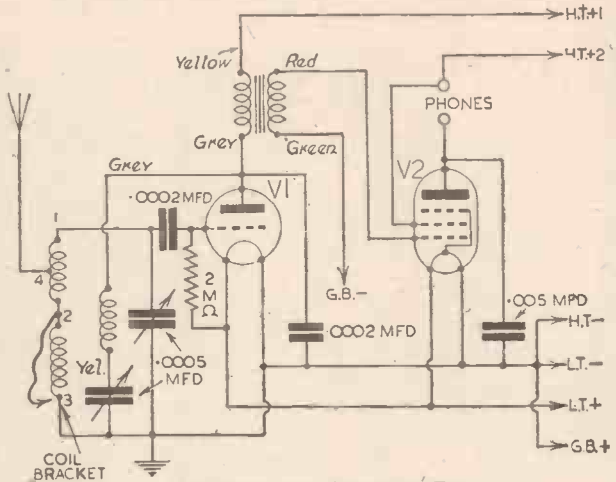


Fig. 1.—Pictorial rear view of the completed receiver, showing wiring connections

Wave-Change Switching

To avoid the fitting of a wave-change switch, the continued operation of which might result in splitting the thin wood of the box, we adopted a crocodile-clip method of wavechanging. A short length of wire is attached to the earth connection on the coil, and the clip is attached to the earthed terminal of the tuning condenser when long waves are being received. This is merely to keep the clip from swinging loose, and perhaps introducing a short-circuit or other trouble. When medium waves are required the clip is attached to connection point No. 2 on the coil. The numbers, incidentally, will be found stamped into the coil former close to the small eyelets. If the small coloured leads on the coil are not long enough, or you desire to preserve uniformity in the wiring, you can unsolder them and attach separate leads. The fixed condensers and grid leak are joined to the appropriate terminals, and the normal wire ends may be used, or, if you make use of standard mica condensers with terminals, short leads may be attached to them.

The battery leads should, of course, be long enough to reach to the battery box, or position in which the batteries are to be kept. An on-off switch has been omitted for the same reason as the wave-change switch, and the set is switched off, merely by disconnecting the L.T. negative lead from the accumulator. Alternatively, a suitable switch may be mounted on a small strip of ebonite, with a strip of metal attached to one terminal of the switch, and drilled to accommodate the terminal on the accumulator. The lead is then attached to the remaining switch terminal, and thus on-off switching may be carried out in the usual way. If you are interested in making a more comprehensive job of the receiver, then automatic bias may be provided by including a suitable resistance with by-pass condenser in the H.T. negative lead in the usual way. This will entail the fitting of an anchoring screw so that the lead may be attached and the secondary of the transformer connected to the H.T. negative lead. Any type of aerial may be used, depending upon the results desired. If selectivity is an important point in your locality, use a small aerial. This may be a length of flex in the form of a throw-out aerial, about 15 to 20 ft. being adequate. If a full-size outdoor aerial is connected to the set then selectivity will naturally be rather poor, and a series-aerial condenser is then desirable to enable certain stations to be separated. The addition of an earth lead will in some cases improve signal strength, but in many cases will not prove essential. Remember, however, that interference can sometimes be removed if an earth connection is used, whilst in other cases the earth lead will result in improved signal strength. A list of the parts which we used for this set is included on this page.



Theoretical circuit of the Pocket Two

LIST OF COMPONENTS

Two variable condensers, .0005 mfd. type C.V.19	Bulgin
One midget coil, type C.40	Bulgin
One midget L.F. transformer, type L.F.58	Bulgin
Two valveholders, type V.H.19 ...	Bulgin
Two 2-socket terminal strips ...	Clix
One .0002 mfd. mica condenser ...	Dubilier
One .0002 mfd. tubular condenser	Dubilier
One .005 mfd. ditto	Dubilier
One 2-megohm grid leak	Erie
One crocodile clip, connecting wire, flex, etc.	
One cigar box.	
One 210 Det, one 220 HPT valve ...	Cossor

NEW INVENTIONS

Tension Tester

TO provide quick and accurate means of measuring the tension on wire ropes used in yacht rigging and aeroplane controls is the object of a new rope tension meter. The method of operation is to clamp the meter to any rope of not more than a certain diameter. The clamped rope is twanged as though it were a string of the "harp that once thro' Tara's halls." The sound produced is compared with the tone of a pre-tuned musical string, which is a part of the apparatus. A rope may be tightened or loosened to harmonise with any of the tones of fifteen pitches. These pitches correspond precisely to various tensions. Consequently, one can guarantee that a rope is not too highly strung. In other words, it can be proved that a rope is qualified to endure when comes the tug-of-war.

To Break a Fall

THE law of gravitation is ruthless. To guard against the merciless impact between a falling workman and the earth, a new safety device has been contrived. This lifesaver consists of harness for a worker in high places to wear. Attached to the harness is a rope which is passed through a shock absorber and then made fast to some part of the building. Should the workman fall, the shock absorber clamps down on the rope, slows his plunge, and brings him to a comparatively smooth stop.

Saved by a Shirt

APROPOS of this fall-breaking harness, I find in one of the pigeon-holes of my memory an example of effective publicity. An outfitter's shop in a suburb of London was being rebuilt. During this operation, apparently falling from the scaffold which surrounded the building was a full-sized realistic dummy workman, the fabric of whose shirt had caught on a nail in a scaffold pole, suspending him between heaven and earth. Fastened to the man was this couplet :

Do not worry, loving wife,
Jones's shirt has saved my life.

By the way, the name of the proprietor of the shop was not Jones. It is obvious that the advertisement vaunted the strength of the shirt in question.

American Trade Names

THE word "Invention" is an omnibus term ; it has many meanings. Ordinarily implying some novel mechanical contrivance or new process, it may likewise signify a verbal fabrication of the type of which that paragon of veracity, George Washington, was never guilty. It is also related to the faculty of the mind which enables Americans to apply striking trade names to their goods. For example, among recent registrations is "Excalibur," King Arthur's Sword, with which a brand of razor blades has been christened. Cats' food and other animal food products have been entitled "Cat's Meow." A liquid preparation for preventing nail-biting is called "No-No," and "Kool-nite" is appropriately applied to pyjamas. "Nu-mown-hay" is employed in connection with antiseptics, disinfectants and deodorants, while men's and boys' dress suits are optimistically dubbed "Ever-last." "Ecstasy," in association with the slogan "Joy in every step," concerns women's shoes. Designed for window-cleaning without water, a preparation has been named "Squirtex." And, lastly, Walt Disney Productions, foreseeing that the title of their new cartoon, *Pinocchio,* would be exploited by traders, have forestalled these gentlemen by themselves registering the name in the United States in connection with more than one class of goods.

Hair-Straightener

IT used to be said that the behaviour of a moistened hair revealed the character of the person from whose head it was taken. When wetted, if the hair did not remain straight, it was a sign of bad temper. According to an inventor who has been devoting his time to the production of an appliance for straightening hair, curly hair is not always a thing to be desired. He declares that the curls that are found on the head of a negro are not an asset either socially or commercially. And he also affirms that to obtain a really satisfactory permanent wave, the hair should be allowed to grow until the old wave has almost disappeared. Therefore, he has devised an appliance for removing or reducing superfluous curl, wave or frizziness from hair.

It seems that it has previously been proposed to provide an apparatus for straightening the hair after treatment with an alkaline lotion. With this apparatus were incorporated a roller on which the hair had been wound and tensioned and a pair of jaws between which the hair was firmly clamped, heat being applied during the operation.

The object of the new invention is to furnish a method which obviates excessive tension on the hair and renders heating unnecessary. Further, it aims at practically straightening the hair without discomfort or destroying its texture and strength.

The method employed consists in first softening the hair to make it pliable. Means are then adopted to comb and mill it. After this there is applied a restorative to re-harden the hair.

I believe that the followers of Beau Brummel regard a graceful undulation on the head as a feature of manly beauty ; but I presume that the *bête noire* is excessive frizziness.

Facts About Metals

(*Continued from page 332 of April issue*)

LIST OF ABBREVIATIONS

The following abbreviations are used throughout this Dictionary :

At. No.	Atomic Number
At. Wt.	Atomic Weight
M.P.	Melting Point
B.P.	Boiling Point
Sp. Grav.	Specific Gravity
Sp. Ht.	Specific Heat
Coef. Exp.	Coefficient of Expansion
Therm. Cond.	Thermal conductivity
Elec. Cond.	Electrical conductivity

Grey Tin.—When tin is cooled to a low temperature, it crumbles into a powder known as "grey tin." Herein lies the cause of the so-called "tin pest" or "tin disease," whereby tin objects, such as organ pipes, sometimes crumble away during a cold winter.

"Grey tin" appears to be a definite variety of tin which is formed slowly at temperatures below 18°C., and it is an extraordinary fact that if a piece of sound "white" tin be placed in contact with a piece of tin suffering from the "disease" or "pest," it will become infected.

Gunmetal.—Name given to a group of bronzes. Gunmetal is composed of copper alloyed with from 82% to 1% of tin, the strength of the alloy increasing (and its ductility slightly decreasing) as the percentage of tin increases. Was formerly used for making cannon. Is now employed for instrument work, etc. Technically known as "Soft Bronze."

H

Hamilton's Metal.—A form of brass introduced in 1826 by Hamilton and Parker. It usually consists of a 50: 50 copper-zinc brass. Sometimes used as an "imitation gold."

