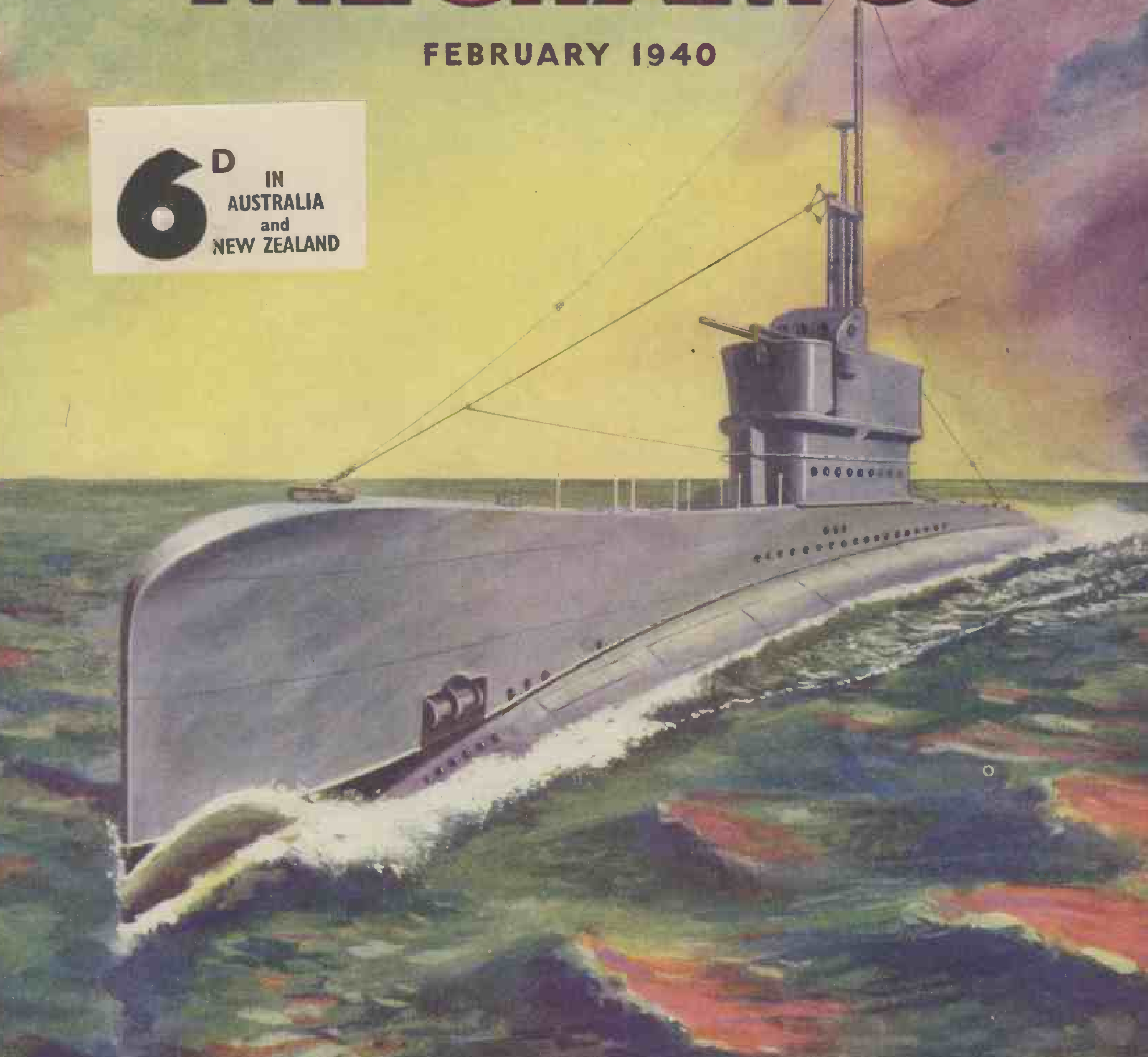
PRINCIPLES OF THE SUBMARINE

NEWNES

PRACTICAL MECHANICS

FEBRUARY 1940

6D IN AUSTRALIA and NEW ZEALAND



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. FEBRUARY, 1940. No. 77

NEW WEEKLY JOURNAL FOR ENGINEERS

By the Editor

ON January 25th the first issue of our new journal *Practical Engineering* was published. It is a weekly journal and its price is 4d., and it has been produced especially for all those engaged in the engineering and kindred trades.

The British Engineering industry is rightly considered as the workshop of the world, for nearly every important process, machine, and system was originated by British engineers. The mass-production system of interchangeability and rapid manufacture of parts was introduced by British engineers, and the numerous new materials now employed were the discovery of British chemists and metallurgists.

The Engineer To-day

THE engineer is called upon to-day to manufacture a vastly greater range of products than he was a quarter of a century ago. The motor-car, the aeroplane, the motor-cycle, the container-vending of goods, typewriters, clothing, furniture, buildings, and agricultural work—all to-day call for the services of the engineer.

Apart from the greatly enlarged range of manufacturing processes which this extension of engineering has brought about, new and special machines have been created to cope with them. New steels and new alloys have been introduced. Many new and important subsidiary industries, such as plastics, have been created and, with them, new professions. The tool maker, the foundry worker, the gauge maker, the capstan setter, the sheet metal worker, the drop forger, the operator of the hydraulic press, the miller, the planer, the shaper, the borer, the fitter, the turner, the precision grinder—these are but a few of the occupations which to-day employ tens of thousands of skilled people. Even the electrical trade is now largely dependent upon the mechanical engineer.

Many months ago it was suggested to us by the executives of important engineering firms that there existed a need for a modern weekly periodical covering authoritatively and extensively the whole field of modern mechanical engineering processes. Support was given to this suggestion by our inquiries among many of the leaders of the engineering trades. It was pointed out that such a journal must appeal to—indeed, act as a link between—not only the manufacturers of machine tools, but also to users of them.

It Fills the Gap

PRACTICAL ENGINEERING, is intended to fill this gap in engineering periodicals. Entirely modern in its selection of subjects, it will deal week by week with every workshop process and the use of every type of machine employed in this country. The leading authorities on special subjects have been retained to serve the new journal, which will be published every Thursday at 4d. The Staff are practical engineers having the highest qualifications.

Practical Engineering will appeal to all the key executives in the metal working industry, to the designers, the shop superintendents, the production and plant engineers; in fact to all those engaged in the engineering and allied industries.

Our Aim

PRACTICAL ENGINEERING will deal with modern processes of manufacture, and machine tools, and also with works lay-out, time-saving methods, the drawing office, finishing processes, test equipment and inspection; in fact, with every sub-division of the mechanical engineering industry. It will review new machines and equipment and explain by practical articles illustrated by first-class drawings the latest methods of manufacture.

We have been encouraged to publish *Practical Engineering* because we feel that such a journal is even more vital to-day than it was several months ago when the idea was first mooted. It will perform a national service, and, we hope, encourage an even livelier interest in mechanical engineering. The news and other features will keep the reader fully informed of the latest developments in this and other countries. The Advice Bureau, consisting of a panel of experts, exists to advise engineers on all matters relating to their business. An important feature will be the informed criticism of matters affecting the engineering trade.

Place your order for *Practical Engineering* without delay.

Unique Book Offer

IN connection with *Practical Engineering* a unique book offer is being made to every reader, who may obtain for a number of tokens cut from the cover and a nominal sum, a copy of *Newnes' Engineer's Handbook* — a valuable compilation of tables, facts, and data needed by all those engaged in the engineering trade. There are special sections on screw-cutting, mensuration, stress formulæ, plane geometry, trigonometry, gear-cutting, the slide rule, pulleys, logarithms, weights of materials, and so on. The book extends to 256 pages and is handsomely bound. It is a volume which in the ordinary way could not be sold for less than half-a-guinea. Full details of the offer appear in the first issue of *Practical Engineering*, now on sale. I hope every reader of PRACTICAL MECHANICS will purchase a copy of our new journal and let us have his opinion of it.

The Principles of the Submarine—Part I

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

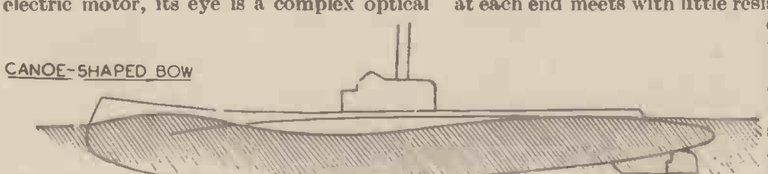
How the Submarine Torpedo Boat has Developed Through Over Thirty Years of Intensive Research. Many Difficulties had to be Overcome Before it Reached its Present-day Perfection

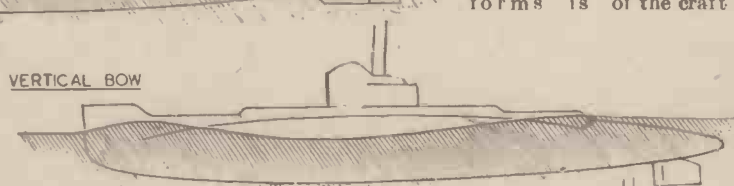
FEW of the scientific creations of man, designed for purposes of peace or war, have a greater wealth of applied principles of physics to offer in a single self-contained unit than the Submarine Torpedo Boat. Its shape is dictated by the laws of hydrodynamics and hydrostatics, its motive power depends upon the heat engine and the electric motor, its eye is a complex optical instrument, its ear in the broadest sense involves both wireless telegraphy and the direct transmission of sound, and its navigation is aided by the gyroscopic compass, an instrument which incorporates the highest principles of mechanics and magnetism.

The designer of a submarine hull has to solve the primary problem of finding a vessel whose form is such that it presents a maximum resistance to the crushing power of a depth of water, and at the same time meets with a minimum resistance when driven through the water, submerged or on the surface. A knowledge of hydrostatics at once suggests a spherical vessel as the one best suited to resist the external crushing power, but it is also known that such a form would meet with considerable resistance when moved through the water. On the other hand a needle-shaped body which is streamlined by a simple tapering to a point at each end meets with little resistance when driven through a fluid and so a compromise between the spherical and needle forms is effected and the familiar cigar-shaped hull with circular cross-section is evolved.

Earlier Submarines

The earlier submarines, those constructed thirty to forty years ago, were almost literally cigar-shaped with the least amount of superstructure added in the form of a tube or box-like conning tower giving access to the interior. But trials with these vessels soon made it evident that the problem of hull design was still some distance from solution. Such boats cruising on the surface were found to cleave the water in such a way that a volume of water was made to mount over the stern, depressing this part of the craft and giving its nose an upward tilt. (See Fig 1). Applications of the laws of hydrodynamics dealing with the motion of a solid body through a fluid were made to the problem and the calculated results tested by studying the behaviour of





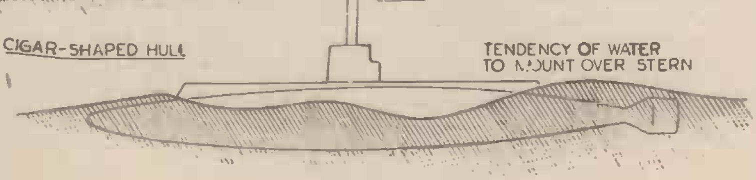


Fig. 1.—The three main types of submarine bow

models in a water tank, and a variety of forms was obtained which prevented the excessive accumulation of stern-water. Typical of these forms are the vertical and canoe-shaped bows. (See Fig. 1).

New Difficulties

However, the modification of the hull form in this way to avoid the depression of the stern engendered new difficulties which in turn called for solution. Any modification in the shape of the hull which makes a marked departure from the feature of circular cross-section weakens that hull and renders it less able to withstand the crushing pressure of the outside water. It became clear therefore, that in order to retain the strength inherent in a boat of circular cross-section and at the same time to preserve the advantages of streamlining, a new conception of hull design was necessary to the further development of the submarine torpedo boat. These needs were satisfied by the design of a double hull which could be made to include an extended superstructure. The double hull in its simplest form would consist of two tubes, an inner tube and an outer tube, arranged about the same axis with the ends tapered to points to facilitate easy translation through water. If the inner tube is retained in this form the boat keeps its strength, and if the outer tube formed from a light skin of plates be shaped to the requirements of streamlining, the boat may be propelled with a least effort. Thus the double-hull design gives the craft both sturdiness and navigability.

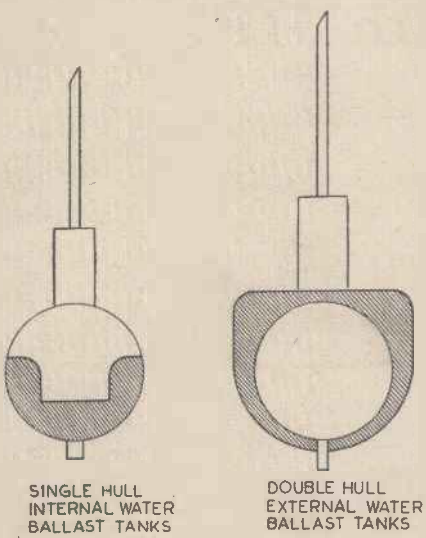


Fig. 2.—Vertical cross sections showing circular pressure hulls and water ballast tanks (shaded)

Superstructure

The superstructure may be described as that part of the submarine built on top of the hull to include the conning tower and to provide deck space along the length of the vessel. It is easily seen that in some cases the outer hull could be made to merge with the superstructure wholly or partially as the designer saw fit, and a variety of constructions has followed in the attempt to find the form most serviceable. Examples are illustrated in Figs. 2 and 3. Foremost amongst the earlier designers was the French engineer, Lauboeuf who further increased the strength of the tubular pressure hull by fitting it with transverse bulkheads, thus dividing the interior of the submarine into a series of compartments which could be made watertight by closing doors and used as refuges in time of emergency.

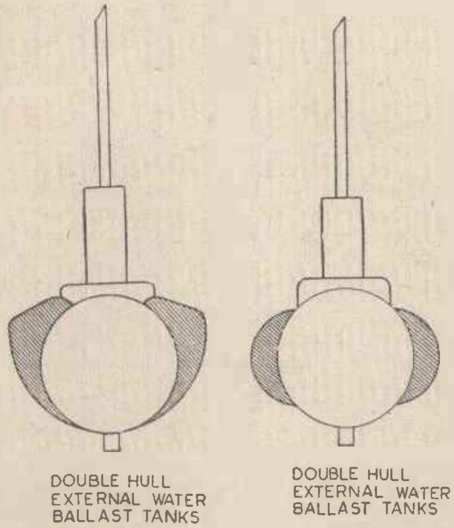


Fig. 3.—Further cross sections (see Fig. 2)

In addition, to solving the problem of combining internal strength with external streamlining, the invention of the double hull brought with it other advantages, chief of which was the new and economic disposition of the main water-ballast tanks. A submarine is submerged by admitting water into tanks built into various parts of the hull. The water enters the tanks through valves which put them into direct communication with the sea, and to bring the boat to the surface again, the tanks are emptied by blowing the water out through the valves under the force of compressed air. These tanks fall into two classes; the main water-ballast tanks which take the bulk of the water needed to submerge the boat, and the auxiliary trimming tanks which admit or expel smaller quantities of water to make the delicate adjustment of the balance of the vessel when submerged or afloat.

Double Hull Construction

In the single spindle-shaped hull these tanks were of necessity contained in the interior of the boat, and space which could have been profitably employed for housing crew, machinery, stores or ammunition, had perforce to be filled with water ballast. The double-hull construction provided space between the two hulls which could be used as main water-ballast tanks, leaving considerably more room in the interior of the submarine. Later it was found that still more free space could be made available inside by extending the transverse bulkheads as far as the outer hull plates to divide up the space between the two hulls into several compartments, some of which could be used as main water-ballast tanks and the others for the storing of the oil required by the heat engines for combustion and lubrication. The auxiliary trimming tanks, being smaller in size, are conveniently located in the extreme ends of the boat, where the space is necessarily very limited on account of the tapered form, although these trimming tanks can in some cases be lodged in the end spaces enclosed between hull and superstructure if the latter be sufficiently long.

It became clear at an early stage in the development of the submarine torpedo boat that a long rather than a short superstructure was advantageous and, in fact, necessary as the size of the boats increased and mounted external armaments. The superstructure serves a number of useful purposes. By making it long, the boat is given a longitudinal stability in surface navigation from the increased area of immersed surface which reduces the factor of "top-heaviness." It also increases the area of deck-space available for mounting guns or derricks, covers the top and part of the sides of the hull, giving an added protection against collision, ramming or shell-fire, and provides an extra storage space between deck and pressure hull where may be housed small boats, cable holders, hatches and other articles which would offer, on account of their irregular shapes, undue resistance to a smooth passage through water were they not thus covered over by the superstructure. Articles stored in this space, however, must not be perishable or liable to deterioration in contact with sea water, as this part of the submarine is permanently open to free flooding. When the submarine submerges the sea floods into this space through open holes made in the superstructure sides just below the deck level, and drives the air out through a large number of smaller holes drilled in the deck surface. When the boat rises to the surface again, this water automatically drains out from the sides and air enters through the vents in the deck surface.