Hardness.—The resistance of a metal to cutting or abrasion. Frequently, the hardness of a metal is increased by the presence of impurities within the metal, so that a pure metal is often softer than an impure one. Thus, for example, gold is hardened by alloying with it a small quantity of copper.

The softness of metals increases (or their hardness decreases) with increase in temperature. Manganese, cobalt and nickel are the hardest of the common metals, lead constituting the softest of such metals.

The property of hardness depends upon the inner attractions of the molecules of the metal for one another. The hardness of metals is nowadays commonly given in terms of their "Brinell Number" (which see).

Harveyized Steel.—This is steel (generally in the form of steel plates) which has been surface-hardened by heating in contact with charcoal.

Heat-Treatment.—The structure and properties of metals and alloys are often very greatly influenced by any heat-treatment which they may receive. Such heat-treatment may embody the heating of the metal to a pre-determined temperature, its retention at a definite temperature for a definite length of time, and, also, its raising or lowering in temperature at a certain definite rate.

All such conditions may affect the strength, hardness, ductility, malleability and other properties of the metal or alloy. Usually, modern alloys are very greatly improved in their properties by suitable heat-treatment.

Hercules Metal.—A form of aluminium brass. Approximate composition: copper, 67%; zinc, 31%; aluminium, 2%. It casts well and is hard and strong. Tensile strength (average), 30-35 tons per sq. in.

Hiduminium.—An important British aluminium alloy. It was developed in the first instance by the Rolls-Royce Company for motor-racing work, and was first introduced into motor engineering on a large scale by the Armstrong-Siddeley Company.

The alloy is produced by High Duty Alloys, Ltd., of Slough, from whence it derives its name—*Hi-du*-minium.

Hiduminium alloys vary in composition, there being many types.

High-Speed Tool Steels.—These, which are also known as "Self-hardening steels," comprise carefully made steels alloyed with tungsten (12-22%), chromium (2-6%), vanadium (.3-.5%), and/or other hardening metals. These steels do not soften even at red heat. Hence tools made from them retain their cutting edges at elevated temperatures, and can be run at far higher speeds than can tools made from ordinary carbon steels.

Holmium.—Metallic element. Chemical symbol, Ho; At. No. 67; At. Wt. 163.5. It is doubtful whether this element, which is related to dysprosium, has ever been prepared in any state of purity. Its oxide was discovered by P. T. Cleve in 1879, and the contained metal was named by him Holmium, from the town of Stockholm.

Honda Steels.—A newly introduced type of magnet steel, having great magnetic retentive powers. They comprise steel alloyed with cobalt (15-36%), nickel (10-25%), titanium (8-25%), and sometimes, also, small amounts of aluminium. Owing, however, to their cost of production, the "Honda" alloys have not been much used.

Named after Professor Honda.

Hyman Alloy.—An aluminium alloy containing: silicon, .8%; copper, 3%; magnesium, .5%; nickel, .5%—remainder aluminium. When heat-treated, it has a tensile strength of about 35,000 lb. per sq. in.

I

Illinium.—Metallic element. Chemical symbol, Il; At. No. 61.

Discovered almost simultaneously in 1926 by Hopkins (in America) and Rolla and Fernandes (in Italy). Named "Illinium" by Hopkins and "Florentium" by Rolla and Fernandes. The former name has now been almost universally accepted.

Practically nothing is yet known about the properties of this metallic element, except that it is a member of the "rare-earth" series of metals.

Illium.—A strong, resistant nickel-containing alloy. It has been made use of in the construction of pressure-resisting chambers and experimental laboratory pressure apparatus. Composition: nickel, 61%; copper, 6%; chromium, 21%; molybdenum, 5%.

Inconel.—An alloy containing nickel, 80%; chromium, 14%; iron, 6%. Is particularly resistant to brine, salt solutions and food acids, and is now being used for the making of food-processing equipment. It also has a high degree of heat-resistance and it is employed for the manufacture of electrical heating equipment.

Indium.—Metallic element. Chemical symbol, In; At. No. 49; At. Wt. 193; M.P. 176°C.; Sp. Grav. 7.4; Sp. Ht. .05695; Coef. Exp. .0000459. Occurs in minute quantities in certain zinc blendes. Discovered in 1863 by two German chemists, T. Reich and F. Richter, who named it "indium" in reference to the bright indigo-blue lines which characterise its spectrum.

Indium is a silver-white, lustrous, ductile metal, softer than lead. It leaves a mark when drawn across paper. Slowly decomposes water at ordinary temperatures, and therefore rapidly oxidizes in moist air. In chemical characteristics, it is very much akin to gallium.

Invar.—A nickel-iron alloy containing about 36% of nickel which, at ordinary temperatures, has the extremely small coefficient of expansion of about 1½ millionth per degree Centigrade. Thus. Invar is practically completely non-expansible, and, as such, is made use of in the manufacture of clock pendulums, thermostat elements, internal-combustion engine parts and the like. It has a bright silvery appearance, and does not tarnish easily. The name *invar* was originally coined as a contraction of the word "invariable."

Iridium.—Metallic element.—Chemical symbol, Ir; At. No. 77; At. Wt. 193; M.P. 2,000° C.; B.P. 2,850° C.; Sp. Grav. 22.38; Sp. Ht. .0323; Coef. Exp. .000007.

One of the platinum group of metals. Discovered in 1802-3 by S. Tenant, who gave it its name from the Greek *iris*, a rainbow, in reference to the varying colours of its chemical salts.

Iridium occurs in the metallic state, alloyed with crude platinum to the extent of about 4%. It is a greyish-white, lustrous metal, which, in common with rhodium, is not appreciably attacked by any acid or mixture of acids. It is absolutely unoxidizable in air, even at red heat, and is thus the most stable and resistant of metals. Iridium has a hardening effect on platinum, and platinum-iridium alloys are frequently in use, such alloys containing between 5% and 20% of iridium. If the latter proportion of iridium is exceeded, the alloy becomes exceedingly difficult to work. Platinum-iridium wire coupled with pure platinum wire is used in thermo-couples for estimating temperatures up to 1,000° C.

An alloy containing 10% iridium and 90% platinum was selected by the International Committee on Weights and Measures in order to preserve the standards of weight and length.

At very high temperatures, iridium is somewhat volatile. Hence, iridium-platinum alloys when constantly heated to such temperatures tend to lose their iridium content and to decrease in weight.

Iridium Black.—A velvety black powder consisting of finely divided metallic iridium. Prepared by precipitating iridium tetrachloride with chemical reducing agents. Has similar properties to Platinum Black (which see).

(*To be continued*)

Practical Mechanics

How to make a Reliable Electric Clock from Standard every room in the house.

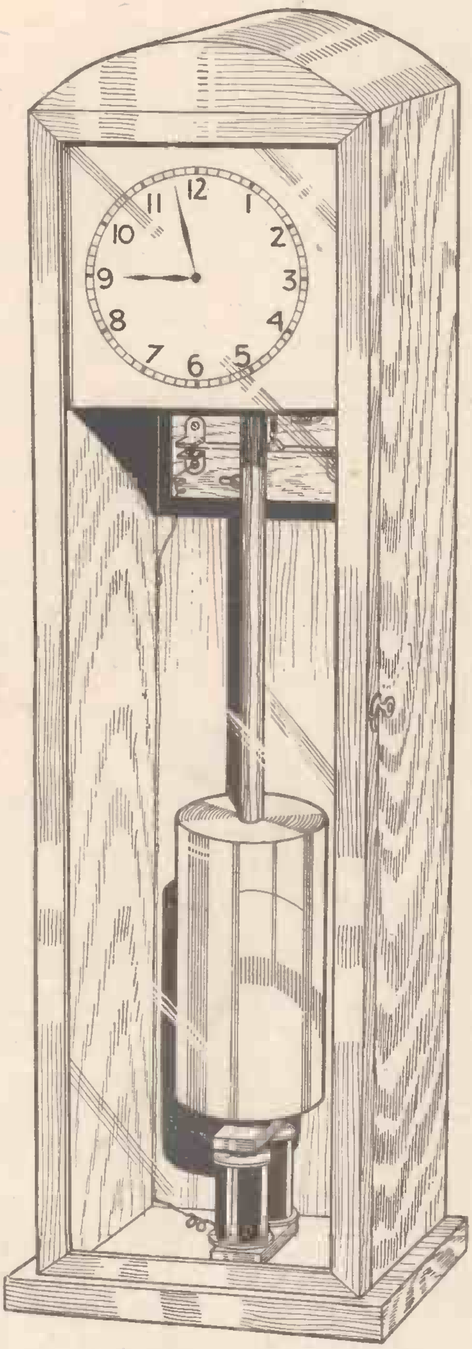


Fig. 1.—The finished P.M. electric clock. It may, of course, be housed in a variety of case styles

ALTHOUGH mains electric clocks have become extremely popular almost to the extent of rendering spring-driven clocks obsolete, at least 50 per cent. of the homes of this country are not wired for electric light and thus an immense market exists for battery-operated devices. This is particularly so in connection with wireless, for official statistics prove that 60 per cent. of the total sales of wireless receivers are for battery-operated sets. We have described several battery-operated clocks in past issues, and those issues have rapidly gone out of print. We have received some thousands of requests for a battery-operated Master Electric Clock which would not only form an electric timepiece complete in itself, but one which would also operate a system of Slave Clocks serving every room of the house.

The basis of the present clock is the movement of an ordinary cheap alarm, and by means of the addition of a few simple fittings easily made it is converted into the pendulum-operated clock shown in the blue print and in the drawings. It operates from a Leclanché cell, and consumes negligible current.

It will be as well to outline the principle underlying the action of the master clock, and so acquaint the reader with the arrangement of the mechanism and purpose of each part.

This article was first published in our October 1938 issue, which is now out of print. In response to numerous requests, we have reprinted it.

Fig. 6 shows diagrammatically the complete mechanism and the manner in which the hands receive their motion, whilst the sketch Fig. 1 is intended to give some idea of how the clock will appear when the components have been assembled. The reader can vary the design of the case to suit himself.

Referring to Fig. 6, A, B and C are three wheels mounted on independent arbors, the wheel C rotates once each hour, from whence it follows that the arbor carries the minute hand. Loosely mounted on the same arbor is the "cannon" J, carrying the hour hand, one end of J is attached to the wheel O, receiving motion through two similar wheels L and L and a pinion K; the wheel L is driven by the arbor which carries wheel C. This group of wheels constitutes the "dial wheels."

The wheel C meshes with the pinion which is mounted on the same arbor as the wheel B which meshes with the pinion D carried by the arbor to which is secured the ratchet wheel A, driven by the "gravity arm" through the medium of the pawl. The gravity arm is secured to an arbor oscillated by a crutch rod and which is engaged at every alternate swing of the pendulum T. The combined weight of the arm and crutch rod must be adequate to cause the pawl to propel the wheel A whilst returning to their initial position after displacement by the pendulum rod.

Matters are so arranged that when the pendulum swings to the left it displaces the crutch rod and gravity arm in the same direction, simultaneously the pawl is withdrawn and picks up a tooth of the wheel A. The pendulum now commences to swing towards the right, but is now followed up by the crutch rod and arm. The energy stored in the arm is now utilised in driving the wheel A one tooth forward, the movement in turn being transmitted through the wheel-work to the hands of the clock.

The Vibration of the Pendulum

The scheme for maintaining the vibration of the pendulum is as follows: An ordinary wooden pendulum, equipped with a heavy "bob" U, has a threaded extension terminating in the armature W. Fixed rigidly beneath the armature is an electro-magnet X, so that the armature just swings clear of the electro-magnet. When, however, the arc of vibration becomes reduced to a predetermined value, a small "finger" or "trailer" Y pivoted to the upper portion of the rod T fails to swing clear of small wedge-shaped block Z attached to a light spring, one end of which is riveted to a bracket, whilst the free end of the spring is equipped with a contact engaging with a stationary contact. On the return swing of the rod T, the finger Y having previously dropped into a nick in the block Z levers down the spring and momentarily the contacts are closed, and the magnet X is energised. When the contacts close, the leading edge of the armature W is just about to pass over the magnet cores, consequently the excitation of

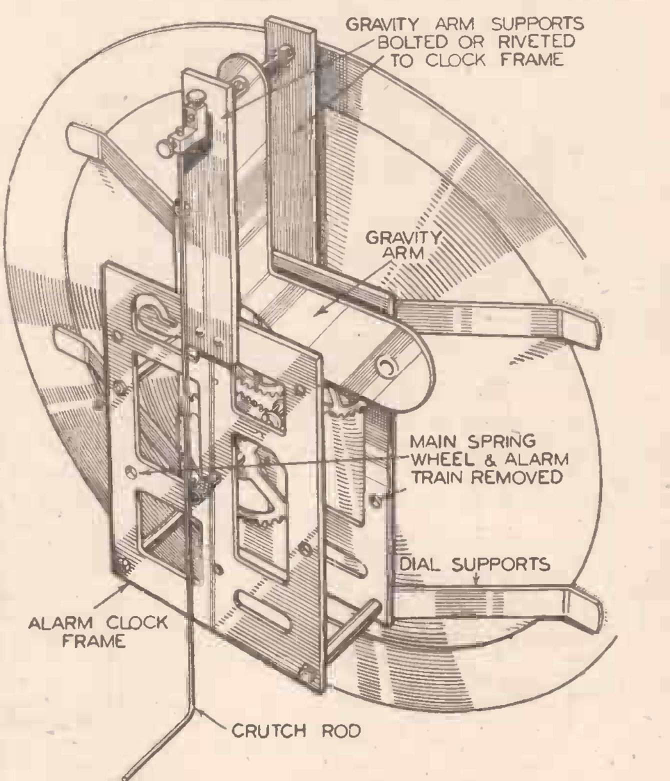


Fig. 2.—General view of the assembled clock unit and dial, seen from the rear. The crutch rod is operated by the pendulum

Master Battery Clock

Parts. It will control a "Slave" Clock System serving (Blueprints are still available.)

X attracts the armature and the pendulum is impulsed. An increased arc of vibration of the pendulum results, so that the finger Y is again carried clear of the block Z for several swings of the pendulum.

Gradually, however, the swing becomes reduced and the finger again fails to clear the block Z, when the contacts are again closed.

This simple means of impulsing the pendulum is automatic in action and economical as far as current consumption is concerned, and two or three quart Leclanché cells should run the clock for at least twelve months without any attention whatever.

A stout art board dial can be obtained for 1s., post free, from the publishers, Geo. Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

The Electro-Magnet

The soft iron yoke (Fig. 7) has riveted to it two soft iron cores, the ends of which are shouldered down and are a driving fit in the holes drilled in the yoke.

For securing the electro-magnet in position the yoke is drilled for two countersunk screws. Slipped over the cores are the bobbins Fig. 8; these are wound with the magnetising coils.

The bobbins are easily built up from thin brass tube of a size to fit the cores snugly, and are completed by soldering to the ends of the tube brass flanges in which a hole has previously been bored for the insertion of the tube. Before winding on the wire wrap a couple of turns of notepaper around the tubes, and well brush with shellac varnish. To insulate the flanges, cut some discs of paper, of course cutting the centre of the disc for the tube; cut through one side so that the discs can be placed on the bobbin, and then well brush with varnish. A couple of small holes may be drilled through one flange of each bobbin for threading the ends of the coil through.

Now proceed to wind on each bobbin as evenly as possible about 3½ ounces of No. 30 single silk-covered wire; cotton-covered wire may be used if at hand. Be particularly careful not to reverse the direction of winding during the process.

When the coils are wound slip them over the cores, and connect the finishing end of one coil with the starting end of the other. The two remaining ends of the coils should now be connected to a couple of dry cells, or Leclanché cells, to ascertain if there are any breaks in the wire; also to check the pull of the magnet with a piece of soft iron.

Assuming the test is satisfactory, finish off the coils with a coat of some insulating varnish, and to give a pleasing appearance the coils may be covered with a piece of black velvet.