Submerging

It can be readily understood that the process of submerging a submarine by admitting water into its tanks is a delicately balanced one and must be finely calculated. By admitting too much water the boat would sink to the sea-bed and might have difficulty in rising again under its own power. By not admitting enough the boat would fail to sink below the surface and would give rise to a state of affairs which

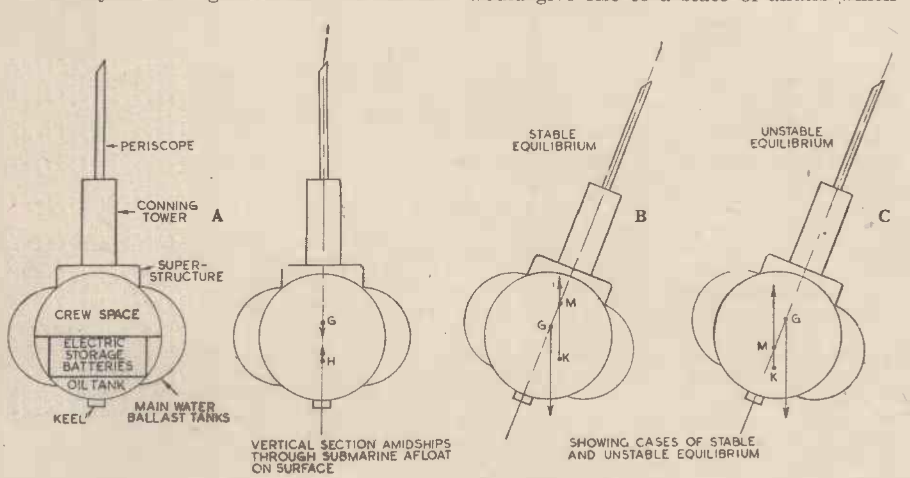


Fig. 4.—Showing how a submarine can recover from a list

in given conditions could be equally as disastrous as the first. The question of flooding and blowing the water-ballast tanks, therefore, demands calculations of a precise nature, and these calculations are bound up with the physical phenomena of buoyancy and the stability of floating bodies.

When a body which may be hollow or solid or open or enclosed, is immersed in a liquid and succeeds in displacing an amount of liquid whose weight is equal to its own, the body will float. This is the phenomenon of buoyancy and has been known for twenty-two centuries since its discovery by the celebrated Sicilian Archimedes. A block of wood will float in water because its density is less than that of water, and a lump of iron sinks because its density is greater than that of water. But, if the iron be hammered out into a sheet and curved to form a closed vessel then the effective volume occupied by the iron is increased and will accordingly displace a greater quantity of water when immersed. If this quantity of water weighs as much as the iron, the iron vessel will float. It is common knowledge that when anything is placed inside a floating vessel, the vessel sinks a little. In the light of Archimedes' principle, this sinking is necessary in order to displace an extra weight of water just equal to the weight of the object added, making the total weight of water displaced equal to the combined weight of vessel and contents.

A Floating Hull

A floating hull may be regarded as consisting of two parts. The part below the water line whose volume is the same as the volume of the displaced liquid, and the part above the water line. This volume above the water line is called the reserve buoyancy of the boat, and the submergence of the boat is governed by the careful control of this reserve buoyancy.

In a submarine the reserve buoyancy is represented by the total volume of the water-ballast tanks. When these tanks are empty the reserve buoyancy is said to be positive and the boat floats. When they are filled with water, the reserve buoyancy has been overcome and is said to be zero. In this condition the submarine is just under the surface, its actual weight plus the weight of water occupying the tanks, being just equal to the weight of the water displaced by the submerged boat, so that, as far as the force of gravity is concerned, the submarine forms a piece of the sea itself and will neither rise nor sink. In this critical condition the shipment of the slightest quantity of extra water will make the reserve boyancy negative and the boat will immediately sink and will continue to sink until the sea bed is reached, unless, of course, the reserve buoyancy is again made zero by discharging some of the ballast or by bringing the power of the submarine's engines into operation against the dive.

Reserve Buoyancy

The reserve buoyancy calculated in terms of the total water-ballast tank space by the naval architect has to be different for different types of submarine. If this volume is a small percentage of the boat's total volume, the shipment of a relatively small quantity of water, intentionally through the valves of the ballast tanks or accidentally through an open conning tower or leak in the hull plates, will be sufficient to send the craft below the surface. Small percentage reserve buoyancies are to be found, therefore, only in those vessels intended for service in the reasonably calm and sheltered waters of bays and harbours, whilst a much greater reserve buoyancy is accorded to the ocean-going type of submarine which is more liable to encounter rough weather. But, although such a vessel has a greater seaworthiness it has the disadvantage of needing a longer time to flood its tanks and dive. For this reason it is customary for submarines which are operating under active service conditions to surface cruise "in diving trim," that is with their tanks three-quarters full in readiness for a sudden submergence made by rapidly flooding the remaining space in the main-water ballast tanks.

Stability

Closely allied with the buoyancy properties of a boat is its factor of stability which determines whether or not a boat will right itself, and with how much ease it will do this, when made to heel over to one side or the other. In terms of pure geometry the stability of a boat is decided by the positions of three points, situated in a vertical cross-section, taken through the boat. These points are the centre of gravity of the boat itself, the centre of gravity of the water which would occupy the space taken by the immersed portion of the boat, and the metacentre. The action of gravity through these three points brings into play forces which determine the boat's ability to recover from a list. The centre of gravity of the boat is the point through which acts in a vertically downward direction the resultant of all the forces of attraction between the earth and all the particles of matter out of which the boat is composed. In Fig. 4 this point is denoted by G. Similarly H denotes the centre of gravity of the water which would fill the space occupied by the boat when the latter is at rest on an even keel in still water. K is the centre of gravity of this water when the vessel has a list from its equilibrium position. The vertical line through K intersects the straight line through G and H at the point M, which is defined as the metacentre. In accordance with the principle of Archimedes the vessel floats when its weight acting vertically downwards through G is exactly counterbalanced by the vertical upthrust of the displaced water through the point H. When these two points lie on the same vertical, the boat is at rest and has no list. (Fig 4a). When there is a list the upthrust through K and the weight acting through G constitute a mechanical couple which tends to turn the boat about its axis. It can be seen from Fig. 4 that the location of the metacentre decides whether this turning movement will tend to right the boat or cause it to capsize. In Fig. 4b the metacentre lies above the centre of gravity of the submarine and the system is mechanically stable, since the couple acts in a counter-clockwise direction and tends to restore the boat to its normal position, whereas in Fig. 4c the metacentre lies below the centre of gravity producing a clockwise couple which turns the boat over.

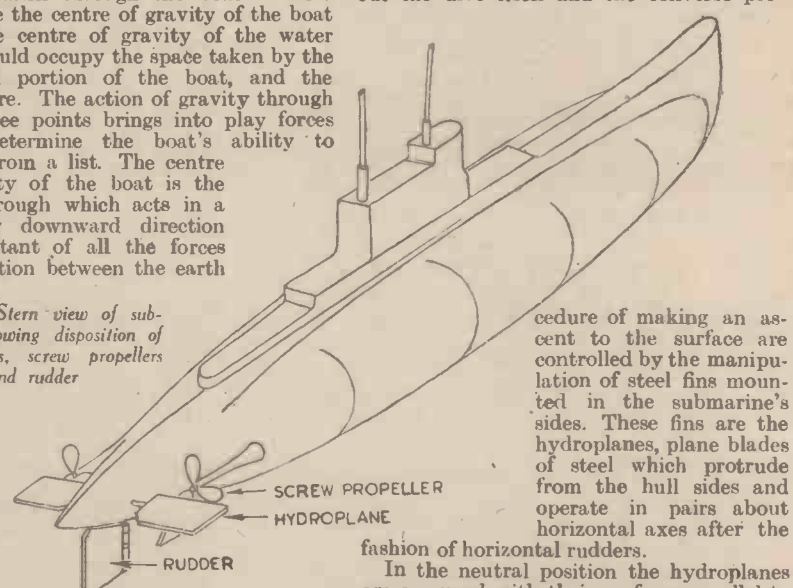


Fig. 5.—Stern view of submarine showing disposition of hydroplanes, screw propellers and rudder

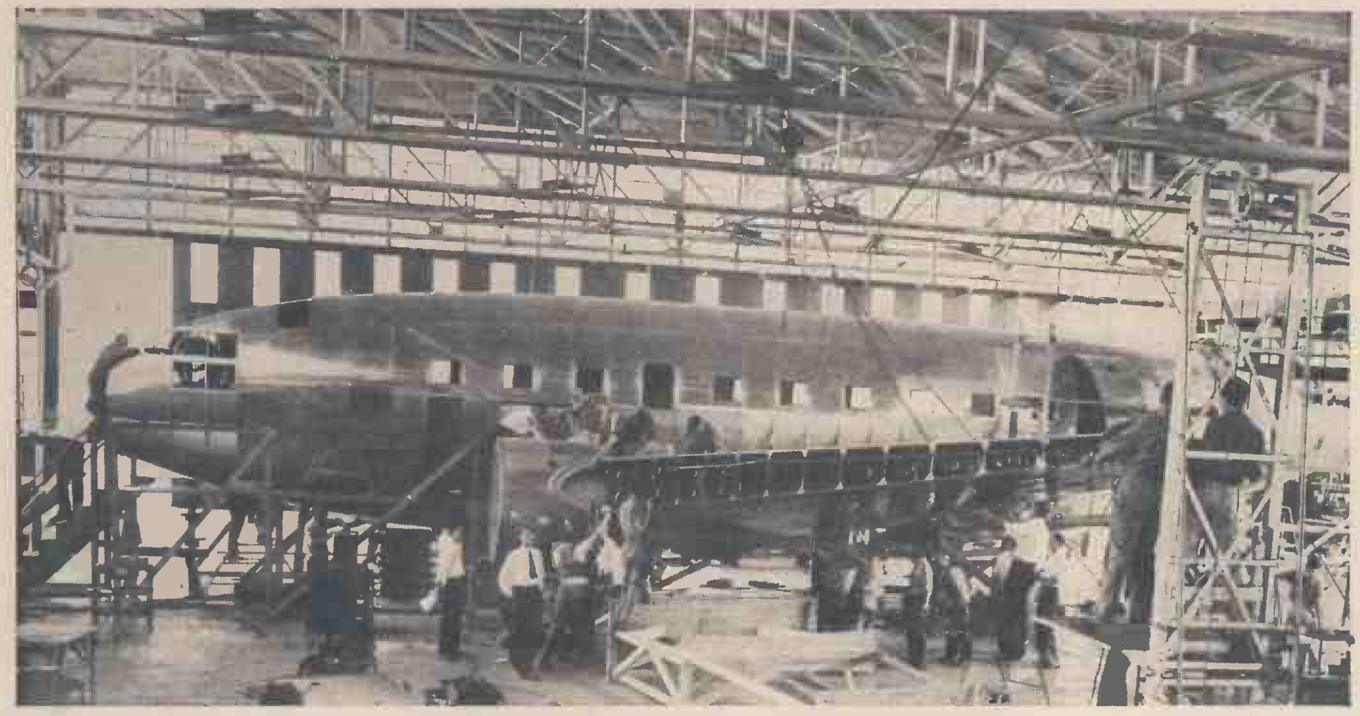
To summarise the main features of a hull successfully designed for submarine purposes, it may be said then that the inner hull must be circular in cross-section to withstand the crushing pressure of the water, the outer hull shaped to give an easy mobility through water, the reserve buoyancy calculated to make the vessel both seaworthy and readily submersible, and the net hull form and distribution of internal load arranged to bring the metacentre above the submarine's centre of gravity for the purpose of stability.

Diving Powers

It has been seen that a submarine has to possess diving powers capable of converting it at short notice from a normal surface cruising vessel into an underwater craft resembling in many respects a steel fish. The process of submergence depends mainly upon the sudden flooding of the water ballast tanks by opening them to the sea, but the dive itself and the converse procedure of making an ascent to the surface are controlled by the manipulation of steel fins mounted in the submarine's sides. These fins are the hydroplanes, plane blades of steel which protrude from the hull sides and operate in pairs about horizontal axes after the fashion of horizontal rudders.

In the neutral position the hydroplanes are arranged with their surfaces parallel to the surface of the sea so as to offer no resistance to the motion of the boat through the water, but during a dive the blades are inclined with their forward edges down in order to receive on their upper faces the thrust of the oncoming water as the boat moves forward. This thrust imparts to the submarine an oblique course into deeper water, and combined with the vertically downward drag of gravity on the water filled tanks produces a dive which is swift without being dangerously steep. Conversely, the submarine passes from a horizontal course under water into a rising course towards the surface by simultaneously discharging the water ballast tanks and inclining the hydroplanes with their forward edges upwards to receive the thrust of the water on their under faces, the steepness of the ascent being controlled by the angle of inclination of the hydroplanes, the velocity of the boat through the water and the rate of discharge of ballast. Some submarines are fitted with two pairs of hydroplanes, one pair in the bows and the other in the stern immediately behind the screw propellers, the latter pair having a larger blade area to enable their effect to predominate over that of the forward blades which are adjusted in response to the inclination of the larger pair to steady the boat in its dive or ascent. The disposition of rudder, stern hydroplanes and screw propellers are illustrated in Fig. 5.

(To be continued)



America's largest twin-engined airliner nearing completion

New Sub-stratosphere Aeroplane

Details of America's Largest Twin-engined Airliner which has been Specially Designed for High-altitude Operation

THE Curtiss-Wright Corporation, pioneer American manufacturer of commercial and military aeroplanes, aircraft engines and propellers, is now completing at its St. Louis (Missouri) Aeroplane factory for initial flight tests America's largest twin-engined, high-speed, civil transport plane, according to Guy W. Vaughan, president of the organisation.

It is the newly designed low mid-wing, all-metal Curtiss-Wright sub-stratosphere plane, built as a club type to transport 30 passengers, a crew of from three to five, and 6,000 lb. of mail and express at approximately 3½-miles-per-minute at altitudes up to 20,000 ft. As a sleeper version —a type which Curtiss-Wright introduced in aviation with the C-W Condor in 1934—it will accommodate 36 passengers by day and 20 in berths at night.

Many Innovations

Designed by Curtiss-Wright engineers working in close consultation with major U.S. air-line experts to develop a larger and faster airliner, it incorporates the latest advances in air travel and many innovations beneficial to the traveller as well as to the pilot. A well-balanced design, it sacrifices neither safety nor economy to obtain its high speed, luxurious accommodation, heavy payload, maximum operating simplicity and advanced aerodynamic efficiency. Its flexible load-carrying qualities qualify it for trans-continental or non-stop service.

Dwarfing in size any airliner now being regularly operated in the United States, it is 75 ft. from nose to tail, has a wing span of 108 ft., is 19 ft. 2 in. high, weighs 24,750 lb. empty, carries a useful load of 13,250 lb., and weighs 38,000 lb. fully loaded. It is equipped with two fuel tanks in each of its two wings, the four having a total capacity of 1,000 gallons.

A cross section of the pressurised fuselage showing two eccentric circles intersecting so that the floor joins their points of intersection

Emphasising safety, yet adhering to the principle that the most efficient as well as the most economically operating transport is one which is equipped with a minimum number of large power plants, its designers have powered the new airliner with two Wright Double-Row Cyclone 14 engines (data restricted) which are calculated to give it a maximum speed of 243 m.p.h. at 13,000 ft., a cruising speed of 210 m.p.h. at 10,000 ft., a climbing speed of 1,440 ft. per minute and a landing speed of 70 m.p.h.

Anticipating that some air-line operators may wish to increase the new design's payload and performance, however, Curtiss-Wright engineers have so designed the new sub-stratosphere type that it may be equipped with power plants of considerably greater power than those now installed.

Power Plants

The power plants are equipped with 15-ft. Curtiss electric "full-feathering" propellers which are the largest ever manufactured for air line operations in the United States. The "full-feathering" type, a design which Curtiss-Wright was the first to develop and manufacture, not only enhances single-engine performance but also eliminates destructive engine vibration likely to occur in case of engine failure when using a propeller which permits "windmilling."

To permit normal cruising at 20,000 ft. with equivalent "cabin altitude" of 6,000 ft., pressurisation of the fuselage is obtained through a new cross-sectional design of two eccentric circles, intersecting in such a way that the floor joins their points of intersection. The floor thus acts as a tension tie to withstand loads caused by the tendency of the two circles to separate under pressure.

Above the floor is a roomy, luxurious passenger cabin—6.9 ft. high by 9.75 ft. wide (at window height) by 35.3 ft. long —with fixed-reclining or swivelling-reclining chairs for as many as 40, or sleeping berths for 20; and below is a spacious cargo hold of 550 cub. ft., capable of accommodating 5,200 lb. of cargo and a separate compartment of 137 cub. ft. to contain such accessories as batteries, water tanks, etc.

The wing design was developed following tests which proved that lateral control can be retained at and below the plane's stalling speed by modifying the airfoil toward the wing tip. Thus the plane may execute three-point landings at minimum speed without chancing "falling off on one wing." Special Curtiss-Wright slotted flaps attached to the trailing edge of the wings, inboard of the ailerons, move directly aft during the first part of their motion to provide added lift for take-off and initial climb, and revolve downward for the latter part of their motion to accomplish air-breaking.