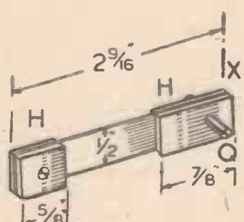


Fig. 3.—Pendulum suspension spring

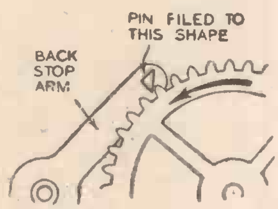


Fig. 4.—Back stop or detent

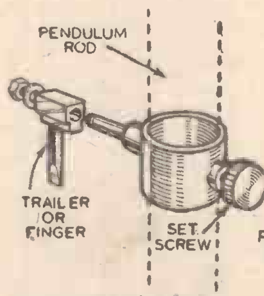


Fig. 5.—Pendulum trailer

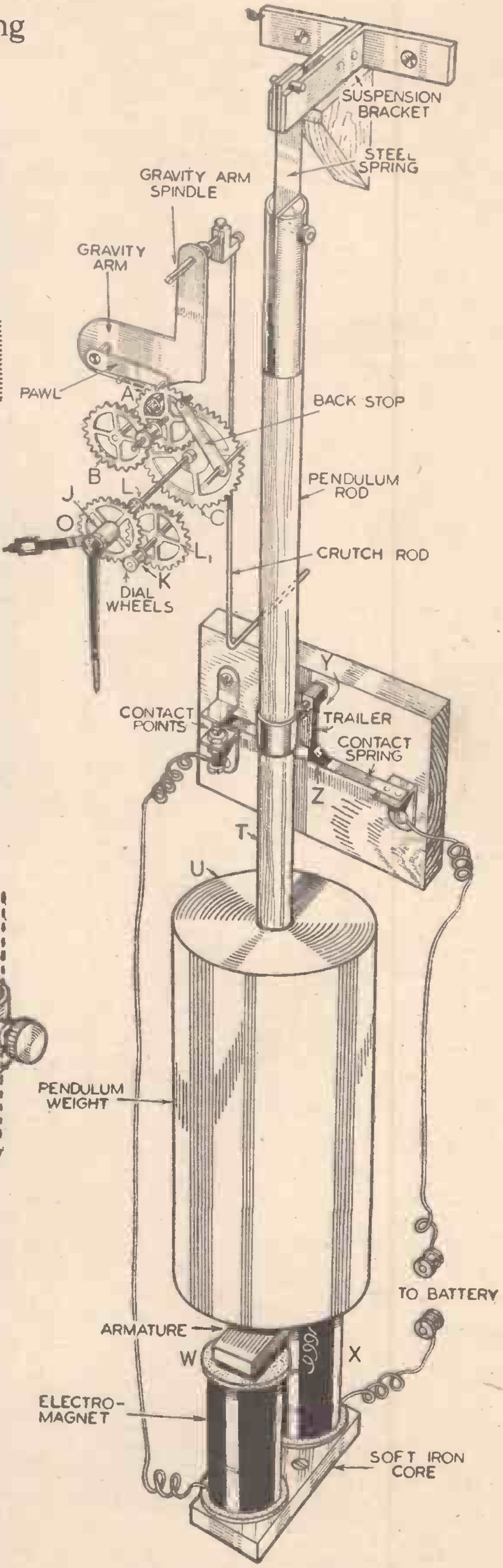


Fig. 6.—General layout of the electric clock

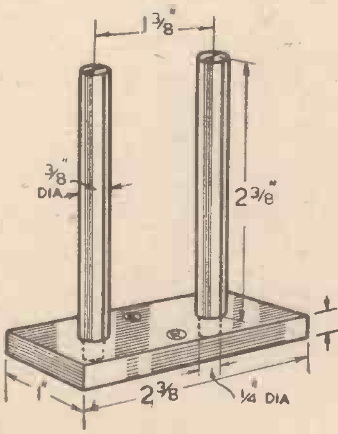


Fig. 7.—The magnet core

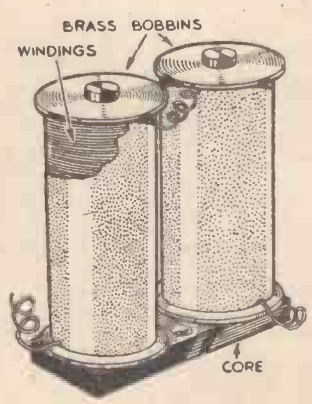


Fig. 8.—The complete electro-magnet

The Suspension Bracket

Two pieces of steel or brass, E and F, Fig. 13, are bent at right angles and drilled with two holes for attachment to the back-board. Inserted between E and F is a distance piece H, a shade thinner than the thickness of the brass at X, Fig. 3. After trueing up the sides of E and F coming against the piece H, the whole is drilled and riveted together, ensuring that the top and bottom edges of the bracket are square and parallel. Carefully cut a V notch in the top edge of E and F to receive the suspension pin Q.

If necessary file out the checks of the bracket until the brass blocks of the suspension spring are a snug fit, and will permit the pin Q to rest in the notches.

Armature

For the armature (Fig. 11) use a piece of soft iron. A centrally drilled hole is tapped to suit the screwed rod attached to the end of the pendulum rod, and is locked in position by a nut. It is as well to anneal the iron by allowing it to remain in the fire overnight.

The Pendulum

The pendulum is built up; a main portion P consists of a piece of half-inch wooden curtain rod, the ends being fitted into pieces of brass tube, A and B (see blueprint).

The tube A is closed at one end with a piece of brass rod, slotted to receive the suspension spring S, a small bolt and nut being the means of attachment. The rod is reduced to fit into the tube and a couple of small holes are drilled through the whole to receive rivets made from soft wire.

The tube B is attached to the rod in a similar manner, but before attachment a quarter-inch brass collar (or nut filed down) is driven into the end of the tube and soldered; screwed into the collar is a piece of threaded rod T, to carry the timing nut and the armature L. Sliding freely over B is the bob M, which should weigh from 10 to 15 lbs. and may be of iron or lead.

Fig. 3 shows the method of attaching the suspension spring to the brass chocks by small rivets.

Use steel ribbons or "feeler" blade steel for the spring, which should be from 3/1,000 in. to 5/1,000 in. in thickness.

The ends of the spring should be a good fit in the suspension bracket and the end of the pendulum respectively; the upper end of the spring has a pin Q that normally rests in the notches of the bracket. The length of the pendulum is measured from the bottom of the bracket to the centre of the bob; any slight error in length is easily corrected by altering the position of the bob by means of the timing nut.

Trailer or Finger

A piece of steel wire D is flattened at one end, the other end is driven into and soldered to the block B; the latter has a hole drilled at right angles to D to take the pin carried by the pendulum fitting.

The whole fitting should be as light as possible; to reduce wear, the flattened end of the wire D should be filed to a point and hardened.

To support the finger, the special fitting (Fig. 5) will have to be built up. This consists of a piece of thick tube R, to fit the pendulum rod T freely, and on opposite sides of the tube are soldered the bosses A and B; these are drilled and tapped to receive respectively the milled screw S and the pin P.

The screw S provides for adjustment of the finger up and down the pendulum rod relative to the contact-maker.

The Wheelwork

To reduce the amount of work and the tediousness of building up the wheelwork, necessitating the correct pitching of the holes for the pivots of the various arbors, it is proposed to utilise the movement of an alarm or other clock.

It will be appreciated that, although certain additions are made to the frames and wheels removed, yet the positioning of the wheels will not be affected.

If the movement has a seconds hand, remove all the wheels in the alarm train, then remove the "balance wheel" and "escapement"; after that, the large wheel carrying the main spring of the going train.

The next matter is to decide whether the clock is going to have a long or medium length pendulum.

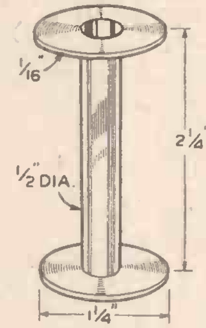


Fig. 9.—Details of the magnet bobbin

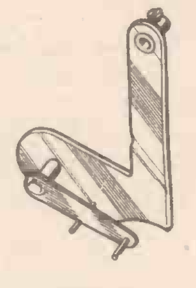


Fig. 10.—The driving piece, operated by the crutch rod

If a ¾ seconds pendulum is used, its length will be 22 in., and the number of teeth in the ratchet wheel will be 40, since a ¾ seconds pendulum makes 80 swings per minute. On the other hand, if a long or seconds pendulum is preferred, with a length of 39.12 in., the ratchet wheel will have 30 teeth. Frequently, on counting the number of teeth on the highest driven wheel of a movement, they will number 40, which is suitable for a ¾ seconds pendulum.

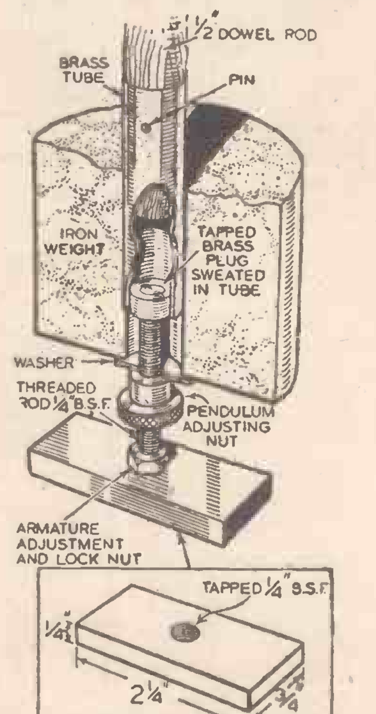


Fig. 11.—Details of the pendulum and armature

In this case it is not absolutely necessary to substitute a ratchet wheel of 40 teeth, but the driving pawl will have to be carefully shaped to fit the teeth of wheel. If it is decided to replace the wheel by a ratchet wheel with either 30 or 40 teeth, a piece of sheet brass may be used in its construction.

The length of the pendulum will not affect the other details of the clock, which can now be considered in detail.

The Frames

To support the arbor carrying the gravity arm it will be necessary to rivet or bolt to the frames two brass strips K. These are tied together at the upper ends by a length of 2BA threaded rod F; a piece of tube slipped over the rod serves as a distance piece when the nuts are screwed up. Viewing the movement from the back, it will be advisable to remove the top right-hand pillar originally fitted for keeping the frames the correct distance apart.

Holes are drilled in the strips K to take the gravity arm arbor O.

On account of clock frames varying in size, it may become necessary to modify slightly the dimensions given in the blueprint, but no great difficulty will be experienced.

The Gravity Arm

This component is readily made from a piece of sheet brass, and should be of ample proportions to have the required weight to propel the ratchet wheel.

A projection Q on the lower end of N carries the pawl R, engaging with the teeth of the wheel W, whilst its upper end is fitted with a bush to suit the arbor O. On account of the clock frames varying in size, the dimensions on the gravity arm can only be given approximately; the constructor can modify this to suit his special requirements.

The pawl is built up from a brass strip R, mounted on and soldered to a piece of thick tube T, to act as a bush, which in turn oscillates on the pin P projecting from Q.

A pin V, riveted to the outer end of R, engages the teeth of the ratchet wheel; the pin should be filed to suit the shape of the teeth.

To prevent the pawl from dropping and picking up more than one tooth when withdrawn by the pendulum, a pin Z may be set in the arm on which the pawl may temporarily rest.

The back stop M can be manufactured in much the same way.

Contact Maker

The device takes the form of a light spring, riveted at one end to a brass bracket screwed to a wooden or ebonite base B. The free end of the spring is provided with a contact G, engaging with an adjustable contact H, carried by the bracket I.

To restrict the play of the spring, an adjustable stop V is introduced; thin strips of leather, etc., may be glued to it to silence the action when the spring is released.

The spring should not be too stiff, otherwise in depressing it a lot of unnecessary work will be thrown on the pendulum.

Crutch Rod Details

Riveted or otherwise mounted on the spring is a small wedge-shaped block M; the latter has a small nick cut at one end for the entry of the point of the finger.

The baseboard B should be provided with slotted holes for adjusting purposes.

The connecting link between wheelwork and pendulum is the crutch rod (Fig. 2).

To render the rod adjustable up and down the pendulum as well as on the gravity arm arbor O, a small fitting B will suit all requirements. This part is cut from a block of brass and has two holes drilled at right angles to take the arbor A and the lever L respectively; tapped holes receive set screws S for locking purposes.