Landing Gear

The landing gear was so designed as to eliminate the possibility of failure. In anticipation of the further development of blind-flying technique, the gear was designed to permit landing at a rate of descent of 800 ft. per minute, the landing being cushioned by an extremely long shock absorber travel. The geometry of the structure has been so worked out that when the aeroplane is on the ground there is no possibility of the landing gear folding even if the power is applied. As long as the weight of the aeroplane is on it, the landing gear cannot be retracted.

While the use of but two engines relieves the pilot of the extra responsibility and effort attendant on the presence of a multiplicity of power plants, Curtiss-Wright engineers have further simplified the pilot's operation of the new skyliner by reducing the number of flight controls in the modern transport 33 per cent.; perfected a revolutionary "tell-tale" safety device which automatically checks the functioning of approximately 50 major instruments and controls and is virtually a "fourth pilot"; devised special radio communication facilities; and lessened the problem of aeroplane and engine "icing."

SPECIFICATIONS

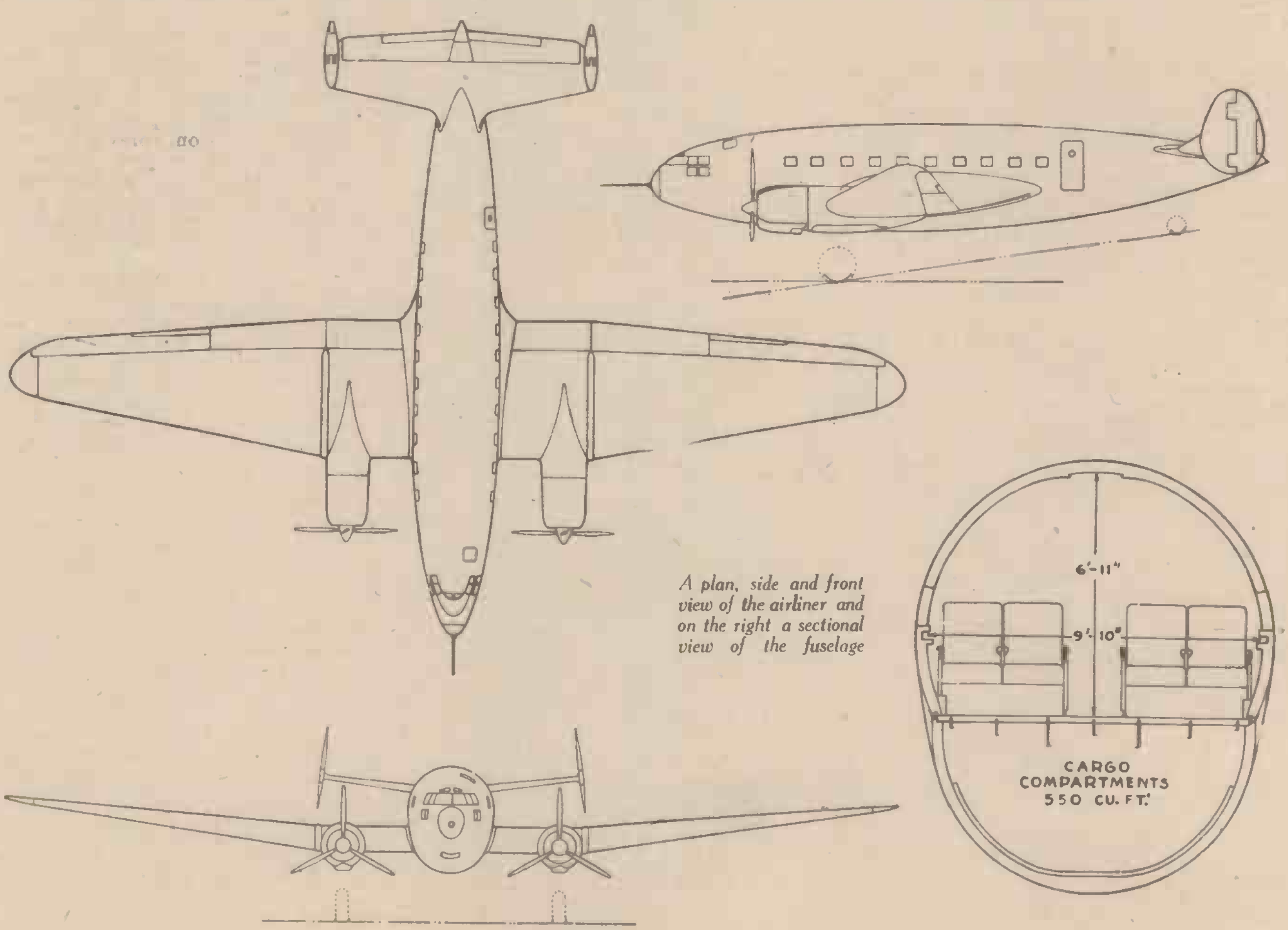
	Cyclone 14	Duplex Cyclone
Dimensions—		
Length		75 ft. 0 in.
Height (tail down)		19 ft. 2 in.
Wing span		108 ft. 0 in.
Wing area		1,353 sq. ft.
Tread		25 ft. 11 in.
Power Plant—		
Wright Double-row Cyclone 14's or Wright Duplex Cyclones.		
Weights—	*Cyclone 14*	*Duplex Cyclone*
Empty	24,750 lb.	28,040 lb.
Useful load ...	13,250 lb.	14,960 lb.
Gross	38,000 lb.	43,000 lb.
Performance—		
Maximum speed	243 m.p.h.	273 m.p.h.
Cruising speed ...	210 m.p.h.	230 m.p.h.
Landing speed ...	70 m.p.h.	74 m.p.h.
Rate of climb (at S.L.)	1,440 ft./min.	1,750 ft./min.
Single-engine ceiling	13,000 ft.	14,000 ft.
Wing loading ...	28.1 lb./sq. ft.	31.8 lb./sq. ft.
Accommodations—		
Passengers (day)		36-40
Passengers (sleeper)		20
Cargo (max.)		5,200 lb.

Comforts

Recognising that the air traveller expects the luxury of a hotel or club in the modern airliner, the manufacturer offers in addition to the comforts of a supercharged cabin, adequate ventilation, heat provided independently of the power plants, indirect cabin lighting, fully equipped food galley, accommodations for both a steward and hostess, separate washrooms and private lavatories for men and women, soundproofing approaching 60 decibels, a heated cargo compartment and other innovations.

The new Curtiss-Wright high-altitude airliner was incidentally the design chosen last year by the American air transport industry for full-sized reproduction (mock-up) and display as a feature of the $500,000 Aviation Building at the New York World's Fair. Approximately 2,500,000 persons inspected it during the five-months' period which ended October 31st, 1939.

Completion of the new airliner marks the return of the Curtiss-Wright Corporation to the air transport field. Engaged in the production of military aircraft in recent years, the company has produced several transports such as the 12-berth C-W Condor Sleeper, the world's first sleeper plane introduced in 1934. The latter was preceded by the organisation's development in 1929 of the 18-passenger Curtiss-Wright Condor club plane, first of America's now popular twin-engined airliners. Both types were operated extensively by major air lines in the United States.



A plan, side and front view of the airliner and on the right a sectional view of the fuselage

WORKSHOP PRACTICE:

Modern Foundry Methods

Methods of Casting and Making the Necessary Moulds

The ladle filled with molten metal being tipped to pour a cylinder-clock casting

IT is not far short of the truth to say that the efficiency and wearing qualities of car engines, etc., are largely determined in the foundry. The designer's calculations cannot be carried out into effect unless the cylinder block casting is accurately made. This calls for control over a number of variable factors, such as the correct mixing of the cast iron, accuracy of the patterns, and the arrangement of the spaces in the casting so that the metal is free from chilling or distortion in cooling.

To-day, the rapid flow of production in a modern factory has called for mechanisation of the foundry, to bring it into line with the rest of the works.

How a Casting is Made

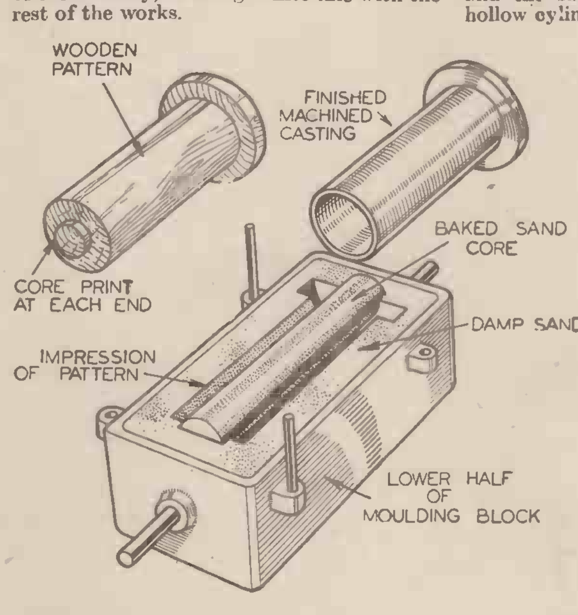
Most of you will probably be familiar with the procedure of making a casting. Assuming, for instance, a simple object such as a hollow cylinder, two boxes filled with damp sand would be used; the pattern for the outside diameter of the cylinder, turned from wood, which would first be pressed into one box for half its depth, as shown in an accompanying illustration, and then into the other, so that when the two boxes are placed face to face, a cylindrical hollow of the same shape as the exterior of the pattern will exist in the sand moulds. A core is also required, of the same diameter as the interior of the cylinder. This is made from sand bound with oil, baked so that it is hard enough to retain its shape, and is supported between the two faces of the moulding box, so that when metal is run in, it will fill the space between the core and the sand moulds. When the metal has cooled the mould is dismantled, and the sand core broken out, leaving a hollow cylinder.

Metal Patterns

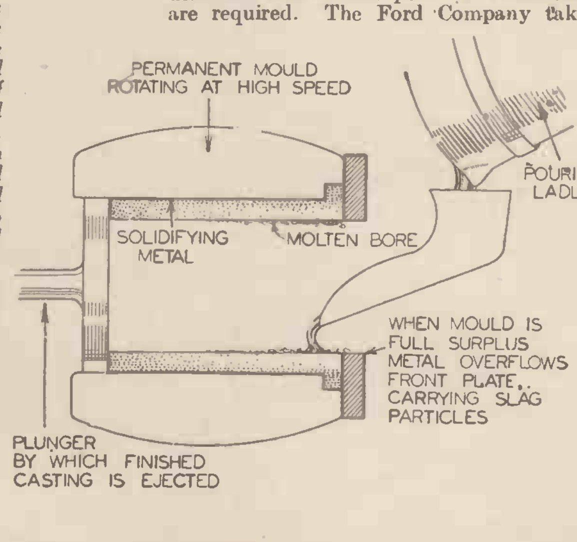
The first step toward speeding up production was the substitution of metal patterns for those of wood : this permitted large numbers of sand moulds and cores to be produced rapidly, whereas a wooden pattern might lose its truth after only a dozen moulds had been made. Moulding of a pattern plate is a fairly simple proposition. In the case of a small component, the two parts of the mould box are assembled with the pattern plate, located by pegs, between them. The moulder then rams sand into the upper half of the box, rolls the complete box over, and rams up the other side. The pattern plate is then withdrawn and the pouring gates cut in the top part of the mould. After reassembling the complete mould, pouring can take place. If the casting is to have a hollow centre, a core of baked sand must, of course, be supported between the two halves of the sand moulds after removal of the pattern plate.

When casting a more elaborate item, such as a cylinder block, precisely the same principle is followed in the majority of cases. In order to provide the openings for the inlet and exhaust ports, cylinders, water spaces, and so on, cores made from baked oil-bound sand are used. Ramming, moreover, is carried out by machinery; modern machines usually operate in pairs, one ramming the top half of the mould, and the other the bottom or "drag" half of the moulding box.

Before the mould and core can be constructed, and the molten metal poured, a number of preliminary processes must take place. At the Morris Works, for instance, the foundry covers an area of over 70,000 sq. ft., and adjoins the railway, so that truck loads of raw material can be delivered close to the point at which they are required. The Ford Company takes



(Left) The principle on which a simple casting is made. The pattern is pressed first into one half of a sand mould, and then into the other. The core, made from sand, bound with oil and baked, is placed between the two halves of the mould when they are assembled. Only the bottom half of the moulding box is shown in the illustration. (Right) Diagrammatic illustration of the method of making a centrifugal casting



matters a step further, possessing the only blast furnace in the South of England, and producing sufficient pig iron to supply not only their own needs, but outside demands.

Quantity Production

The pig iron is lifted from the railway trucks, lorries, or storage bins, as the case may be, and lowered into trucks which convey it to the foundry, where its contents are raised by a crane to the charging platform of the huge cupolas, and fed automatically into the furnace. Coke, steel and limestone are weighed and fed into the cupola in the same way. When the molten iron is ready for pouring it is allowed to flow into ladles, from which the pouring is done.

In another part of the foundry the sand for moulding is delivered to rotary dryers which are capable of dealing with ten tons of sand per hour. Different types of sand are used for different castings and for making the cores. The sand is passed on to an elevator which delivers it automatically into small storage hoppers, situated above a battery of moulding machines. These are operated by compressed air. On opening a valve a stream of sand falls into the moulding box. On operating a further control, the head of the machine is swung above the box, and the plate of the machine raised to squeeze the pattern into the sand. The process is completed in the space of half a minute.

Core Blowing Machines

Meanwhile, the cores of sand bound with oil are made in core-blowing machines. The core boxes are assembled and placed in the machine, the sand being forced in under air pressure. The boxes then pass on to a roller track, where they are dismantled, the cores being transferred to the suspended racks on which they pass through a continuous drying oven.

After inspection the cores pass to the main assembly point, where they are fitted into the moulding boxes, the completed mould being passed on a further roller track until it comes under one of the ladles filled with molten iron, which is tipped to allow the metal to pour into the mould.

After pouring, the mould is taken to a cooling shed where the fumes are drawn off by fans; cooling may take five or six hours. The mould is then taken to the "knock-out" section, where the casting is knocked out of the box and the sand surrounding it removed. The used sand falls through a grid on to a conveyor, passes under a magnetic device which removes particles of metal, and returns to the sand mill to be cleaned and remixed.

Finishing the Castings

The casting has the rough edges removed and is cleaned up or "fettled" by a high-speed grinding wheel, and after being submitted to a shot-blasting process, is inspected. As many as 35 gauges may be employed on some types of cylinder blocks, while hammer and punch tests are also made to detect any possible blow holes or internal defects. Finally, the castings are tested under water pressure before being passed to the stores.

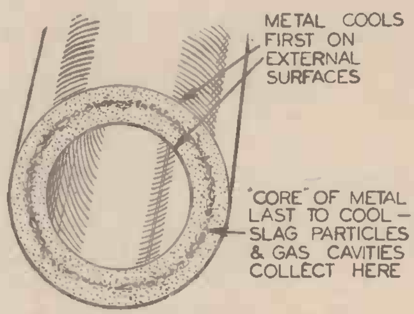
The foregoing is typical of the sequence followed in the foundry of a large car manufacturer or a specialised cylinder-casting firm.

There is, however, a growing tendency to make use of a procedure known as the "all-core" method. The principle underlying this is that with a normal sand mould and core, the core is mixed with an oil binder, or sometimes molasses, and the box sand with a water binder. Consequently, the finished core is warm and dry, whereas the mould is damp. When the molten metal comes into contact with the damp sand it is chilled. Chilled cast iron is not only extremely hard, but also very brittle. The metal surrounding the baked cores, on the other hand, retains its normal characteristics. As a result, exactly the opposite to the ideal state of affairs is obtained, since it is preferable that the cylinder walls should be hard, while the exterior surfaces should be easily machinable, instead of vice versa.

Core Pieces

The all-core method overcomes this difficulty. At the Morris works, the whole of the mould is built up of cores, which are largely hand-made. As many as 31 separate core pieces are used in a Morris "Eight" cylinder block. The main outer cores are located by dovetails in the sides of the moulding box, while the smaller core pieces interlock with one another.

The moulding boxes are passed by a conveyor along the assembly line, each man adding his core and passing the box to his neighbour. The mould is checked by special jigs at each stage, although the least inaccuracy in one core will prevent it from assembling correctly with the others, so that the box can be rejected before a scrap casting is made. A further advantage is that control over chilling is possible, because the same sand mixture can be employed throughout to produce the same degree of hardness all over, or different sand mixtures can be used for certain cores to obtain greater hardness at particular spots. At the Morris works, the same sand mixture is used throughout, so that, as there is no risk of local chilling, a harder cast iron than normal can be employed.



When a cylindrical casting is made with a sand mould and core, the outside surfaces of the metal tend to solidify first, an unreliable "core" results

Centrifugal Casting

Cylindrical castings, such as cylinder liners, and the cylinders or "pots" from which piston rings are parted off, are often cast by what is termed the centrifugal or spun-cast method. The main reason for this is that when a metal is cooling it does not suddenly become a solid block of metal. Instead, as the metal cools, groups of atoms begin to "cohere," forming in each case the nucleus of a crystal. As the temperature drops further, the nuclei become growing crystals, until at last the crystals meet on all sides, and the metal is solid.