Hands and Dial

The design of the hands and the dial are left to the constructor's taste; the former should be fairly light and correctly fitted to the movement. The dial may be of cardboard, brass, etc., and about 7 in. across; suitable dials may, however, be purchased for a few pence, although there is no reason why it should not be home-produced.

There are various ways of mounting the dial (obtainable from us for 1s.); one is shown in Fig. 2, and shows the dial secured in position by metal brackets soldered to the clock unit.

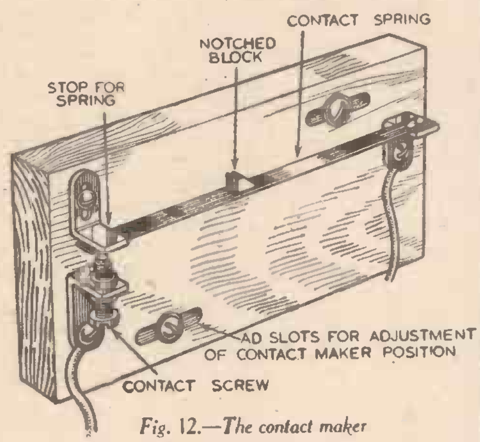


Fig. 12.—The contact maker

Mounting and Wheelwork, etc.

All the components are erected on a substantial backboard, so that the whole may ultimately be placed in a suitable case; the batteries may also be housed in the bottom of the case. The clock frame is attached with brackets to the backboard.

The backboard should have drawn on it a centre line, and is then hung up or set so that the line is truly vertical. Screw the pendulum suspension bracket to the top of the board so that the pendulum hangs in front of the line on the board. Next place the electro-magnet in position so that the cores are central with and about 1/16th in. below the armature; the gap can be reduced to a minimum later by packing up the magnet with a piece of cardboard. The magnet is best supported by a bracket or shelf.

The position of the contact-maker is found by experiment, mounting its baseboard a little above the mid-position of the pendulum rod. The rod should hang vertically at the time and the board set so that the nick in the steel block is on the left of the finger.

Now lower the finger attachment on the pendulum until the former is about 1/16th in. below the block. A little experimenting will be necessary to get the best results, raising the finger may be necessary if the spring is depressed more than, say, 1/32 in.

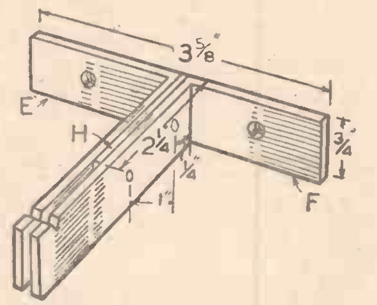


Fig. 13.—The pendulum bracket

Modern Air Photography

How the R.A.F. Take Snaps for Reconnaissance Work

THE means of taking reconnaissance photographs from the air have greatly improved since the last war.

Then, cameras were mounted in such a way that true levelling was difficult. Level sometimes had to be guessed at, and many of the pictures were far out of the vertical. For oblique pictures, quite another sort of camera was used, roughly described as like a coffee pot. It had two handles, which the photographer held over the side, trying to avoid the slip-stream, as he pointed the camera at the objective.

Nowadays one camera can take both vertical and oblique views. The spirit levels in the mounting immediately show any deviation. Adjustment is quick and easy.

An Advantage

The use of film instead of the old-fashioned plates is another obvious advantage. In the last war a big job needed a stock of half a dozen magazines, each of which held only 18 plates, and there was always the risk of passing over a magazine a second time, causing the inverted metal sheets to jam, so that they could be cleared only by unshipping the camera and shaking the plates back into the box. The magazine of the camera now in use contains sufficient film for 125 exposures 5 in. square, and is little bigger than one of the old magazines. It takes only a few seconds to load the film into the magazine.

The Camera

The camera itself is strongly made; it can be worked either electrically or by hand.

A clever device worked by the operating lever also photographs on to the left-hand corner of the picture the exact time at which it was taken.

Cable Improvements

A WELDED stainless steel sheath for small cables is now produced at Pirelli-General Cable Works, Eastleigh. It is particularly suitable for use as an aerial cable for telephone or pilot purposes, also in ships and factories.

Pirelli-General lead extruding machines have now been developed in three sizes, and are used by many prominent cable manufacturers in this country, while one machine has been exported to Canada.

Considerable progress has been made in the use of plastics as applied to cables, as the result of investigations undertaken by Pirelli-General in a specially equipped laboratory at their Southampton Works. Various wire conductors have been developed, and many types of cable possessing new and desirable properties are in production. Not only are plastics being used as cable insulation, but they are also being employed in conjunction with rubber. In due course much is likely to be heard of Pigelan and Pigeplas insulations, which are two of many types.

Loudspeaking Telephones

AN automatic telephone known as the "Reliance Loudspeaking S.10" instrument, incorporates loudspeaker and key calling facilities, thus enabling much time and labour to be saved.

The "loudspeaker" feature leaves both hands free whilst telephoning, as replies are heard over the loudspeaker, even at some distance from the instrument. The "key calling" facility eliminates dialling. Stations with which communication is frequently desired may be obtained simply by pressing a button.

These features are provided without the need for multiple cable. Only a twin wire is necessary to connect an instrument to the Automatic Exchange, irrespective of the number of stations included in the installation.

New Measuring Instruments

How Radio Apparatus is used for Testing Purposes

MANY interesting instruments have been developed by Salford Instrument Works. A new heterodyne reactance comparator takes the form of a portable mains operated test set and enables coils or condensers to be checked rapidly against standards.

Frequency Oscillators

Two radio frequency oscillators, one of which is variable, are made to beat against each other, and the resultant signal is rectified and heard on a loudspeaker contained within the instrument. The variable oscillator is controlled by a knob and drum drive. An accuracy of +0.1 per cent. is obtained.

Other new instruments include a thermionic test set giving a wide range of both A.C. and D.C. voltages and currents; a "Q" meter for measuring the "Q" of inductances and capacitances of high frequencies; a miniature illumination meter with range 0 to 250 candles, and also further valve voltmeters.

A Hardness Tester

The Salford hardness tester, which is now available, has been designed specially to measure very thin metal sheets or foils. It makes an impression of only .002 or .003 mm. (.00008 to .00012 ins.) and is suitable for hardness measurements on thin sheets and foils of the order of .02 to .03 mm. in thickness.

Our Busy Inventors

By "Dynamo"

Mechanical Tickler

TO-DAY the bugle has in many thousands of cases, supplanted the alarm-clock; the reverberation of the reveille has superseded the tintinnabulation of the bedside tocsin. However, there is a vast army of workers, many engaged on munitions, who still need to be punctually aroused. I understand that, like a scared conscience, one's ear can become inured to the clamour of the alarum. Therefore, a more effective awakener may be necessary. An alarm device has recently been patented in the United States which is striking, though not in the manner of the conventional alarm-clock. In this case the alarm is silent and yet it is well qualified to awaken the sleeper. The new invention arouses the recumbent worker by means of tickling. Part of the mechanism overlies a portion of the bed and, at the psychological moment, the lethargic sleeper is awakened and annoyed by ticklers.

To Disperse Fog

FOG, like the black-out, is discomforting. Any invention which will remove the nebulous cloak in which Mother Earth is occasionally enshrouded will lighten the lot of the benighted human family. I note that the subject of an application to the British Patent Office is a method of preventing and dispersing fog. The system proposed is the warming of the air above a street by electric heaters in channels along and across the roadway. For the convenience of transport and layout the channels are in sections of 12 inches in length and 10 inches in depth. The interior is semi-circular and of white glaze finish.

It is a curious fact that, in a fog, one is apt to stray from the path; it is not easy to pursue a straight line. In fact, one may even emulate a boomerang and return to the point from which one set out. A friend of mine informed me that, in a fog, he asked the same person the way three times

Pockets for Bathers

IN these times when the cult of the sun bath strews the foreshore with innumerable prone and supine mermen and nereids, a swimming costume fitted with convenient pockets is undoubtedly a desideratum. Articles such as smoking requisites, watches and treasury notes (if any) have to be stowed away somewhere. And it is imperative that the receptacle should provide absolute security against water. There have been many proposals for the use in garments of waterproof pockets, in which the pocket is clamped in the closed position. But it seems that one of the main objections to these proposals has been that the obvious presence of the pocket detracts from the appearance of the garment. Bearing this fact in mind, an inventor has devised a pocket or pouch secured to a belt in which the existence of the pocket is practically concealed.

Furnace Reflections

ONE generally associates the mirror with the fair sex, although "mere man" has been known to look in the glass. But the mirror has uses not connected with vanity. For example, it forms an essential part of the periscope which plays an important role in naval warfare. A mirror is incorporated in a new device for viewing the interior of highly-heated enclosures, such as retorts and ovens, or the flues of such enclosures. This invention will be useful, for instance, for examining the state of the walls of heated coke-ovens or coal-carbonising retorts, or the condition of the flues of such structures while they are at a high temperature. The mirror consists of a polished plate of stainless steel, the reverse surface of which is provided with a jacket through which a cooling fluid is circulated. Consequently, the reflecting surface of the mirror remains cool despite the heated surroundings, and a clear view is always obtained. The invention also permits the walls of the enclosures to be photographed by means of a camera focused on the image in the mirror.

I am reminded of the Greek myth of Perseus. This intrepid hero slew the Medusa, whose horrid head turned instantly to stone everyone who looked directly upon it. Perseus overcame this difficulty by glancing only at the fearful creature's reflection in his highly polished shield.