There must always be particles of slag in suspension in the molten metal, while gases are also dissolved in it. In the case of cast iron, the larger particles of slag rise to the surface and are skimmed off before pouring is carried out. Nevertheless, small particles remain. The growing crystals reject all foreign matter, so that particles of slag tend to collect in the portions of the casting which solidify last. In all sand castings, the outer corners solidify first, the interior of the metal being the last to cool. Consequently, in the case of a normal cylindrical casting for a cylindrical liner or piston ring pot, the slag particles or gas cavities tend to be trapped in the middle section or "core" of the metal.

Removing Slag Particles

This is overcome by pouring the metal into one end of a cylindrical sand mould which is rapidly rotating. The molten metal is flung outward against the interior surface of the mould, and begins to cool, but the interior of the bore remains liquid; here the slag particles rejected by the cooling metal tend to accumulate. When the mould is full to the rim of the front plate, as shown in an illustration on page 201, a little extra metal is added, and this, as it overflows the edge of the plate, carries with it the impurities. Spun pot castings, therefore, have no unreliable core. Moreover, owing to a more rapid rate of cooling, a close, even grain is obtained which is not otherwise possible.

Camshaft and Crank Castings

A fairly recent innovation is the introduction of cast camshafts. Cast camshafts can be produced in small batches at comparatively low costs. Apart from the production engineer's point of view, the designer finds this an advantage owing to the ease with which valve-timing can be altered. Alteration of the dies of a drop forging machine is a far more expensive matter. The camshafts are usually cast in pairs, the moulds being built up on plates with the aid of metal patterns. It has actually been found possible to eliminate straightening of the shafts, although tests are made, of course, to ensure that the castings are not distorted. The shafts are cast very closely to the finished dimensions, only about .030 in. being left for can grinding. Moreover, tappet and valve noises are reduced owing to the smoother action which arises from the self-lubricating and work-hardening properties of cast iron.

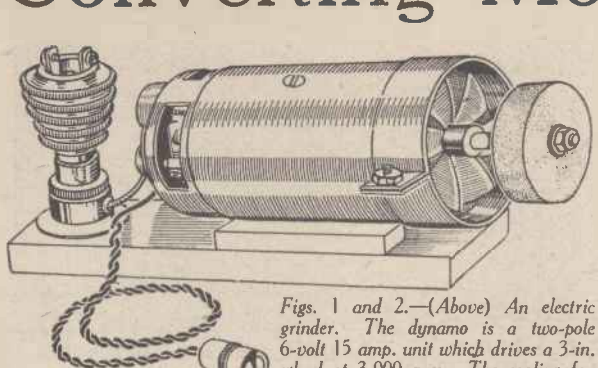
Ford Practice

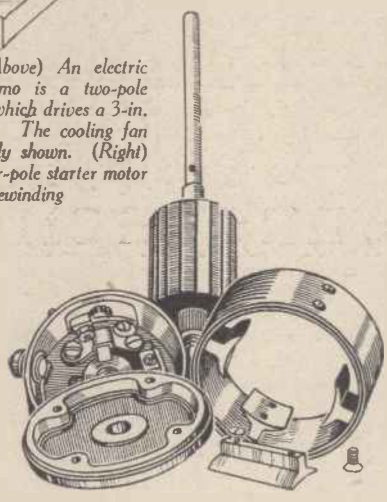
A further unorthodox development is the use of cast crankshafts by the Ford Company. Although cast crankshafts have been used for low-speed engines, they have not until recently been considered safe for the modern high-speed power unit. After lengthy laboratory experiments, and extended practical tests, the Ford Company have evolved an alloy cast-steel crankshaft which shows a marked reduction in failures in use, as compared with forged crankshafts.

The crankshaft is cast fairly close to its finished dimensions. Only nine pounds of metal is removed during machining, as compared with 24 pounds on a similar drop-forged crankshaft. The total weight of the shaft, in its finished form, moreover, is reduced from 66 to 56 pounds, while the lower co-efficient of friction of the alloy cast-steel still further improves engine performance.

Converting Motor Car Dynamos to A.C. Motors

This Article appeared in an issue of "Practical Mechanics" long since out of Print. It is here reprinted for the guidance of Querists





Figs. 1 and 2.—(Above) An electric grinder. The dynamo is a two-pole 6-volt 15 amp. unit which drives a 3-in. wheel at 3,000 revs. The cooling fan and guard are clearly shown. (Right) Parts of a 6-volt four-pole starter motor ready for rewinding

THE efficiency of these converted machines is not very high, but as they are of small capacities this does not matter. The chief difficulty to be overcome is the heating of the field coils and magnets due to the rapid reversal of the current. With large machines this cannot be overcome, and they must only be used as short-period motors where they are in operation for a few minutes at a time. A test machine taking 4 amperes was run for seven minutes before the field magnets were hot, and then a further ten minutes before it had to be shut down. For the home shop a 1/16th h.p. is quite sufficient for light polishing and grinding, but for heavier work, a 1/8th h.p. will be required. These machines run at constant speeds, and when suitably wound are ideal for model driving and general experimental work.

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

How to Commence

If the machine is working as a dynamo, it will not be necessary to test the armature, but if there is any doubt, get another machine, as the armature is not rewound, and is not touched in any way. Dismantle the machine and remove all surplus oil from the case, field magnets and brush gear with clean petrol, and wash out the bearings, removing all grease and grit, and put a few drops of light oil in them. It is unnecessary to stuff the bearings with grease, as a little light machine oil frequently applied is more efficient for our purposes. With third brush machines, remove the third brush and connect the two brushes together; similarly, with four-brush machines connect the brushes together, or connect the pigtail of each brush to the frame of the machine. You should use a stout wire here, as a machine having 1 ampere flowing through the field coils has about 10 amperes circulating through the armature, hence the necessity for a good commutator and brush gear. With most machines there is some arrangement whereby the end plates can be replaced in only one position. This is generally a small stud, and should be filed flat so that the ends may be turned round. The brush gear end should be free, but the driving end may be left in its original position, although, if this is free, it may save drilling extra holes for the fixing bolts (see Fig. 3).

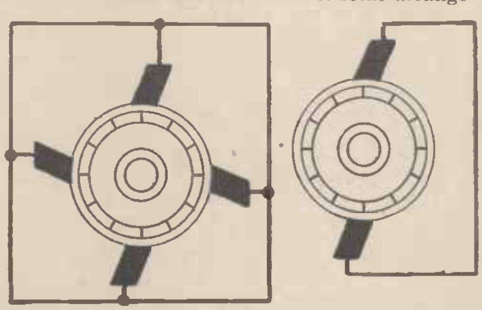


Fig. 3.—(Left) Brush connections for a two-pole motor. (Right) Connections for a four-pole motor

Removing the Pole Pieces

Remove the pole pieces; it may be necessary to use a cold chisel and hammer on the screws, but it can be done. Make a former from suitable wood, using one of the original field coils as a guide. It may be found that these coils can be rewound a little larger than the originals, if so, make use of this, as it is impossible to get too much wire on. One coil is required for each pole, and for the average two-pole machine about 1 lb. of No. 26 D.C.C. should be used, and not less than ¾ lb. For a four-pole heavy-duty machine, use No. 22, and for a light experimental motor, No. 30 or No. 32 will be large enough. Exact quantities of wire cannot be given, but it is not possible to use too much, as a series resistance has to be connected in the circuit, except with the very small motors. Make the former to the pattern shown in Fig. 4, and wind to the maximum capacity, putting the wire on as evenly and tightly as possible. When finished, the coils are wrapped with insulating tape, placed on the pole piece, and fixed in position; take care not to trap any material between the pole pieces and the yoke ring. Wind the coils in the same direction, and to ensure the correct polarity connect the beginning of the first coil to the end of the next, and so on. Test for consecutive north and south poles with a pocket compass and a two-volt battery in series with the field. With the smaller machines the ends of the field coils are connected to a length of standard flex, the joint is insulated and fixed inside the motor case; and a standard plug or adapter should be fitted. If these small machines heat up too much, then a resistance such as a 100-watt lamp must be connected in series.

The Brush Gear

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

The mounting of the machines depends upon the work that they are designed to

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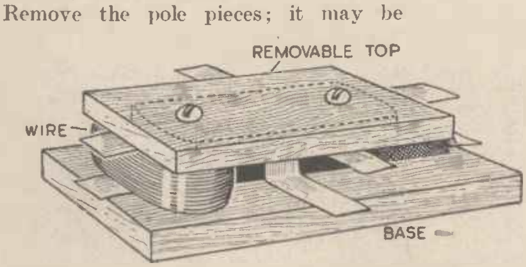
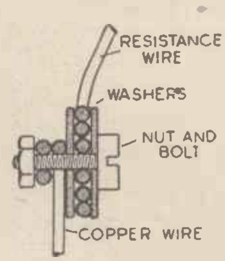
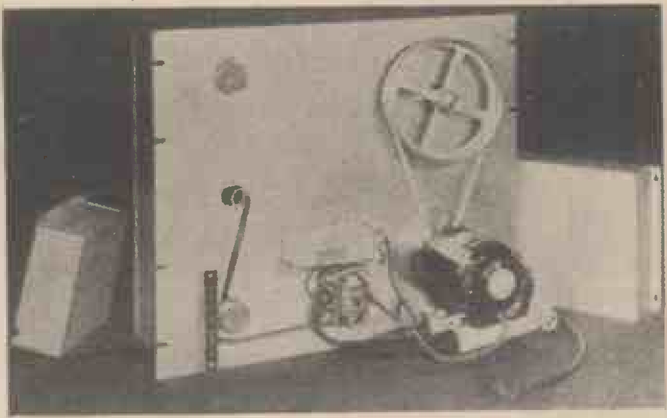




Figs. 4 and 5.—(left) Details of the former. (Right) The connections on the heater or resistance unit



Figs. 1 and 2.—(Left) Rear view of machine showing driving arrangement. (Right) Recording and reproducing amplifier used with the tape machine for the weather-announcing system

Weather-Announcing Tape Machine

Government Weather Forecasts for New York and Vicinity are now Available to the New York Telephone Users, and may be had by Telephoning a Weather Forecast Bureau

A WEATHER-ANNOUNCING machine is now installed at the West Fiftieth Street central-office building of the New York Telephone Company. With this machine, telephone subscribers throughout greater New York may receive authoritative forecasts of weather conditions. Information for these announcements is supplied hourly between 7 a.m. and 11 p.m. by the local office of the United States Weather Bureau over a direct teletype connection.

Magnetic tape recording is well suited to services of this type where it is necessary to change the recorded message frequently and where permanent preservation of the record is of no importance. The record is made by producing in a moving steel tape of high retentivity a magnetic pattern corresponding to the voice current coming from the microphone circuit. This pattern remains in the tape and can be "picked up" electrically many thousands of times until erased, which is done by saturating the tape with a heavy magnetic field. The entire process of erasing, recording a new message, and reproducing is controlled by a few keys at the operating turret. No experience or technique is required to obtain faithful reproduction of the announcement, and since the steel tape may be used again and again indefinitely, there is no continuing expense for record material and there is no processing cost involved.

Three Machines

Three of these machines are mounted, each with its associated amplifier, on the relay-rack bays that carry the apparatus for control and distribution of the service. The tape machine employs slightly over forty feet of tape wound on three accurately machined brass drums. The two ends of the tape are electrically welded to form a single tape loop, which is driven at a very uniform velocity. About twenty-five seconds is required for the passage of the tape between the recording and reproducing pole pieces. Fig. 3 shows the general arrangement of the machine, which is mounted on a steel panel bolted to the relay rack. The brass drums for holding the tape are arranged in a triangle, as shown, with their front ends supported by the triangular plate attached by channel struts to the main panel. The drum shafts run in large wick-oiled bearings. Variations in the length of the tape due to temperature changes are compensated by a spring idler, which appears behind the circular hole in the front plate and maintains a light but uniform tension in the tape. Certain improvements in fundamental design of the equipment, which have had notable effect on the quality of the recording, were contributed by D. E. Wooldridge of the Research Department.

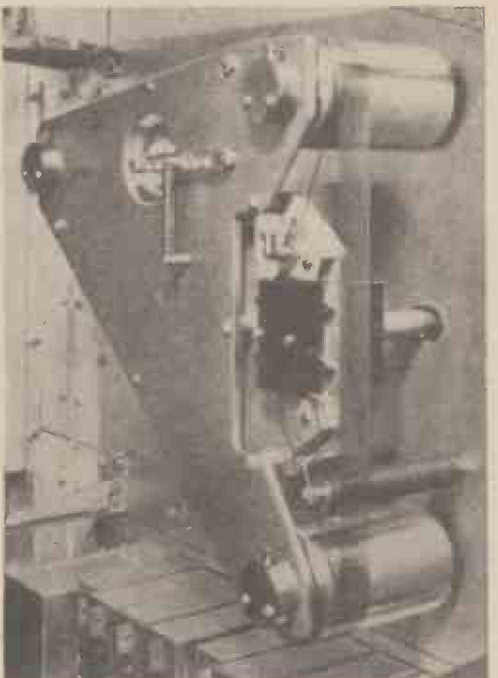


Fig. 3.—Front view of tape machine with cover removed

The Combs

A unique method was developed for storing the long tape loops in a small space. The design employs combs, consisting of spaced washers, for maintaining the position of the tape on the drums; and it requires no cross-over idlers. One of the combs is visible just above the lower drum in Fig. 1. (Space is provided for a tape loop of three times the present length if a longer message appears desirable in the future.) The drums above and below the pole-piece unit are driven by the tape. The drum, whose bearing appears at the extreme left of the figure, is driven by the large pulley which may be seen in Fig. 1, showing the back of the main panel. A small split-phase induction motor is mounted on a hinged support so that its weight maintains proper tension in the driving belt. To maintain the extremely constant speed required in all forms of satisfactory recording apparatus, a flywheel is attached to the motor shaft, which runs at 1,725 r.p.m.

On the rear of the panel there is also a condenser used with the split-phase motor, and beneath it a relay to permit control of the motor (110-volt, 60-cycle) from the 48-volt D.C. control circuits of the system. Two covers have been removed for the view shown in Fig. 1; the one on the right protects the pulley and the belt from accidental contact, and the one on the left covers the exposed A.C. terminals on the condenser and relay. The plug, shown in the foreground, is used to supply A.C. from a standard conduit outlet. The terminal board on the left provides con-

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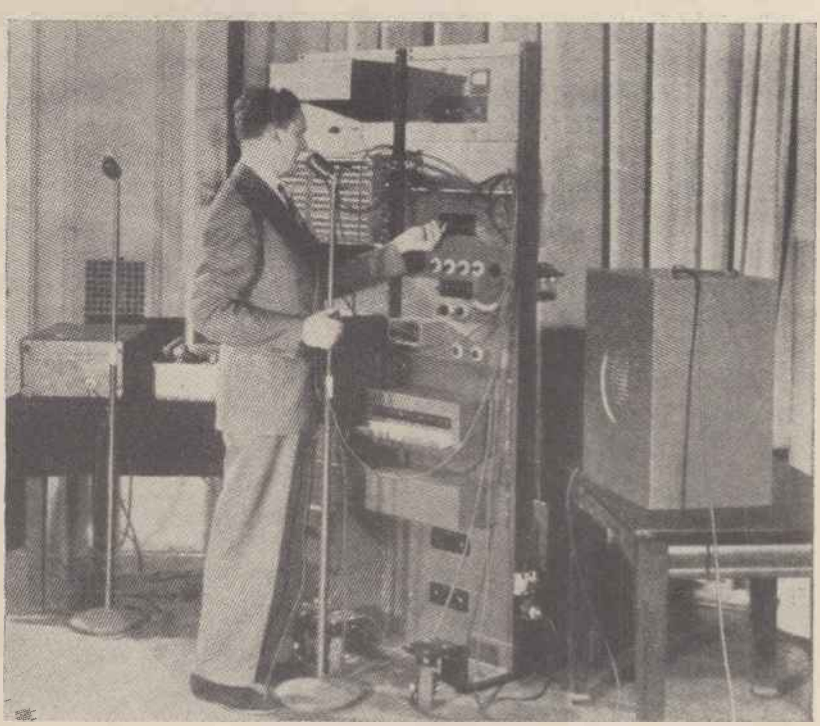
THE VOCODER



A Device which Creates Spoken Sounds and Combines Them into Connected Speech

AT the World's Fairs in New York and San Francisco great interest was shown in the speech synthesiser in the Bell System exhibits. Known as the Voder, this device creates spoken sounds and combines them into connected speech. Its raw materials are two complex tones, a hiss and a buzz; selection of one or the other and its intensity and tone quality are controlled by an operator through a keyboard.

The Voder is an offshoot of a more extensive system first demonstrated in its experimental stage some three years ago. That system analysed spoken sounds, and then used the information to control the synthesising circuit. At the time World's Fair displays were under consideration, so it was naturally perceived that the synthesiser, manually controlled, could be made into a dramatic demonstration. Development was for a while concentrated in that field; as a successful Voder became assured, attention was shifted back to the broader and parent system. Shortly afterwards the system was given the name "Vocoder" because it operates on the principle of deriving voice codes to re-create the speech which it analyses.

The Circuit

Fig. 1 shows the over-all circuit for remaking speech; the analyser is at the left and the synthesiser at the right. Electrical speech waves from a microphone are analysed for pitch by the top channel and for spectrum by a group of channels at the bottom.

In the pitch analysis the fundamental frequency, which for simplicity will be called the pitch, is measured by a circuit containing a frequency-discriminating network for obtaining this frequency in reasonably pure form; a frequency meter for counting, by more or less uniform pulses, the current reversals therein; and a filter for eliminating the actual speech frequencies but retaining a slowly changing current that is a direct measure of the pitch. (Unvoiced sounds, whether in whispering or the unvoiced sounds of normal speech, have insufficient power to operate the frequency meter.) The output current of the pitch channel is then a pitch-defining signal with its current approximately proportional to the pitch of the voiced sound and equal to zero for the unvoiced sounds.

There are ten spectrum-analysing channels, the first handling the frequency range 0-250 cycles and the other nine, the bands, 300 cycles wide, extending from 250 cycles to 2950 cycles, a top frequency which is representative of commercial telephone circuits. Each spectrum-analysing channel contains the proper band filter followed by a rectifier for measuring the power therein and a 25-cycle low-pass filter for retaining the current indicative of this power but eliminating any of the original speech frequencies.

The Analyser

The operation of the analyser is illustrated in Fig. 2 by a group of oscillograms taken in analysing the sentence "She saw Mary." To insure that the same speech was analysed in obtaining the various oscillograms, the sentence was recorded on a high-quality magnetic-tape recorder and reproductions therefrom supplied current to the analyser. The speech wave input to the analyser is shown in the line next to the bottom while the output is shown in the other oscillogram traces; the pitch-defining signal is at the bottom in the figure and the ten spectrum-defining signals in numerical order at the top. For convenient reference the oscillograms are lined up together, whereas in the actual circuit the speech-defining signals lag about 17 milli-seconds behind the speech-input wave. The inaudible speech-defining output signals contain all the essential speech information as to the input wave, but it is to be noted that they are slow-changing and in this way correspond to lip or tongue motions, as contrasted with the higher audible vibration rates of the rapid-changing speech wave itself. The dropping of the pitch to zero for the unvoiced sounds "sh" and "s" is also readily seen.

Fig. 2 gives an idea also as to the synthesising process. In the analyser the speech wave is the input and the eleven speech-defining signals are the output; in the synthesiser the eleven speech-defining signals are the input and the speech wave the output.

The Buzz and Hiss

The steps in speech synthesis are indicated at the right of Fig. 1. The relaxation oscillator is the source of the buzz; and the random noise circuit the source of the hiss. The hiss is connected in circuit for unvoiced sounds and for quiet intervals. (In the latter case no sound output from the synthesiser results because there are no currents in the spectrum channels.) When a voiced sound is analysed a pitch current other than zero is received

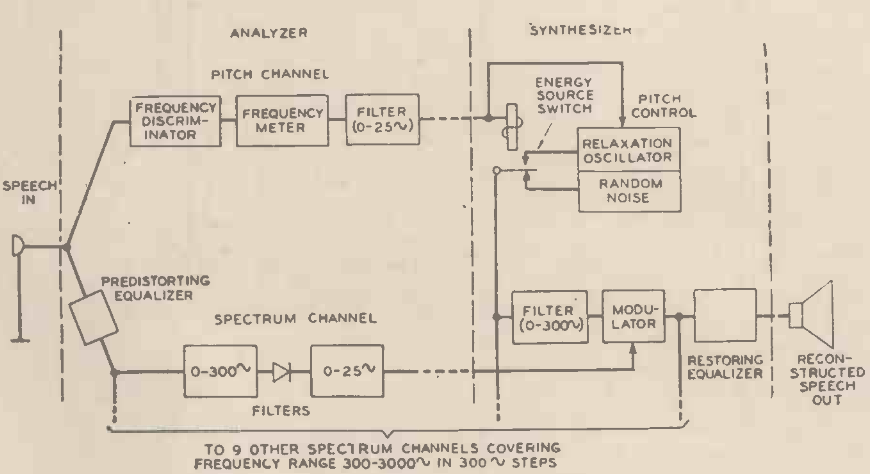


Fig. 1.—Simplified circuit diagram of the Vocoder

with the result that the buzz is set for the current pitch by the "pitch control" on the relaxation oscillator; also, the relay marked "energy source switch" operates, switching from the hiss source to the buzz source.

The outputs from the spectrum-analysing channels are fed to the proper synthesising spectrum controls with the band filters lined up to correspond. The power derived from the energy sources of the synthesiser in these various bands is then passed through modulators under the control of the spectrum-defining currents. The result is that the power output from the synthesiser is sensibly proportional in each filtered band to that measured by the analyser in the original speech. From the loudspeaker comes, then, speech approximately the same in pitch and in spectrum as the original. This synthetic speech lags the original speech by about 17 milliseconds due to the inherent delay in electrical circuits of the types used.

Control Switches

In the present models of the Vocoder, control switches have been introduced which permit modifications in the operation of the synthesiser. Through the manipulation of these controls interesting effects are produced. Some of the possibilities of the Vocoder were recently demonstrated by H. Dudley and C. W. Vadersen before the Acoustical Society of America and before the New York Electrical Society. In those presentations Mr. Vadersen supplied by his own voice the incoming speech which was picked up by a microphone as shown in the heading : and at the same time he manipulated the controls to produce desired effects. A remote-control switch was also provided through which, for purposes of comparison, the author could switch the microphone directly to the loudspeaker and so let the audience hear how the speech would sound if it had not been modified by the Vocoder.

In these demonstrations comparison is first made between direct speech and the best re-creation that the apparatus could make. Then by manipulation of dials and switches, speech is modified in various ways. Normal speech becomes a throaty whisper when the hiss is substituted for the buzz. Although the hiss is relatively faint, it is shown to be essential for discrimination as between "church" and "shirts."

Ordinarily the re-created pitch moves up and down with that of the original. If variation is prevented, the re-created speech is a monotone, like a chant. When the relative variation is cut in half, the voice seems flat and dragging; when the swings are twice normal, the voice seems more brilliant; when four times normal it sounds febrile, unnatural. The controls can be reversed so that high becomes low; the tune of a song is then unrecognisable and speech has some of the lilting characteristics of Scandinavian tongues. Another control fixed the basic value of the re-created pitch; if this is "fluttered" by hand, the voice becomes that of an old person. By appropriate setting of the basic pitch, the voice may be anything from a low bass to a high soprano, and several amusing tricks can be performed. In one of these, the basic pitch is set to maintain a constant ratio of 5 to 4 to the original. This is a "major third" higher and harmonises with the original. In two-part harmony, the demonstrator then sings a duet with himself. Connecting a spare synthesiser set for a 3 to 4 ratio he then sings one part in a trio, the others being taken by his electrical doubles. Finally, with the basic pitch-control of the apparatus he becomes a father reprimanding his daughter; then the girl herself, and then becomes the grandfather interceding for the youngster.

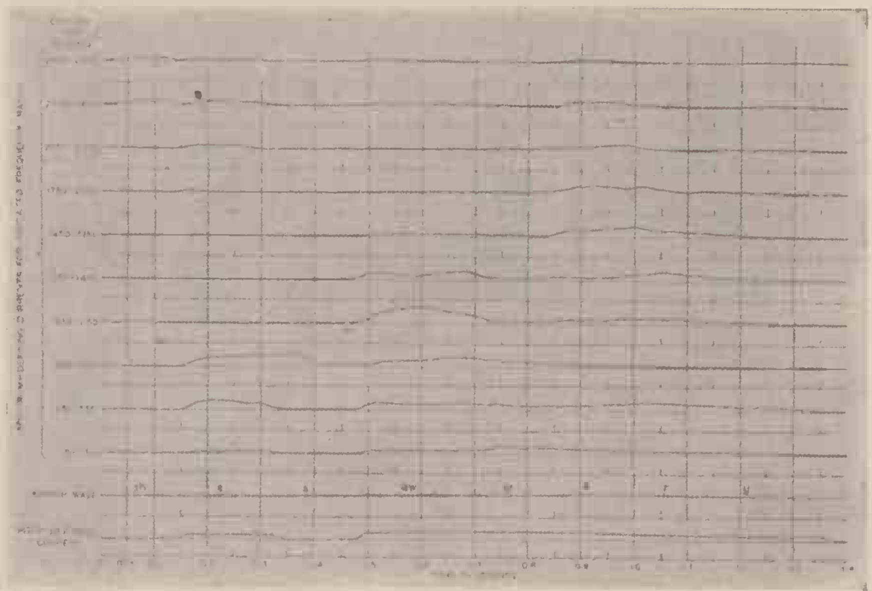


Fig. 2.—The original speech wave and an analysis of its components, expressed as the variation of several direct currents

Demonstrations

For the vocal-cord tones of the original, the Vocoder substitutes the output of a relaxation oscillator. But any sound rich in harmonics can be used: an automobile horn, an aeroplane roar, an organ. In some demonstrations, the sound, taken from a phonograph record, replaces the buzz input from the oscillator. Keeping careful time with the puffs of a locomotive, the demonstrator can make the locomotive puff intelligibly "We're—start—ing—slow—ly—faster, faster, faster" as the puffs come closer together. Or a church bell may say "Stop—stop—stop—don't—do—that." A particularly striking effect is that of singing with an organ to supply the tones. Although the words may be spoken the demonstrator usually sings them to hold the rhythm. It makes no difference, whether his voice is melodious or not; the tonal quality comes only from the musical source.

These tricks and others have suggested uses for the Vocoder in radio and sound pictures. It appears to have possibilities as a tool in the investigation of speech, since by its numerous controls important variables in speech can be isolated for study. The engineering possibilities which may grow out of the application of the principles employed in this device are hard to predict at the present time. The speech-defining currents, however, do have features of simplicity and inaudibility which may open the way to new types of privacy systems or to a reduction in the range required for the transmission of intelligible telephonic speech.

(*Reprinted from Bell Laboratories Record*)

WEATHER-ANNOUNCING TAPE MACHINE

(*Continued from page* 204)

nection to the control circuits and to the pole pieces. The pole-piece circuits are fed, by the cable shown, through the panel to a plug and jack which facilitates the removal of the pole-piece unit for any necessary servicing.

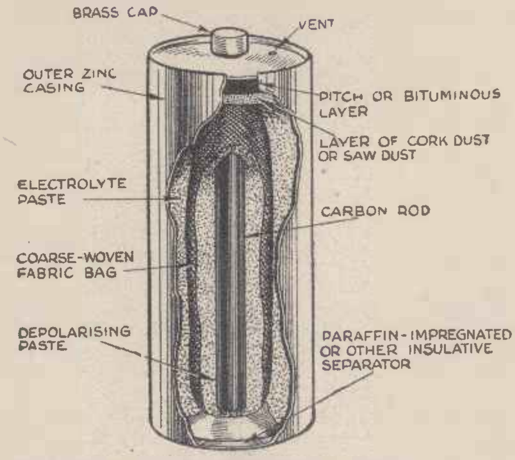
The Amplifier

The amplifier, shown in Fig. 2, is mounted immediately above the machine on the rack. Since it is used both in recording a message and in reproducing it, input and output relays are provided which during recording enable the low-level microphone current to be amplified to the correct level and supplied to the recording pole pieces. The self-contained rectifier which supplies D.C. power for the valves of the amplifier also supplies the erasing and biasing currents for the pole pieces as switched by these relays. In reproducing, the relays reconnect the amplifier to amplify the relatively weak potentials obtained by the pole pieces from the magnetic patterns on the tape to a sufficient level for feeding the power amplifiers associated with the distribution system. The amplifier—like the tape machine—requires a 110-volt, 60-cycle A.C. power supply. Separate controls are provided for adjusting recording and reproducing levels.

Since the machines are mounted on racks containing amplifiers and other vacuum-tube apparatus, it was essential that vibration and acoustic noise be reduced to low levels. This has been accomplished by mounting the motor assembly on rubber pads. As a result, the machines have proved to be unusually quiet in operation. (Reprinted from *Bell Laboratories Record.*)

Making Your Own Dry Batteries

The Following Topical Article has been Specially Written in View of the Battery Shortage



From this diagram the essentials of dry battery construction may be seen at a glance

THE prolonged shortage of torch and pocket-lamp batteries—one of the unexpected consequences of the present war—has resulted in many amateurs attempting to make their own dry cells.

The making of serviceable dry batteries of varying shapes and sizes is a task which is by no means beyond the abilities of the average home technician. It is a job which is inexpensive, too, for the active material of dry batteries costs but little, and a few pounds of the stuff will go a very long way indeed.

Let no amateur, however, imagine that, with all his efforts, he will be able to turn out as excellent an article as the average present-day torch battery comprises. During the last two decades much thought and experimentation has been given by manufacturers to the inner details of the design and composition of dry batteries, and since, in many instances, the active material of commercial dry cells possesses a more or less secret composition, it will be impossible for the home worker to produce dry batteries of equal capacity or "life" as those of the commercial variety.

Such facts, however, should on no account deter the home constructor from taking up the interesting task of battery making.

The best way to begin battery-making is to get hold of two or three spent dry batteries and to dissect them carefully. Note that all the "4-volt" batteries are made up of three individual cells which are connected together in series, the carbon element of the one cell being connected to the zinc of the next. Cylindrical batteries have their cells arranged one above the other, whilst those of the "flat" pocket-lamp type are fixed within an outer cardboard case in a side-by-side manner.

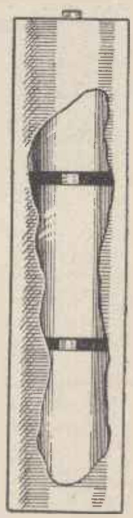
Constructional Principle

Despite the actual arrangement of the individual component cells of a battery, the actual constructional principle of the component cells is identically the same in every case.

Each cell consists of an inner central carbon rod provided at its upper end with a brass cap or connecting piece. Around the carbon rod is a moist paste of material which is enclosed in a coarsely-woven fabric bag. This is known as the "depolarising paste."

The carbon rod with its bag of depolarising paste is placed centrally within an outer zinc casing, the bag resting upon a paraffin-impregnated or other insulative circular card washer, disc or other type of separator, and between the bag and the zinc case is packed another moist chemical mixture which is known as the "electrolyte paste."

Over the upper part of the cell is usually placed a shallow layer of cork granules or coarse sawdust and over this, sealing off the cell contents from the outer air, a layer of pitch or some type of bituminous or asphaltic insulative composition is placed. Through this layer is pierced a tiny vent hole, the function of which is to allow the escape of the gases generated within the cell. If this vent hole is omitted, the cell may actually burst under its own internal gas pressure, although usually it will cease to function long before this gas pressure is attained.



Showing the three-cell construction of the well-known cylindrical type of torch lamp battery. Electrical contact is made at the upper carbon electrode and the bottom-most zinc base

A dry cell of the above nature generates approximately 1.55 volts. Hence it is that the usual flashlamp battery containing three component cells is rated at 4.5 volts. Individual cells having an E.M.F. of 1.55 volts will serviceably light up flashlamp bulbs designed for that low voltage, but such bulbs are far less robust than those of the higher voltage.

Recharging

It is best to begin the task of dry battery making by simply recharging the individual cells of an old battery. Carefully strip the outer cardboard casing away from the battery, doing as little damage to the former as possible so that it may eventually be replaced, disconnect the individual cells (after in the case of a "flat-type" battery, melting away the upper layer of insulative pitch), and then, by dint of gentle heating, run the insulative material out of the top of each cell. This removed, a firm steady tug at the central carbon rod will usually result in the entire carbon rod and depolarising paste bag assembly coming neatly and cleanly out of the zinc container. All the active material of the cell, within and without the fabric bag should be discarded. The zinc container should be washed out in hot water and the carbon rod similarly treated. It will be advantageous, of course, to prepare a number of zinc containers and carbon rods in this manner before commencing filling operations.

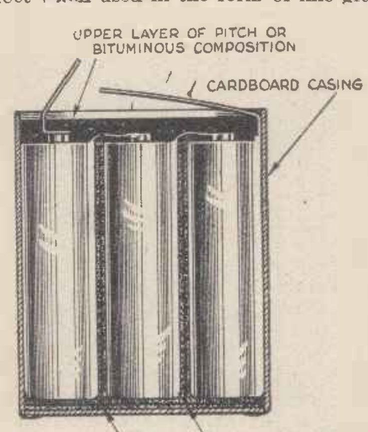
The actual filling of the dry cells is apt to be, particularly at first, a messy operation, especially when small batteries are being dealt with. Commercially-manufactured batteries are nowadays, of course, filled and compacted mechanically so that each individual cell contains just the right amount of material compacted within it at the right degree of pressure. These are refinements which the amateur cannot hope to attain on his home-scale of manufacture.

Many formulae for the active material of batteries have been published from time to time, and, as we have previously remarked, much of the active material in modern batteries is of secret composition. The best all-round formulae for amateur use, however, are the following:—

Depolarising Paste

This consists of a mixture of approximately equal quantities of carbon or plumbago powder and manganese dioxide (pyrolusite) made into a paste with a 1 per cent. solution of gum tragacanth. This latter solution may, also, with advantage, contain a very small proportion, a few drops, say, of glycerine in order to retard its evaporation.