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

Automatic Warning

A SIMPLE and reliable form of air raid warning has been the object of the designers of a device which should be helpful to air raid wardens and police officers. It is asserted that, upon notice of a threatened air raid being received, the gas pressure in the mains will be reduced as a precautionary measure. The inventors in question propose to utilise this reduction in gas pressure to operate warning devices in the houses of those whose services would be particularly required during an air raid. The invention comprises a diaphragm exposed at its lower side to the pressure in a gas main, and at its upper side to the pressure of the atmosphere. There is a weight supported by the diaphragm. On the sinking of this weight, due to the fall in gas pressure, movement of the aforementioned member by the weight closes a pair of electric contacts to complete an alarm circuit.

Light and Lubrication

IN order to touch the spot, light on the subject is necessary. This is especially the case when oil has to be applied. The aim of a new invention is the provision of an oilcan with means whereby the point to be lubricated is illuminated for the period that the oil is actually supplied. Mounted upon the can, which is of the plunger type, is a flashlight. And the circuit of this electric torch is completed by the operation of the plunger. As a consequence, there is a useful blend of light and lubrication.

Pocket Stove

THAT already overloaded receptacle—the vest pocket—has yet another contribution to its contents. This time it is a pocket spirit-stove. The inventor remarks that hitherto spirit-stoves have been too large to be accommodated in the waistcoat pocket, and therefore their bulk makes them inconvenient for use on journeys and excursions. He has prepared a spirit-stove for heating canned food in their tins. It comprises a fuel container having on its upper surface hinged or pivotable buckles. These are adapted to engage in the flange on the bottom of a canned food tin, thereby serving as a support for the tin. The fuel container has an inwardly pressed wick tube closed by a metal closure plug. The spring is situated in a recess of the fuel container.

This spirit-stove, though conveniently portable in an overcoat pocket, would, I imagine, make the normal vest pocket bulge. It might appropriately be dedicated to the goddess of fire, Vesta.

Not a Matchless Cigarette

A MATCH combined with a cigarette is not a novel idea. In the past the match has, in one instance, been wrapped inside the paper of the cigarette. It has, in other cases, been affixed to the exterior of the cigarette by a thread, a band or by means of an adhesive. A simpler expedient has now been adopted. The match is attached to the cigarette by enclosure in a fold or crimp of the paper in such a way that it can be easily extracted and lit by striking on a suitably prepared surface. A strip of paper having a coating of an appropriately igniting material may be affixed to one of the edges of the packet. The improvement, it will be observed, consists in the fact that no additional fixing means is required. And as the head of the match projects beyond the end of the cigarette, this facilitates its removal by the hand.

Magnetized Cigarette

WHEN the "cigarettist," as an American has termed the chain smoker, puts down a lighted cigarette, it occasionally misbehaves itself either by allowing its ash to trespass on the tablecloth or by leaving a permanent impression upon the walnut case of the piano. Even when placed on an ashtray, it will leave the path of rectitude. To ensure that a cigarette shall "stay put," the power of magnetism has been pressed into the service. There has been patented a cigarette containing magnetisable material which secures it to a rest, also magnetised, on an ashtray.

Collar and Carrier

IT is now possible to employ a canine aide-de-camp. According to a device recently patented in this country, a dog can be fitted with a collar which will enable him to fetch and carry small parcels of light weight without soiling them. The collar is furnished with a subsidiary strap-part having a releasable fastener and forming a holder in which light articles can be carried and easily removed from the collar.

"PRACTICAL MECHANICS"

EXCLUSIVE OFFER

to You AT HALF PRICE!

INDOOR MODEL RAILWAYS

(HO and OO Gauges)

By E. W. TWINING

(With a Foreword by F. J. CAMM, Editor of *Practical Mechanics*)

HERE is a striking opportunity for all model railway enthusiasts to obtain a comprehensive, lavishly illustrated standard work on the subject at half the published price! The author is well known to readers of PRACTICAL MECHANICS, and his book deals with scales and dimensions, electric traction motors, reversing gear, modelling prototypes, motor mechanisms, carriages, waggons, third-rail and two-rail systems, etc. It contains 126 specially prepared drawings and photographs.

Send in the Order Form below at once. Supplies of this book are strictly limited, so hurry if you wish to take advantage of this bargain offer.

This fully illustrated 5/- book is offered only to readers of PRACTICAL MECHANICS at the special price of **2/6**

(Plus sixpence only for packing and postage)

POST THIS ORDER FORM WITHOUT DELAY!

To The Book Publisher, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2

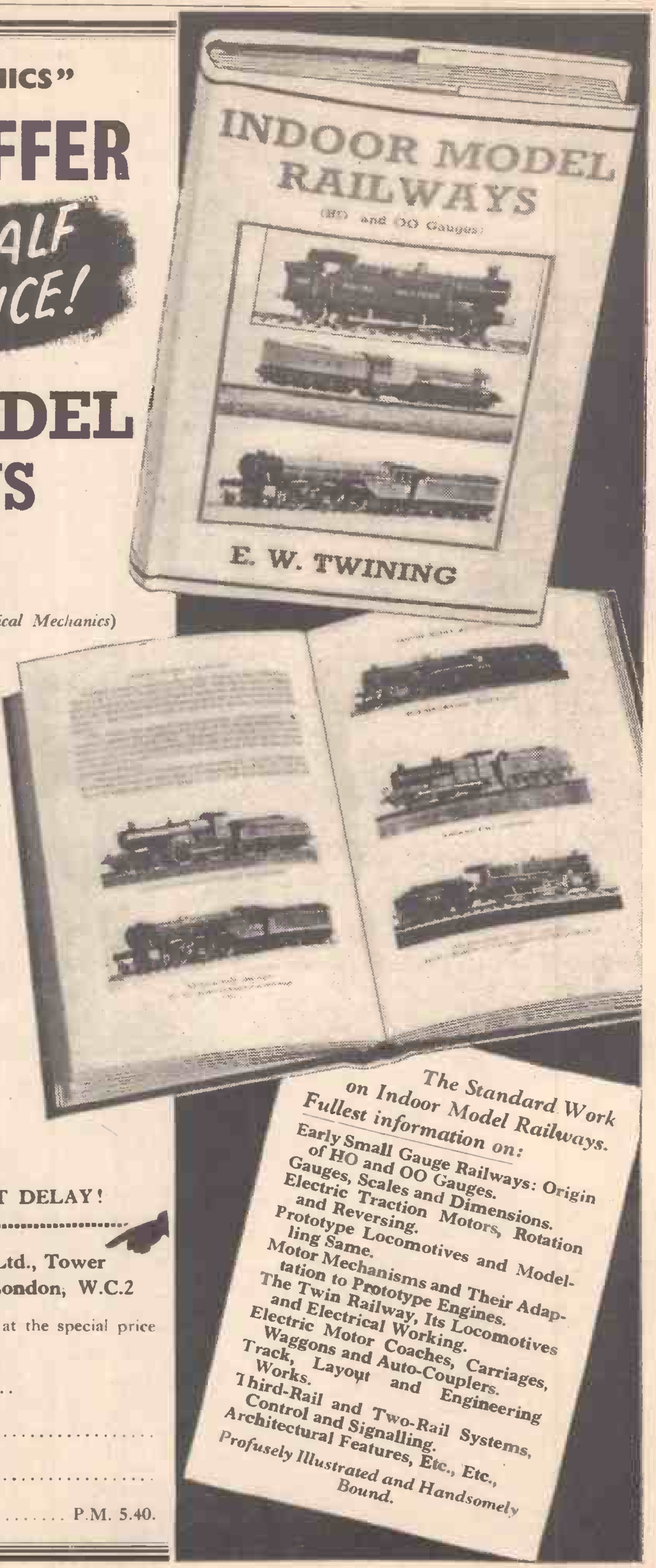
Please send me INDOOR MODEL RAILWAYS at the special price of 2/6 plus 6d. for postage and packing.

I enclose P.O. value 3s. No......................

NAME..

ADDRESS..

.... P.M. 5.40.



QUERIES and ENQUIRIES

A stamped addressed envelope, three penny stamps, and the query coupon from the current issue, which appears on page iii of cover, must be enclosed with every letter containing a query. Every query and drawing which is sent must bear the name and address of the sender. Send your queries to the Editor, PRACTICAL MECHANICS, Geo. Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

Hydroponics

COULD you tell me where I could obtain any books or information dealing with the water-culture of plants, and also what effects electricity has on plant growth?—F. J. H. (near Doncaster).

AS far as we are aware no books whatever have been published on the subjects you name, since, as a matter of fact, very little is known about them.

Some years ago a popular gardening paper published some information concerning the effect of electricity on plant germination and growth, and, also, at a later date, on the water-culture of plants. Also, the Director of Kew Gardens, Kew, may be able to refer you to any recently published papers on these little known subjects.

A Chemical Lavatory

CAN you, please, tell me the chemicals used in a chemical lavatory, and the proportions?—J. K. (West Hartlepool).

ALL these chemical lavatory fluids are supposed to be of secret composition, and hence their formulœ have not been published.

You can make up very similar fluids by mixing equal quantities of strong solutions of sodium hydrosulphite (*not* sodium hyposulphite, the photographer's "hypo") and potassium permanganate. Alternatively you may use a strongly deodorant fluid consisting of a strong solution of bleaching powder to which a little carbolic acid has been added.

Neither of these solutions keeps very well after being made up, and they should be stored in the dark.