Finely powdered carbon should be avoided, since this material gives a better effect when used in the form of fine grains.



Showing the arrangement of the individual cells in a "flat" pocket lamp battery

Electrolyte Paste

This is made up of about 85 per cent. of plaster of Paris and 15 per cent. of ordinary flour mixed to a "just-wet" paste with a strong solution of sal ammoniac, which latter should also contain a little glycerine (or else zinc chloride) to retard evaporation.

For the making of the fabric bag to contain the depolarising paste, the thinnest butter muslin may be used. A better (and an equally cheap) material is "mull," which is a very coarsely-woven cotton fabric used by bookbinders and sold everywhere by such establishments.

The fabric bag is best stitched together around a wooden rod or cylinder of requisite diameter to act as a "mould." It is removed from this "mould," the carbon rod placed centrally within it and the depolarising paste packed equally around it and with as uniform pressure as possible. Finally, the upper ends of the bag are neatly tied around the carbon rod at its upper end.

Having placed at the bottom of the zinc container a wax-impregnated "washer," strip or other type of insulator, the carbon rod with its bag of depolarising paste is held upright centrally within the zinc container, and between the bag and the walls of the zinc container is packed the electrolyte paste, also with an equally uniform pressure. This paste should be "just wet," but it should not be sufficiently sloppy to "run."

Packing the Paste

The electrolyte paste is packed and gently tapped down with a pencil or other implement until it reaches the upper level of the carbon bag. It is then advantageous to cut a circular washer out of waxed paper to fit down over the top of the electrolyte paste and the carbon bag and, over this, to lay a shallow layer of cork grains (which are non-absorbent), or, failing these, of coarse sawdust. Finally, a quantity of pitch or some similar bituminous or other plastic and insulative composition should be melt up in an iron spoon and carefully poured over the upper surface of the cell. Just before the plastic material finally becomes hard, a thick needle should be plunged downwards through the pitch so as to provide the minute yet necessary vent hole through which the internally-generated gases of the cell can make their escape.

The cell thus made will usually not be operative at once. It should be put away for twelve hours in order to allow its contents the necessary amount of time in which to "balance" themselves.

The greatest difficulty in dry cell making lies, perhaps, in the fitting of the depolarising bag within the zinc cylinder and the packing of the electrolyte paste uniformly all round it. When making up the depolarising bag, the tendency will be to pack this too full so that it becomes over-distended and consequently wedges against the inner wall of the zinc container. Bearing, however, this point in mind, it will be possible for the reader, even at his first attempt at battery making, to steer fairly clear of this practical difficulty.

Large Cells

Large dry cells, of course, may be constructed upon exactly the same principle as the small cells and utilising precisely the same materials and ingredients. A large cell will not give any higher voltage than a miniature cell, but its capacity will be very much greater than the latter so that it will last very much longer than the small cell.

If the amateur can procure sheet zinc of about 1/32 in. thickness, he will be in a position to make his own zinc containers for his cells. The best containers are seamless or, at any rate, the seams are gently welded together at a comparatively low temperature without the employment of any lead solder, whose presence might set up electrolytic bye-reactions within the cell and so continuously waste its "active material." It will not be easy for amateurs to make the small sizes of zinc containers in any great number. Hence, it is recommended that such containers should comprise the cleaned-out zincs of used cells, whenever such can be obtained in reasonable condition.

For the carbons of dry batteries (which themselves do not deteriorate), suitable lengths can be sawn off arc-lamp carbons of the low-resistance "uncored" variety, which articles are manufactured in many different diameters and lengths.

AROUND THE TRADE

Items of Interest from the Manufacturers

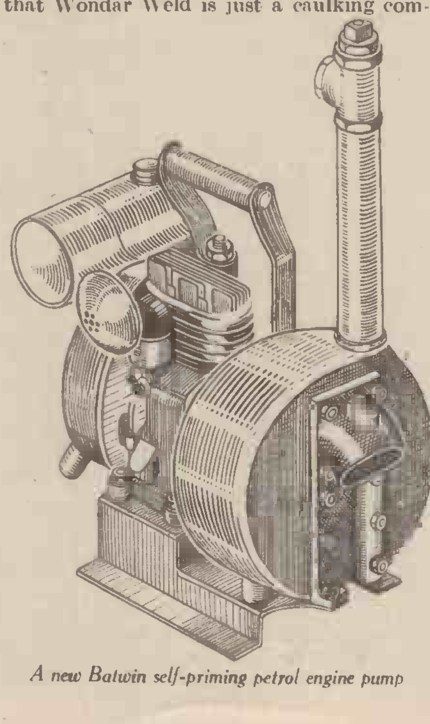
A Portable Pump

THE new Batwin self-priming petrol engine pumps mark a distinct departure from accepted practice. The engine comprises a ¾-h.p. single cylinder four-cycle air-cooled engine with high tension magneto, heavy duty ball bearing crankshaft, fly ball mechanical governor, suction feed carburetter and fuel tank. It can be used as an ordinary power unit when not pumping water.

The pump is 100 per cent. self-priming with a minimum of 60 gallons per minute at 10 ft. total head. It has a wide open trash type impeller and handles 1-in. solids. A built-in swing-type suction check valve holds the priming water in the pump and suction line, whilst the angle suction inlet is a distinctive feature and prevents the hose kinking. Another feature of the pump is that it is easily transportable. It costs £24 complete with rope starter and suction strainer.

Wondar Weld

WHEN we encounter a very cold spell of weather like that experienced at the beginning of January, the water system of the house, unless adequately protected, is liable to be cut off through water freezing in the pipes. The hot water system is generally the first to freeze as the pressure of water in these pipes is considerably less than that in the main pipes. When the hot water stops running it is the usual practice to let the boiler fire out as the steam being trapped in the boiler is liable to burst it. A boiler repair invariably means a large plumbing bill, but providing the burst is not too extensive there is a compound on the market known as Holt's Wondar Weld Domestic, which will repair it for you for a small expenditure. It is sold in a tin which has two containers; A contains a powder and B a liquid. First you must drain the system to boiler level so that you can disconnect the feed pipe. Now mix the contents of A container in a bucket of cold water. Heat the water in the boiler very hot and pour in the contents of the bucket. The liquid contents of container B are now poured in and the water is then made to boil until the leak stops. This takes roughly ½ hour. It is most important to allow the boiler to cool before refilling the system. Do not think that Wondar Weld is just a caulking compound which may block the pipes. It is a liquid metallic preparation for effecting a permanent repair and will not clog even the smallest bore pipe. The cost of the tin is 20s., and by laying out £1 you may save yourself several.



A new Batwin self-priming petrol engine pump

P.M. Battery Charger

T. W. THOMPSON'S, the makers of the specified transformer for the P.M. Battery Charger described in our July 1939 issue, inform us that the Osram Argon valve is no longer obtainable, and the only counterpart of this is the Philips rectifying valve type 1038, which retails at 14s. 6d. This valve has identical characteristics to the Argon and can, therefore, be substituted without any modification to the original design.

Loss to Bassett-Lowke Ltd.

WE regret to announce the death of Captain A. B. Lockhart, D.S.C., R.N., works director of Bassett-Lowke, Ltd.

He joined the Board of Directors on his retirement from the Royal Navy—after a distinguished career—in October, 1936. On the outbreak of war he rejoined for active service, but was taken ill and invalided home early this month. He passed away on December 14.

Pelmanism

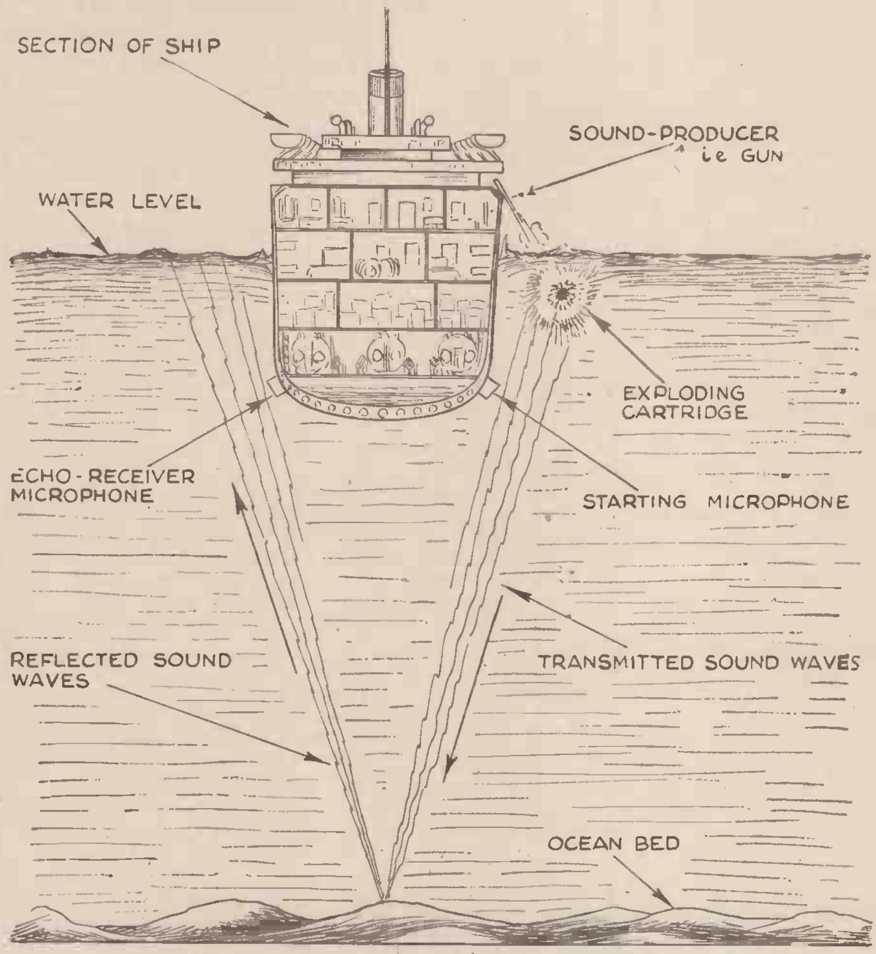
DURING the past few months the Pelman Institute has once again thoroughly revised and rearranged its famous Course, to bring it right up to date with the latest advances in Psychology.

The Institute has now been established over forty years, and during this time over half a million men and women have taken the Course.

There is one remark made with surprising frequency by students of the Pelman Course: "I wish I had known of this ten years ago."

The benefits derived from a Pelman training are, indeed, nothing short of surprising to those who take it up, and these include men and women engaged in every possible profession, business, and trade.

DETERMINING THE DEPTH OF THE OCEAN



The fundamental principle of the modern "echo" system of ocean depth sounding

The Marvel of the Modern "Echo Sounder"

"LOG, latitude, lead." Such were the "three L's" of the old-time navigator, and, indeed, if we accept the third of these factors in its modernised form, they still constitute a trio of indispensables for the guidance of ships at sea.

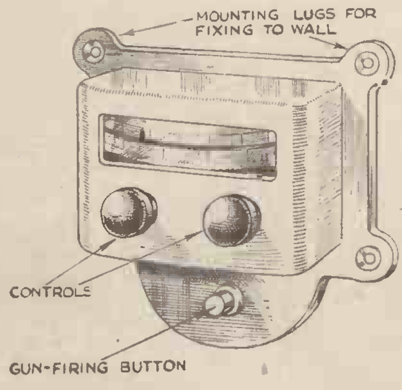
The "log," the hour-by-hour journal of the ship's voyage to her destination, is, even in these days of wirelessed directions to mariners at sea, much relied upon for guidance by navigating officers. The knowledge of a ship's latitude is also necessary for position-finding, whilst the third of the above "three L's," a knowledge of the "lead" or depth of water under the ship, is frequently of paramount importance, particularly when the vessel approaches "difficult" coasts, shallow waters, and unfamiliar seas.

The "lead" factor of a ship's position at sea is simply the depth of water under the vessel. It is so called because from very early days up to practically the beginning of the present century, the only known way of estimating the depth of water under a ship consisted in actually throwing out a measuring line weighted with a lump of lead at the end of it.

"Heaving the Lead"

In comparatively recent times, the vessel was hove to and a 14-lb. lump of lead, having a flat bottom smeared over with grease or tallow for the purpose of collecting and bringing up samples of the ocean bed, was attached to a length of line which was generally about one hundred and fifty feet from end to end.

This was cast overboard and allowed to sink below the waters until a sudden cessation of tautness of the line indicated that the lead weight had reached the bottom. A note was made of the length of line paid out, and this was taken as representing the depth of the sea below the water-line.



Showing the depth indicator instrument dial by means of which the sound impulse is indicated and the sea depth read off at a glance in fathoms from the calibrated dial

This method of sounding the sea's depth by means of the practice of "heaving the lead" was not only inefficient, but it was also more or less inaccurate. The task occupied the labours and attentions of six men and an officer for the better part of an hour, and, what is more, the vessel had to be stopped whilst the operation of depth sounding was being performed. No wonder, therefore, it was that mariners in many countries had for decades looked around for some improvement upon this traditional but nevertheless extremely wasteful procedure.

The most significant advance in the technique of depth sounding came into practice about the beginning of the present century as the result of the introduction by Lord Kelvin (formerly Sir William Thompson) of his "depth-sounding machine."

Lord Kelvin, whose fame will ever be inseparably connected with the first successful laying of the Atlantic cables, had thought long and hard about this matter of ocean-depth sounding, and his device, which, indeed, in many instances, is still being used at sea, was the result of the close attention which this master of science gave to the problem.

Kelvin's Depth Sounder

Kelvin's depth sounder is, like many efficient inventions, very simple in principle. All it consists of is a heavy lead weight or "sinker," which is attached to the end of about one thousand feet of pianoforte wire. Just above the sinker is fixed to the wire a perforated metal case containing within it a glass tube coated inside with silver chloride and having its open end downwards.

The pianoforte wire cable is coiled around a steel drum, and on the release of a brake attached to the freely revolving drum, the lead sinker was enabled to speed swiftly downwards through the water to the ocean bed. The deeper the lead sank through the water, the higher up the glass tube was the water forced. Since the sea water caused a brownish discoloration of the silver chloride with which the sides of the glass tube were coated, it was easy to form an exact estimate of the length of wire which had been run out into the sea.

This method of depth sounding was an enormous advance upon the previous traditional mode of "heaving the lead." In the first place, the Kelvin lead could be projected with great velocity to the sea bed, and immediately it made contact with the latter, the lack of tautness of the cable threw into operation an electrical winding gear, which immediately hauled up the line again in a few seconds. Only one man was needed to work the apparatus and, still more important was the fact that the vessel need not be stopped whilst the sounding was being taken, it being possible to make accurate soundings at any speed up to and including 15 knots.

A Chain of Soundings

Hence, by the Kelvin method, it was possible to make a " chain of soundings " with a very small interval of time between them. This facility was, of course, a very great one, particularly to the navigator who was engaged in guiding his vessel through shallow and treacherous waters. Indeed, the Kelvin method of depth sounding took much of the irksomeness out of coastal and other types of navigation, so much so that after its establishment had been effected in maritime circles it was considered that the problem had been almost completely solved in its every respect.

Scientific achievements, however, seldom remain unchallenged for long. Just as Germany was beginning to launch the 1914-18 war against the world, one of her physicists was, in Kiel harbour, putting the finishing touches to a depth-sounding invention which he had been engaged upon for nearly a dozen years. The invention was made practical after the latter war, and its use has since that time spread rapidly throughout the world.

Briefly, this new depth-sounding device consists in projecting a sound wave downwards through the water to the bed of the sea and in measuring the time which the sound takes to echo back from the sea floor to the ocean level.

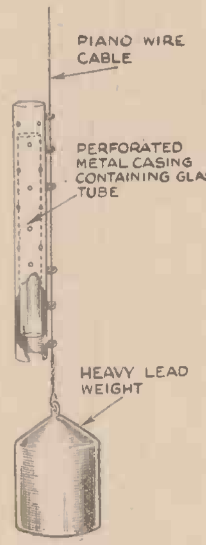
In principle, the *modus operandi* of the now almost universal " echo sounder " is simplicity itself, although several complexities are involved in the details of the installation.

Attached to one side of the vessel is a " sound-producer," which consists of a fixed gun from which a small explosive cartridge equipped with a brief time fuse can be shot into the water as the vessel moves through it. The time fuse of the cartridge is so adjusted that the latter explodes with a loud report after it has attained a depth of a few feet below the water level.

Sound Waves

The sound waves from the exploding cartridge travel outwards and downwards. Attached to the keel of the ship on the same side as the sound-producer is what is called a " starting microphone." This picks up the sound waves from the exploding cartridge as they pass it on their way downwards to the floor of the ocean, and, having done so, immediately sets into action a time-interval recording mechanism.

At the other side of the ship's keel, and in an opposite position to that occupied by the " starting microphone," is fixed the " echo receiver " microphone. This picks up the echo or the reflected sound wave from the ocean floor as it travels upwards to the surface of the waters, and, having done so, it instantly stops the time-recording mechanism which was put into action by the current impulse from the "starting microphone."