Fireproof Enamel

I HAVE several objects of iron and metal, such as taps, handles, pots, etc., and I wish to give them an enamel finish to withstand fire. I cannot use enamel paint because this will not resist fire. I have an electro-plating outfit, but I do not know if this is good for the above requirement. Can you suggest me a practical method, and if in the affirmative can you tell me where to obtain the necessary ingredients?—A. S. (Malta).

YOU will find it absolutely impossible to enamel your taps, handles, and other iron articles so that they will withstand fire. The type of enamelling to which you refer is "vitreous enamelling." This process consists of spreading thinly over the cleaned iron articles a layer of enamel mixture in the semi-liquid form. The articles are now placed into a high temperature furnace in which they are "fired" or heated for several hours, during which time the ingredients of the enamel actually melt or "flux" together and flow in an even layer over the metal surfaces. After this has taken place, the articles are withdrawn from the furnace and allowed to cool.

It is quite impossible for any amateur—or, indeed, anyone without practical experience in the art—to produce this type of vitreous enamel. It is, of course, not possible to produce an enamel surface by any type of plating, as you suggest in your letter, and as a furnace for producing vitreous enamelled articles would cost several hundred pounds, we do not for a moment suppose that you will wish to go further with the matter.

Many of the modern cellulose enamels, however, dry out with a hard, glazed surface and, if allowed to set thoroughly, they show a surface which is very like that of a true vitreous enamel. Such surfaces, however, will not resist fire.

Running an Engine on Gas

HOW can I run an 8-h.p. car engine off town gas? I propose to store the gas in a container at low pressure.—P.K. (Middlesex).

THE question of running a car engine on town gas is one which has received the attentions of many inventors, but, so far, no one has succeeded in effecting this as conveniently and as economically as on a petrol or benzol supply.

Assuming that you propose to store the gas under low pressure you would require a seamless steel cylinder, itself quite an expense, and, also, a suitable compressor for charging the gas into the cylinders. The only alternative to this scheme is to employ the "gasbag" method of storing the gas. If, however, you desire to use a steel cylinder, you may be able to procure one of suitable size and capacity (about 80 cubic feet) from the British Oxygen Company, Wembley.

You will require to replace the carburetter of your engine with a "mixing valve," which is a fairly simple type of valve which feeds the coal gas into the intake manifold of the engine charged with the requisite amount of air. Such mixing valves are not manufactured commercially, but it is possible that you may be able to procure a small one of an approximately suitable type from Messrs. Crossley Brothers, Gorton, Manchester.

We are afraid that we cannot be of any further assistance to you in the problem which you raise, since the subject, although by no means a new or untried one, possesses very little published data. Your only way, therefore, of endeavouring to gain first-hand information on the question of a suitable mixing valve is to approach the enquiry departments of large engineering firms, as, for example, Crossley Bros., of Manchester.

A Heating Powder

I HAVE seen in use recently a brown metallic powder which, when water is added, gives out heat for a prolonged period—up to about 30 hours. This heat is comparatively gentle, and when the powder is contained in a waterproof case, is suitable for use as a source of warmth when travelling.

For flying, small containers can be placed in gloves and clothing generally. The metallic powder appears to be iron and the heat is probably due to some oxidising process. As the composition of this material is of scientific interest, I shall be much obliged if you will give any information which may be available.—H. F. J. (Kent).

WE have not actually seen the brown powder to which you refer, but, in composition, it will most probably comprise a mixture of finely-divided iron and iron (ferric) oxide. This, and several similar mixtures, give out a gentle heat over a number of hours when moistened with water, the evolution of heat being due to the chemical action of the water upon the ingredients of the powder.

We understand, however, that such powders have not found any large-scale commercial application, chiefly owing to the fact that the powders will only work in the freshly-prepared condition and that they are difficult to retain in such condition.

Electrolytic Deposition of Copper

IN the electrolytic deposition of copper on the wax blanks of gramophone records during manufacture, it is found that if the blank is put directly in the solution the deposit is thicker at the edges of the disc than in the centre. What is the cause of this, and how is it avoided in the actual process of manufacturing?

The copper is of course deposited on a graphite film on the wax cutting.—E. L. (Bristol).

THE trouble which you are experiencing in the deposition of copper on graphited wax blanks may be due to deficient "throwing" of the metal or to the unequal conductivity of the graphite film, or to both these causes. Be sure that you employ the finest possible graphite for the purpose, and that you get a film of this material of equal thickness on the blank. In some commercial processes the graphite is sprayed on to the blank, whilst in other systems a special form of mechanical dusting is resorted to. Whilst you cannot hope to imitate these methods, you should take every care to have the graphite film as uniform as possible over the blank.

The "throwing" of the metal is determined by many factors, chief among which is the shape and situation of the copper anode used in the plating bath. In your case this should comprise a copper disc immersed in the electrolyte so that it faces squarely the wax blank and is about 3 or 4 inches distant from it. Varying the position of this disc will give you much information regarding the type of deposit obtained on the blank.

In actual fact, the processing of modern disc records is very much a trade secret, and there is no published literature on this subject. It will, therefore, be necessary for you to experiment patiently, but you may be assured that in the above two directions your main source of trouble arises.

Cleaning a Stone Altar

COULD you, please, let me know the best way to clean an altar built of Caen stone?

I have cleaned marble, and other stone with acids, but none of my acids have any effect on the altar.—J. B. O'R. (Co. Cavan).

IT is a pity that you do not state the condition in which your altar of Caen stone is, that is to say, whether the stone is badly stained or whether it has become merely dirty or else just "mellowed." Stonework in the latter condition is best left alone, but you will find that dirty stonework is best cleaned by scrubbing it over with a strong solution of sodium metasilicate and soap.

Sodium metasilicate may be procured from Messrs. Alcock (Peroxide) Ltd., Luton, Beds, price about 4s. for 12 lbs. (plus, of course, any import duties which may be payable in Eire). The above-mentioned quantity should be sufficient to treat any ordinary-sized altar, plus any small statues which may need similar cleaning.

It is bad practice to use any acids on stonework, particularly marbles and limestone, since the acid treatment destroys the surface of the stonework, rendering it porous. Thus an acid-cleaned stonework quickly attracts dirt and rapidly becomes dirtier than ever.

After you have cleaned your Caen stonework, you should rub it over with a thick paste of whiting and water, using a heavy wooden block for applying the rubbing pressure. Finally, of course, wash away all the whiting, dry, and then rub the stonework over with a soft rag impregnated with turpentine or raw linseed oil.

If the sodium metasilicate treatment does not suffice (which we consider hardly likely) your only alternative method will be to rub the entire stonework over with a fine carborundum block. Blocks for this purpose can be obtained from The Carborundum Company, Ltd., Trafford Park, Manchester.

Improved Book Matches

I HAVE thought out an idea for an improved type of match book. Is it novel and worth patenting? — G. B. (Glasgow).

THE improvement in book matches is thought to be novel from personal knowledge, and forms fit subject matter for protection by letters patent. It is not thought, however, that the invention has any great commercial value since the additional cost of the proposed construction would probably militate against its extended use, because it must be kept in mind that cost in the production of book matches—which are often given away—is a predominating feature.

Making Lead Shot

CAN you give me any details of a machine suitable for the manufacture of small lead balls for loading sporting gun cartridges?—P. P. S. (Musta-Malta).

YOU will not find the manufacture of small lead pellets easy, for this is a task needing special skill and experience. However, the machine which you must devise for this process operates upon the following principles:

The liquid lead is allowed to fall through a mesh or a sieve from a great height like rain. During their fall, the tiny globules of lead assume a spherical form. They also solidify during their fall so that when they reach the ground they are solid.

The perfectly spherical lead pellets are then separated from those which are not perfectly spherical by causing them to roll down an inclined surface. The spherical pellets roll to the bottom of the incline, but the non-spherical ones fall off at the sides.

Finally, in order to provide for the spherical pellets all being of a standard size, they are passed through a sieve of a given mesh, thus ensuring that only pellets whose diameter does not exceed a certain maximum are passed by the sieve.

Much of the equipment for making lead pellets is of a semi-secret nature, and it is not usually possible to purchase machinery for this purpose. However, you might make enquiries for such machinery (and, also, for the lead pellets themselves) at Messrs' Walkers, Parker & Co., Ltd., Low Elswick, Newcastle-on-Tyne, England.

Motor Fuels

AS a motorist and an amateur chemist, I am desirous of making a study of various types of motor fuel. Benzole, as a home-produced spirit interests me greatly. Can you tell me where I can obtain some reliable information about this?—W. E. N. (Hornsey, London).

THE study of motor fuels is an extremely interesting and useful hobby for anyone with sufficient time and the right kind of equipment. Any information you require regarding benzole as a motor spirit, could be obtained from the National Benzole Association, Wellington House, Buckingham Gate, S.W.1, the technical body concerned with benzole standards in this country. "Standard Specifications for Benzole and Allied Products," second edition, 1938, published by the above association would also be of great help to you, for this book, which costs 7s. 6d., aims at being useful to both the user and the producer of benzole. It contains separate chapters on methods of testing, specific gravity, flash points, as well as full standard specifications. Remember that you are not allowed to keep more than two gallons of spirit at home or in a laboratory, unless you have a special permit or a storage tank licensed by your local authority. Fuel kept in the petrol tank of a car, is, of course, excepted.

ORDER NEXT MONTH'S COPY WITHOUT DELAY!

FREE SERVICE FOR READERS

READERS requiring information concerning goods or services advertised in PRACTICAL MECHANICS should give names of Advertisers from whom particulars are desired. Any number of names may be included and we will obtain for you catalogues, lists, and any other information you may be wanting. THERE IS NO CHARGE FOR THIS SERVICE.