The Kelvin " sinker " for estimating ocean depth. The glass tube hangs open end downwards and is coated interiorly with silver chloride, which discoloured in contact with sea water

The result of this automatic process is that a needle swings across the dial of the " depth indicator," which is mounted in a convenient position in the ship's instrument room and almost immediately after the shot has been made from the sound-producer, the depth of water below the vessel is indicated on the dial of the instrument.

The marvel of this method of depth sounding and the great accuracy with which the instrument is made to operate may be gathered from the fact that sound travels 300 ft. (50 fathoms) through water in approximately one-sixteenth of a second. Hence, at all " normal " sea depths the interval of time between the setting into operation of the interval-recording mechanism by the current impulse from the starting microphone and its cessation by the echo receiver microphone is very short indeed.

When the vessel is proceeding through shallow waters, as is very frequently the case, this time interval becomes so excessively short that special devices have to be employed to cut the detonation sharp and to ensure the absolute precision working of the interval-recording mechanism.

" Sound Shadow "

In the case of large ocean-going vessels of great bulk, a fairly effective and efficient " sound shadow " (roughly conical in shape) is cast below the keel. In such instances, the sound waves projected to the sea bed from one side of the vessel do not become confused with the echoes reflected upwards to the other side of the vessel.

However, with ships of lighter draught, this " sound shadow " is very much less effective, so that in these instances a relay has to be fitted to the echo receiver microphone sufficient to throw it out of operation for a few hundredths of a second so that the detonation sound waves which are projected to the sea bed may pass it and die away before the reflected sound waves from the sea floor rise upwards to it. This electrical relay forms a mechanism of marvellous complexity. It is sensitive to intervals up to one-thousandth of a second, and seldom, indeed, has it been known to give faulty results.

The echo system of depth sounding can be put into effect when the vessel is travelling at its normal speed. It is almost instantaneous in its results, and it can be carried out without any expenditure of human energy. Moreover, the system is more or less foolproof, since the human element does not enter into it, except for the final reading of the water depth upon the dial of the " depth indicator." If necessary, a depth sounding may be made at half-minute intervals by means of this modern system of " heaving the lead."

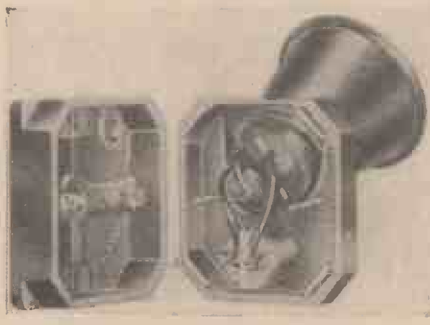
It is only a matter of time before every ocean-going vessel is equipped with the echo system of depth sounding. The apparatus is necessarily expensive and delicate, but it is capable of adjustment and, given reasonable care, it will remain in good order over a long period.

AN AUTOMATIC SWITCH-DIMMER

IT is now becoming customary for a door switch to be employed to control the hall or passage light. One of the neatest and most effective methods is, of course, to insert a Crabtree " black-out " switch in the lamp wire of the lighting circuit. This ensures that the light is instantly and automatically switched " off " as the door is opened and " on " again immediately the door has been closed sufficiently to prevent light leakage.

Under certain conditions, however, a sudden and complete blacking out of the light may be unnecessarily drastic. In many cases, a dimmed light may be sufficient and will prove a real help to the householder. This is especially true where an outside door is screened or heavily curtained, where it is covered by a porch or faces a wall. A dimming effect can, of course, be obtained by connecting a second lamp in series with the existing light and controlling the circuit by means of a Crabtree " black-out " switch.

The new Crabtree automatic switch-dimmer, however, combines a lampholder, switch and all the necessary interconnections in one compact unit. In addition, the base is provided with easily removable " knock-outs " which make the switch suitable for either surface or back entry wiring.



The Crabtree automatic switch-dimmer

The method of inserting the switch-dimmer in a one-way lighting circuit is extremely simple. All that is necessary, is to interrupt the lamp wire at the ceiling rose and lampholder terminals and run twin cable back to the switch-dimmer and connect to the easy fixing terminals provided. In effect, this provides a special dimming circuit which only comes into operation when the switch, controlled by the action of the door, is opened.

As the switch-dimmer is designed to project the light upwards, any " spot light " effect is entirely eliminated and a soft, diffused glow is obtained. And since the lampholder embodied in the unit is suitable for the interchange of standard bayonet-cap lamps, the amount of illumination required can be varied quite easily.

Watch Repairing and Adjusting—8

Watch Case Repairs

THE watch case is too often treated as an ornamental box which holds the movement rather than an important part of the whole assembly. Many watches suffer from the fault of being fitted into inferior cases—the type often offered for sale as *solid* gold cases—solid, of course, but the total weight barely ever exceeds two pennyweights! The watch case should always be strong enough to protect the movement from damage as well as exclude the dust.

Case troubles present many difficulties, probably the most common source whereby dust and dirt enter the movement is through a worn winder hole or pendant as it is called. To cure this fault, take a piece of brass bush wire a little larger than the hole, place it in a suitable lathe chuck and turn it down until it just fits the hole in the case. Cut it off; leaving a small shoulder as shown in Fig. 1. The bush must not protrude too far into the case to interfere with the movement. To secure the bush apply a little flux and a very small piece of solder to the inside of the case and gently warm over a small gas or spirit flame. When soldered open the hole with a broach until the winding shaft is just free to turn.

Thin Backs

Some gold cases have a very thin back, so thin, in fact, that the back end of the centre pinion and other raised parts of the movement make an impression on the back when the watch is worn. A very undesirable state of affairs, as the pressure is likely to create friction with a consequent erratic rate. Considerable improvement can be made by soldering an old hour hand to the back of the case over the indent caused by the centre pinion. The socket will now rest upon the back plate and keep the back of the case away from the movement.

A very difficult "case" in which the balance staff was damaged by the case being gripped tight was cured by making a brass disc to fit inside the case back. As well as a hole being drilled to free the centre pinion, a hole resembling the balance bridge was cut in the disc with a piercing saw thereby removing undue pressure from the balance staff. Two small holes were drilled at the edge of the disc by which the disc was soldered to the back of the case. Fig. 2 gives an idea of the disc.

A Broken Loop

Many a watch has sustained damage through a worn or broken loop; to-day, however, there is less risk as the strap attachment is very often a sturdy built-in affair. When a wire loop is broken away from the case at one side or even both sides it is a fairly simple matter to refix it. With some cases holes are drilled in the band of the case and the loops inserted before being brazed, with others the loops are only brazed on to the surface. If holes are drilled to receive the loop it will be easier to adjust it into position before securing it with a piece of soft iron binding wire.

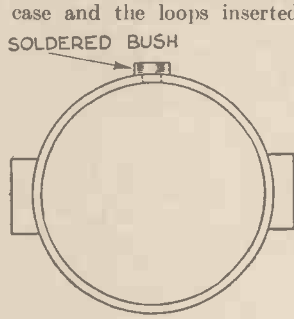


Fig. 1.—Repairing a worn winder hole

Black iron binding wire is used to minimise the risk of its being fused to the article being brazed. Before "rigging" up a case for brazing, both the back and the bezel should be removed. To do this drive out the joint pins or hinge pins as they are sometimes called. These pins are usually inserted from the right-hand side when holding the back or bezel toward the body. Apart from the ill effect of the intense heat upon the joints or hinges the removal of the back and bezel will prevent unnecessary polishing.

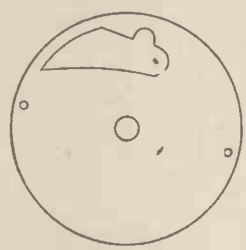


Fig. 2.—Details of the brass disc for fitting inside the watch case

When the loop has been bound into position everything is ready for brazing. Brazing, hard soldering or gold and silver soldering is rather different from soft soldering. A different solder and a different flux have to be used, also an intense heat is necessary to fuse the metals. To prepare the flux take a crystal of borax and rub it down on a piece of wet slate until it produces a creamy paste.

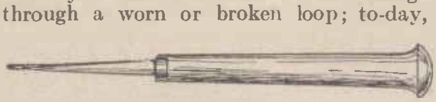


Fig. 3.—A joint pusher which consists of a slender steel punch fitted with a handle

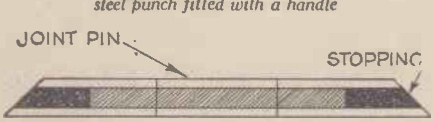


Fig. 4.—Details of the joint pin

Brazing

Sharpen a piece of plywood to a chisel shape and apply a little borax paste to the parts to be brazed. A small piece of solder should be placed into position and the case put on a piece of charcoal or asbestos.

First, gently warm the case all over, for a sudden application of heat to the borax and solder will cause the borax to bubble up and deposit the solder anywhere except in the desired spot. As soon as the solder has settled the heat can be directed on to the parts which are to be brazed. For small and light-weight cases an ordinary mouth blowpipe will be suitable as the heat can be more easily controlled. Immediately the solder glistens stop blowing, as this will be the signal that the metals have fused.

As soon as the case is cold the binding wire can be removed. The case, especially around the loop, will be badly discoloured; the discoloured parts will have to be treated before the case can be re-polished. Any surplus borax will have assumed a glazed and brittle state, but this can be removed with a few light blows from a small watchmaker's hammer. A gold case can be cleaned with some strong hydrochloric acid applied with a sharpened piece of wood.

Cleaning Methods

Hydrochloric acid will leave the case a pale green colour, the case, however, can soon be restored to its original gold colour with the aid of a little metal polish and a final application of rouge. A slightly different method of cleaning has to be adopted after brazing a silver case. When the surplus borax has been removed the case is reheated (not a red heat) and immersed in some "pickle" (slightly diluted sulphuric acid).

Allow the case to remain in the "pickle" for five or ten minutes. When removed from the "pickle," the case, which will be a creamy colour, should be well rinsed in water, preferably warm. By scratch brushing the case with stale beer a brand new finish can be produced, plus, of course, a final buffing with rouge. A scratch brush is a brush having bristles of fine brass wire. The small brass wire bristles sold for cleaning suede shoes are quite suitable for this work. Stubborn stains can be easily removed by rubbing the affected part with a little powdered pumice.

Replacing a Hinge

The replacement of a complete hinge (back or front) is not a common repair, the replacement of the centre portion is, however, frequently necessary. The first step is to remove the joint pin or hinge pin as it is sometimes called. Usually, the pin is inserted from right to left; but as it may be inserted from left to right care must be exercised in driving out the pin. Too much pressure in the wrong direction will easily split the hinge or joint as it is usually called.

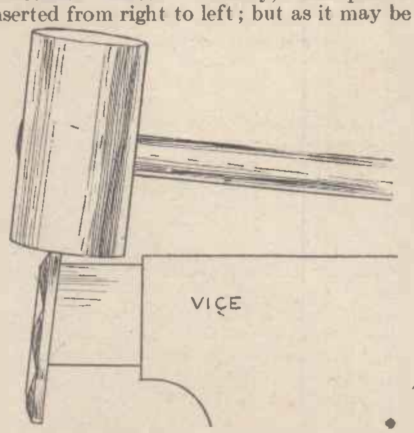


Fig. 5.—Contracting a bezel in a vice

In some instances a push with a joint pusher (a slender steel punch fitted with a handle—see Fig. 3) will be sufficient to remove the pin, in others a few taps with a small hammer may be necessary. High-grade cases usually have a short joint pin which is inserted well within the three joint sections, the open ends being filled with a "stopping" of gold or silver. Before the joint pin can be taken out these "stoppings" have to be removed. A well-sharpened graver will be the most effective tool to remove these "stoppings" which are entered from each end. Fig. 4 shows this type of joint.

Making a New Joint

When the back, bezel and broken joint have been removed, preparations can be made to braze a new joint. A very shallow groove should be filed with a round file at the original joint position. Select a suitable sized piece of gold or silver joint wire and cut off sufficient to make a new joint; the joint should be filed until it just fits the joints on the back. Next, the joint wire is laid with its seam downwards in the groove on the band of the case and tied with soft iron binding wire. Borax should be made and applied as described when brazing a loop and a narrow piece of solder slipped between the binding wire to enable it to flow around the base and seam of the joint wire. After brazing the case should be cleaned and polished as previously described. It is better to use too little rather than too much solder as any excess will be difficult to remove.

Before filing up a new brass joint pin the three joints should be broached out to prevent binding. The centre joint should be a trifle larger than the others, as it is very bad form to see the joint pin turning with the back and bezel. When the pin has been filed to fit it should be cut off to the required length about $\frac{1}{16}$th inch shorter each end than the length of the joint. After the joint pin has been inserted the "stoppings" (gold or silver) should be fitted.

A Lost Bezel

The loss of a bezel is a frequent occurrence with the strap-on and two-piece case. The bezel needs to be contracted or the case expanded. To contract the bezel; first remove the glass then place the bezel on a circular stake or hammer head which has been fixed in a vice as shown in Fig. 5 and gently tap the edge all around with a light mallet. Pliers should never be used as these only kink the edge. A hinged bezel which

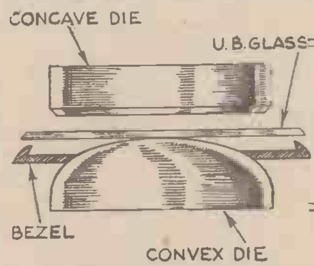


Fig. 6.—Method of fitting unbreakable crystal

has been strained can be made to snap if a needle is placed between the bezel and the band of the case near the hinge and the bezel forced downwards.

The most popular watch glass is the unbreakable, more correctly called the unbreakable watch crystal. These crystals

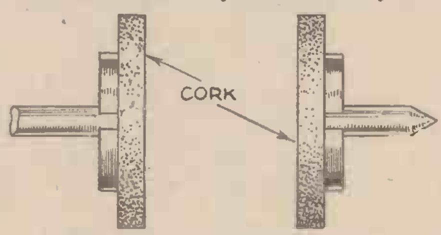


Fig. 7.—How the cork chucks are made

can be obtained in a complete range of sizes both round and fancy shaped, gauged in millimetres. To fit a crystal, first make sure that the bezel groove is clean cut, next measure the diameter with a millimetre rule. Unlike ordinary watch glasses these crystals are flat and the necessary curvature is produced by fitting an oversize crystal.

The curvature for most watches can be produced by selecting a crystal 2 millimetres larger. The press used for fitting these crystals is a simple affair consisting of a number of wooden dies, concave and convex. The bezel is placed over the lower or convex and the crystal placed on the die, the upper or concave die is then pressed on to the crystal until it is domed sufficiently to enter the bezel. If the bezel is an in between size it may be necessary to turn out a size especially. Take a square of unbreakable material, place the bezel on the square and mark around it, next cut out the circle with a pair of scissors.

Cork Chucks

The cork chucks used to turn the crystal are quite simple to construct. Procure two pieces of steel both about $\frac{3}{4}$ inch long which will fit No. 50 chuck, on the end of one turn a shoulder about $\frac{1}{8}$ inch, on the other piece turn a shoulder at one end and a conical pivot at the other. A disc of brass should next be soldered to the shouldered end of each piece of steel as in Fig. 7. Two slices from a good cork can now be fixed to the discs with shellac or sealing wax and the cork chucks are finished.

The plain chuck is placed in No. 50 lathe chuck and the conical chuck in the female centre of the tail-stock. Place the unbreakable material between the corks and screw up the tail-stock. When true proceed to turn a bevelled edge with a well-sharpened graver. The rest should be well above the centre as the slightest dig will lift the crystal out of the corks. An "inside and outside" measuring rule is the best means of checking the size as this can be done without removing the crystal from the corks. When the crystal is 2 millimetres larger than the bezel it can be fitted in the usual way.

Ordinary watch crystals have an advantage over unbreakables—they do not scratch. Scratches, however, can be removed from unbreakable crystals by polishing them with ordinary metal polish on a piece of cotton wool.

A Film Economiser

HERE is an idea which will allow you to make twenty-eight or thirty exposures on a normal eight exposure $2\frac{1}{4}$ in. by $3\frac{1}{4}$ in. roll film. The pictures are much smaller, but can, of course, be enlarged up again to whatever size you may want them.

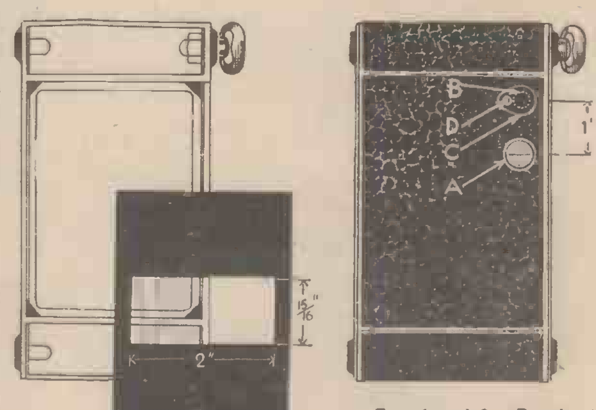
The main basis of the idea is to fit a mask of black paper into the back of the camera to cover all but the required portion of the picture. The mask should be accurately cut from fairly stout paper, and must lie flat and as near the film as possible, to prevent halation round the edges of the window in the mask. The window should be cut dead in the centre of the normal space occupied by a full exposure, to ensure the subject coming accurately into the centre of the smaller exposed area.