Readers desiring particulars from a number of Advertisers will, by this method, save time and postage. If any Advertiser stipulates that stamps or postal orders are necessary before samples or catalogues are sent, please enclose the necessary amount with your instructions. You are cordially invited to make full use of this Service.

ADVERT. SERVICE DEPT.,
PRACTICAL MECHANICS,
TOWER HOUSE, SOUTHAMPTON STREET, STRAND, W.C.2

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

Advertiser	Page No.	Information Required

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

BUY, EXCHANGE OR SELL

Advertisements are accepted for these columns at 3d. per word (minimum 12 words at 3s.—advertisements of less than 12 words are charged at the minimum rate of 3s.) subject to a discount of 2½ % for 6 consecutive monthly insertions or 5% for 12 consecutive monthly insertions. TERMS :—Cash with order. Cheques, Postal Orders, etc., should be made payable to George Newnes, Ltd. *The Proprietors reserve the right to refuse or withdraw advertisements at their discretion.* All advertisements must be received on or before the 5th of the month preceding date of publication and should be addressed to the Advertisement Manager, "Practical Mechanics," George Newnes Ltd., Tower House, Southampton Street, Strand, W.C.2.

CANOES

BOATS AND CANOES. Low prices; few second-hands.—Metacraft (P), Christchurch, Hants.

MODELS

WANTED. Trix, Dublo and Marklin "OO" gauge railways. Cash or exchanges. Georges', 11 Friars Street, Ipswich.

MODEL AIRCRAFT

CANTERBURY.—East Kent Model Engineering Co., 21b Burgate Street. We have comprehensive stocks of popular duration, solid and flying scale kits, balsa, cements, dopes, propellers, wheels, petrol engines, spark plugs, ignition coils, condensers, etc. Please call.

WOLVERHAMPTON.—Wolverhampton's aeromodellers' rendezvous. START & SONS, 61 Victoria Street. Kits by all the popular makers, petrol engines, etc., selected balsa wood, spruce, cements, dopes, rubber, etc., and the most complete range of materials and accessories.

JUBILEE WORM DRIVE HOSE CLIPS

The long-life clip with the ever-tight grip

The Best Known

For Radiator Joints, Air, Oil, and Water Hose Joints

We guarantee a Tight Joint

Stocked by all Garages and Accessory Dealers

L. ROBINSON & CO., 25, London Chambers, GILLINGHAM, KENT

use "Baker's" SOLDERING FLUID *"For a quick clean job!"*

"Easily the Best Soldering Fluid Obtainable." This statement by a regular user of "BAKER'S" expresses the general opinion of the Motor and Engineering Trades.

Sold in 6d., 1/- and 1/6 tins, also in bulk.

SIR WM. BURNETT & Co. (CHEMICALS) LIMITED GREAT WEST ROAD · ISLEWORTH · MIDDLESEX TEL. HOUNSLOW 0676

OUR ADVICE BUREAU COUPON

This coupon is available until May 31, 1940, and must be attached to all letters containing queries, together with 3 penny stamps. A stamped addressed envelope must also be enclosed.

PRACTICAL MECHANICS, MAY, 1940.

MUSICAL INSTRUMENTS

BAND GUIDE. Hints on the Bugle, Drum, Flute, Staff Parade formation, etc. Free, post paid.—Potter's (Manufacturers), West Street, London, W.C.2.

PHOTOGRAPHY

PHOTOGRAPHIC MATERIALS. Plates, films, mounts, chemicals. Interesting money-saving lists free.—"Kimber's," 105 Queens Road, Brighton.

SITUATIONS VACANT

AERO AND ENGINEERING INSPECTORS, VIEWERS, etc. Work of National Importance and Reserved Occupations for men over 21. For FREE GUIDE to rapid preparation and Employment Service for these vacancies, apply National Institute of Engineering (Dept. 372), 148 Holborn, E.C.1.

MISCELLANEOUS

BE TALLER!! Inches put you Miles Ahead!! Details 6d. stamp.—Malcolm Ross, Height Specialist, BM/HYTE, London, W.C.1.

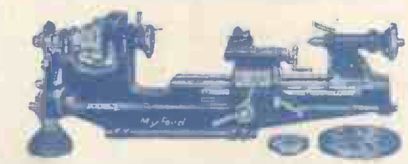
CASTING MOULDS.—For Lead Soldiers, Indians, Animals, etc. Sample mould, 2/9. Catalogue stamp.—Industries 2, Waldegrave Park, Twickenham.

TELESCOPES, MICROSCOPES, Scientific Instruments, etc. Send for lists. Sale or Exchange.—C. V. Bolton, F.S.M.C., 49a Leigh Road, Leigh, Lancs.

WANTED FOR PROMPT CASH. Miniature Cameras, Enlargers and Accessories, Cine Cameras, Projectors and Films. Microscopes, Telescopes and Binoculars. Small Lathes and Precision Tools.—Frank's Camera Exchange, 67 Saltmarket, Glasgow.

3⅛ MYFORD 3½

BEST VALUE—INEXPENSIVE



SUPPLIED TO NUMEROUS LARGE WORKS AND INSTRUCTIONAL CENTRES, ETC.

Bench - Treadle - Motorised Lathes & Accessories

Send P.C. for free illustrated list (your tool merchant's address would be appreciated)

MYFORD ENG. Co., Ltd., Beeston, Nottingham

FOYLES

BOOKSELLERS TO THE WORLD

New and secondhand books on all technical subjects

113-125 CHARING CROSS RD., LONDON, W.C.2

Telephone: Gerrard 5660 (16 lines)

CUT THIS OUT

Practical Pen Coupon Value 3d.

Send five of these coupons with only 3/- (and 2d. stamp) direct to the **Fleet Pen Co., 119, Fleet Street, E.C.4.** By return you will receive a handsome lever self-filling **FLEET S.F. PEN** with solid gold nib (fine, medium, or broad), usually **10/6.** Fleet price **4/3**, or with 5 coupons only **3/-**. De Luxe Model. **FLEET SELF-FILLER, 2/- extra.**

WATCHMAKING

WATCH & CLOCK REPAIRERS. Send 4d. for complete list of material and tools.—Blakiston & Co., Ainsdale, Southport.

TOOLS

GRAYSON'S Glass-boring Outfits and Tube. Cutters avoid risk.—Below.

DRILLS, Taps, Dies, Files, Chisels and Punches. Best quality at keenest prices.—Grayson & Company, 300 Campo Lane, Sheffield.

BRAND NEW POWER TOOLS of quality. 10-inch bandsaws, 54s.; Jigsaws, 22s. 6d.; Bench Drills, 11s.; Circular Saws from 25s.; 3-inch S.C. Toolroom Lathes, from £4 5s. New 1-inch chromium-plated Micrometers, 12s. 6d.; Electric Drills, 37s. 6d.; Grinders.—John P. Steel, Bingley.

CHEMISTRY EXPERIMENTS IN YOUR OWN LABORATORY

Post Free OFFER of SAMPLE PARCEL containing many useful pieces of

CHEMICAL APPARATUS 2/9

Write also for FREE PRICE LIST of other Sets.

BECK (Scientific Dept. A), 60, High St. Stoke Newington, London, N.16.

Booklet, "Experiments in Chemistry," 6d. P.O.

HAVE YOUR OWN CINEMATOGRAPH SHOW AT HOME

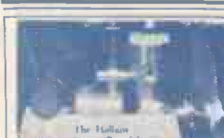
The New "Homray" Projector

Hand Turned Model for 60 & 300ft. **32/6**

Mains Motor Driven Model (Universal) **£3.17.6**

Obtainable from leading Stores and Photographic Dealers. Write to-day for illustrated list and name of nearest stockist

HOMRAY PROJECTOR COMPANY (Dept. P.M.), 46 High Pavement, Nottingham



Easily made from our castings

From 12/6 Per Set

J. HALLAM & SON Upton, Poole, Dorset.

MINIATURE PETROL ENGINES . . . for Aeroplanes and Speed Boats. 1 to 60 c.c. *Send 3d. for particulars.*

Price £3-7-6

Machine Vice 12/-

The 'ADEPT' Bench Hand Shaper

Length of stroke of ram, 3½ ins.; Length of cross travel of slide, 3 ins.; Size of Table, 4½ ins.—4 ins.; Rise and fall of Table, 2 ins.; Vertical feed of tool slide, 1¾ ins.; Maximum distance between tool and table, 3 ins.; Weight, 18 lbs. Also the 'Adept' No. 2B.H. Shaper, 6½-in. stroke. Price £6-19-0.

Manufactured by F. W. PORTASS SELLERS STREET, SHEFFIELD.

All applications respecting Advertising in this Publication should be addressed to the ADVERTISEMENT MANAGER, GEORGE NEWNES LTD., Tower House, Southampton Street, Strand, London, W.C.2. Telephone: Temple Bar 4363

Published about the 30th of each month by GEORGE NEWNES, LIMITED, Tower House, Southampton Street, Strand, London, W.C.2, and Printed in England by THE SUN ENGRAVING CO., LTD., London and Watford, Herts. Sole Agents for Australia and New Zealand—Gordon & Gotch, Ltd. Sole Agents for South Africa—Central News Agency, Ltd. Subscription Rates: Inland and Abroad, 8s. 6d. per annum. Canada, 8s. per annum. Registered at the G.P.O. for transmission by Canadian Magazine Post.