The mask can be fixed with four small triangular pieces of insulating tape pressed into the four corners of the frame of the camera. (See Fig. 1).

The next thing is to decide on the provision for advancing the film 1 in. at a time instead of the $3\frac{1}{4}$ in. provided for by the numbers printed on the roll. It entails the drilling of the back cover of the camera and the fitting of a dark cover. This method has the obvious advantage of immediate usage with any roll exactly as it is bought, but has a disadvantage, in that light may get through and fog the film. This will be particularly noticed on exceptional fast films although with care it may be avoided. Fig. 2 shows how the back cover is marked out, drilled and fitted. A is the normal registering window covered with red or orange celluloid. B is the position of what can be called the "marking" hole and should be just large enough to take the point of a pencil. C is a black celluloid cover which excludes light entering the hole. The cover is secured to the case with a short screw tapped into the metal. When using the device, insert the roll film into the case in the usual way the mask, of course, being between the lens and the film, place the back on and wind up till number 1 shows up through the registering window.

Marking the Film

The cover C is moved over from the marking hole and a mark made on the red paper with a pencil or a stylo pen. Then expose the picture and wind up the film until the spot appears in the centre of the registering window. Then make another mark and expose and so on. You will get three more pictures after the No. 8 marking has passed. On developing the film you will notice that there is approximately space for three more exposures previous to the No. 1 marking. Make a note of the position on the paper at which the film is attached and when the next film is inserted into the camera, only advance the first or second warning spots to the centre of the registering aperture. It is possible to get thirty-three pictures from some makes of roll film.



Figs. 1 and 2.—Details of the black mask and how the back cover of the camera is drilled

Our Busy Inventors

By "Dynamo"

Bad News for Rats

IT is said that the Egyptians and the Phrygians made a god of the rat. That is not the attitude of those worthy folk who organise an anti-rat week. They do not deify but defy the baleful rodent.

To guard against the sharp teeth of the vermin in question what is termed a Gnaw-proof Container has been patented in America. This container is made entirely of small gauze wire. It is flexible and an excellent protection against the gnawing of rats. It has a Zipp type of fastener which, when closed, is practically safe from attack by the pests who were such an inconvenience to the good people of Hamelin.

Shelf-reacher

SHORT people are handicapped when they have to reach down a book or some other article from a high shelf. Even those folks who go to great lengths are baffled by the altitude of the shelf. And, failing the assistance of a ladder, they are compelled to emulate an Alpine climber.

To assist people to get things down, what is termed a Shelf Reacher has been patented in the United States. This invention comprises a staff, on which a pair of jaws are pivotally mounted; means for gripping articles; a handle on the staff, and means connecting the handle and the jaws.

I presume that the jaws can be so padded and manipulated that articles can be gripped with the softness of the mouth of a spaniel.

Butter Dispenser

FOR the use of restaurants, hotels, clubs, hospitals and other large institutions, there has been constructed a machine which delivers pats of butter of any size as fast as the operator can handle the plates upon which they are placed. The appliance is designed to contain butter and ice in separate compartments, and the butter is never touched by hands or ice. As a consequence, it is kept free from finger prints, germs and discolouration. This machine, it is affirmed, cuts up 100 butter pats a minute and allots to the plates 36 to 90 pieces from a pound. The invention enables butter to be supplied in more than one shape. It may be extruded in rectangular, rotund or in massive form; to use plain language, in squares, rolls or bulk. And it is instantly adjustable to any thickness of butter.

Efficient as is this magic dispenser of the familiar unctuous comestible, in these unhappy days it is subject to the ration rules ordered by the State.

Anti-rust Roof

I LEARN that a recently built factory has a porcelain enamelled corrugated steel roof. It is claimed that this is the first installation of the kind in connection with a factory. Should it prove satisfactory, it bids fair to be the pioneer of many such installations in industrial plants, garages and other buildings.

It is a well-known fact that Dame Nature never has a holiday. By day and night, her oxygen-charged breath eternally assails all exposed iron and manufactures what chemists term ferric oxide, which the man in the street knows as rust.

Now, it is maintained that porcelain enamel is almost completely resistant to the ravages of the weather. It is also eminently suitable for buildings where fumes are very hostile to ordinary roofing. And the porcelain coated roof is pleasant to the sight.

The Wool Age

THOSE learned scribes who ferret out the secrets which Mother Earth conceals in her bosom tell us that there have been a Stone Age and an Iron Age. The present may be styled the Wool Age, judging by the abnormal activity of knitting needles in the hands of the fair who are making innumerable pullovers, scarves, socks, gloves and "Balaclava" caps. These genial garments are intended for our heroes in the Navy, Army and Air Force.

Wool has the reputation for not being as brave as these valiant warriors. Sometimes it shrinks. To prevent this weakness, certain inventors have applied to the British Patent Office to protect a process which they claim will diminish the shrinkage of wool. Their method is to treat the wool with a solution containing what is known as a protease, preferably in association with a substance which accelerates the action of the protease.

Wool in Hot Water

AS regards shrinkability, many people believe that the proof of the wool is in the washing. These good folk think that, when wool gets into hot water, it necessarily has a habit of shrinking. However, I am informed by a laundry expert that this is not accurate. It seems that bad washers quarrel with their wools. In other words, shrinking is not always the fault of the fabric but is sometimes due to the way it is treated when washed. The afore-mentioned expert tells me that a woollen garment should be put into hot, soapy water, adding that the secret is not to allow it to remain in this water too long. It should be rinsed in water of the same temperature.

I am further advised that woollen articles should invariably be dried flat. If hung on a line, the moisture left in the upper part of a garment naturally gravitates to the lower part. And the wool, owing to the weight of water at the bottom of the garment, instead of shrinking, is apt to stretch, pulling the article out of shape.

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."

Bag-filler

IN the reign of Queen Victoria the young were taught some moral verses which began:

Little drops of water,
Little grains of sand,
Make the mighty ocean
And the beauteous land.

In our day the little grains of sand are playing an important rôle in the defence of the realm. Now, filling sandbags by hand labour is a very tedious process. When the bag is filled by means of a shovel, the latter has to be placed well into the mouth of the bag, to ensure that each shovelful is properly deposited in the bag. It is natural, therefore, that the inventor should think out an expeditious way of getting the work done. One of the latest methods of bag-filling is the subject of an application which has been accepted by the British Patent Office.

According to the new invention there is provided a hopper or large funnel the mouth of which is so formed that shovelsful of sand can be readily thrown into the hopper without having to be deliberately placed therein. Within the hopper an arrangement for normally closing its lower opening is also adapted to regulate the flow of sand. This controlling means is preferably operated by the foot, though it may be made to work by hand. Lastly, this useful contrivance, which is mounted on a wheel, can be transported with ease.

Rubber Lantern

IN the bowels of the earth, from which our coal supply is derived, some form of illumination is absolutely necessary. An application for a patent has been made to the British Patent Office to protect a newly-devised electric hand lantern. This is specially suitable for use in mines and other places where a lantern has constant wear and is subject at times to rough handling. In order to make this lantern as shock-proof as possible, there is employed in its construction as much rubber as is practicable. The accumulator is well packed to keep it in good condition, reduce evaporation and avoid the spilling of the electrolyte. The inventors have aimed to produce a lantern not only robust, effective and economical, but light in weight and capable of being re-charged without dismantling any of its parts. There is an adjustable cover in front of the lamp, so that this dark lanthorn (as our forefathers used to spell it) would have been very welcome to Guy Fawkes.

For Illegible Writing

A SEMI-CIRCULAR rod-shaped lens which covers the width of a telephone directory column and enlarges print to twice its size, is not an absolutely new object. However, this convenient magnifier has now been incorporated with a letter opener. It will, I opine, prove most useful in an office where the correspondence received is not always typed or written in block letters. Signatures, by the way, are sometimes annoyingly indecipherable. Therefore, a magnifying glass which doubles the proportions of the cryptic characters will make it easier to guess what they are intended to be.

Washing-up Made Easy

AFTER the meal is over, washing up is a task which even the industrious housewife does not relish as much as she does the luscious food which makes the cleaning necessary. Since husbands expect every woman to do her post-prandial duty, it is fortunate that an inventor has devised a convertible dishcloth and scraper. The dishcloth is of the usual rectangular shape but has a triangular pocket. When turned inside out, this pocket reveals an abrasive attachment which acts as a scraper. When not in action, the scraper does not interfere with the washing operation of the dishcloth.

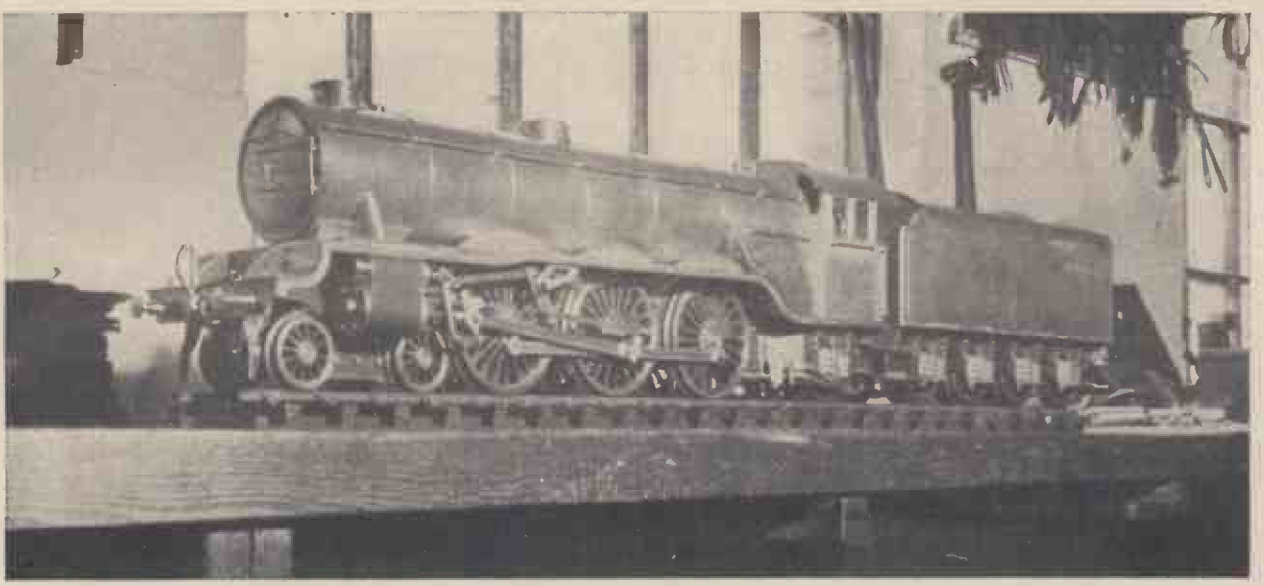


Fig. 1.—A picture of our 2½ in. scale model of the famous L.N.E.R. "Flying Scotsman"

Building a 2½ in. Gauge Model of the "Flying Scotsman"—1

Constructional Details for a Powerful Model of a Famous Prototype

FOR some time we have had a desire to present to our readers a working scale model of one of our famous main line express locomotives and accordingly we commissioned that well-known Northampton firm, Bassett-Lowke, Ltd., to build an accurate scale model of the L.N.E.R. Pacific type locomotive "Flying Scotsman." The scale drawings were prepared, after the model had satisfactorily passed its steam test by Mr. E. W Twining. We have arranged with Messrs. Bassett-Lowke, Ltd., to supply all materials, castings and blueprints.

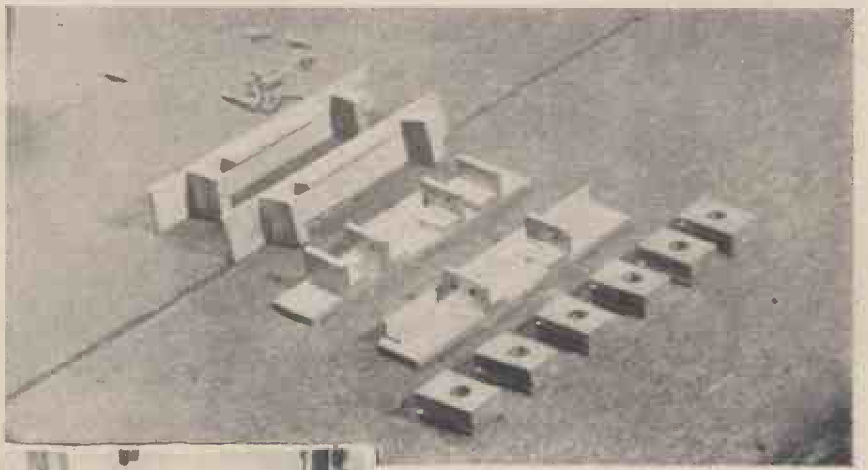


Fig. 3.—Buffer beams and axle boxes ready for assembling

Fig. 2.—Sheet metal, tubing, and castings used in the construction of the model

The scale of the model is ½ in. to one foot, giving a rail gauge of 2½ in., and the illustration, Fig. 1, shows the realistic appearance of the model completed at the Northampton works. All working details of the original are followed, as well as the characteristics of external design. The finished model is an example of the finest model engineering craftsmanship, and would be a valuable addition to any 2½ in. gauge garden railway.

The completed model, complete with tender, is over 3 ft. long, and burns methylated spirit, the boiler being of the "Smithies" type with five water tubes, and a superheater. The tender contains a water tank and spirit tank, the spirit supply being controlled by a needle valve; a small force pump is fitted in the water tank for feeding water to the boiler when the locomotive is stationary. When the locomotive is running a pump driven by an eccentric fixed to the driving axle feeds water to the boiler. The cylinders are automatically lubricated, by means of a displacement lubricator fitted between the main frames, just above the front bogie-wheel axle.

Constructional Details

Before proceeding with details of construction it would be as well to study Fig. 4, which gives a side elevation of the locomotive, with dimensions, and also Figs. 5 to 8, which give details of the engine main frames.

The first job to tackle is the marking out and cutting of the engine main frames. These are marked out with a scriber from the dimensions given in Fig. 6. They are cut out with a cold chisel and metal saw, and finished with a file. Note that the frames have to be pinched in at the rear ends.

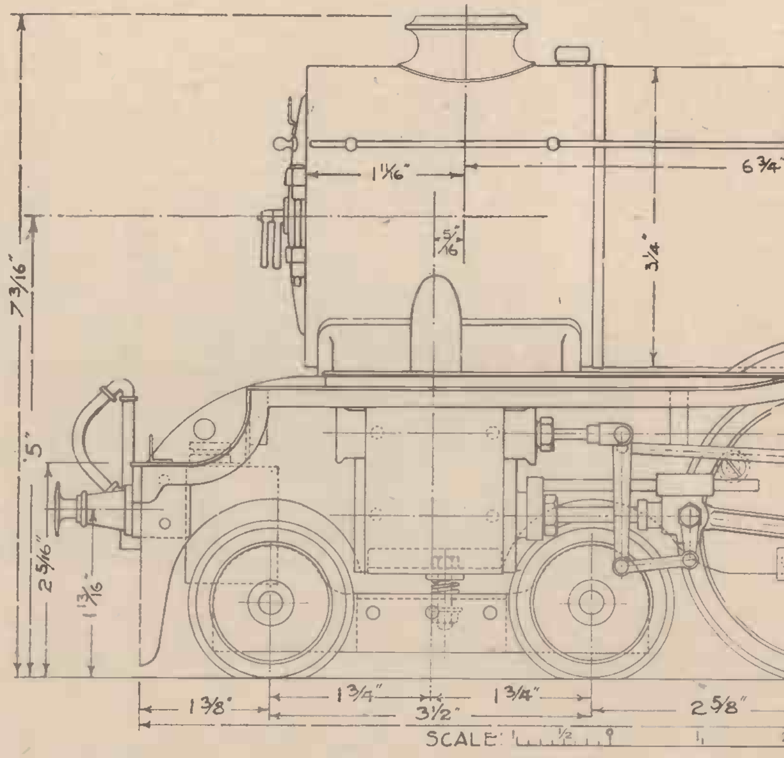
Next the hornblocks and dummy springs are filed up ready to be fitted to the frames, after which comes the fitting of the hornblocks and springs. All holes must be carefully marked and centre-punched before drilling, most of the holes being 3/32 in. diameter.

Axle Boxes

The axle boxes and keeps have now to be fitted. The axle boxes are machined out of the solid, and the keeps are made of 3/8 in. angle brass. There are six of these altogether, and all the necessary holes for fixing should be carefully marked off from the diagram, Fig. 6.

The two stretchers, or circular distance pieces between the frames, are made of 3/8 in. brass rod, 1 15/16 in. long. These are drilled at each end and tapped 1/8 in. Whitworth. The stretchers secure the frames rigidly together and hold them true.

Next come the buffer beams which, although shown as being built-up from angle brass and 1/8 in. by 3/4 in. brass strips in Fig. 6, can also be made from castings (see Fig. 3). These are fixed by 3/32 in. screws.



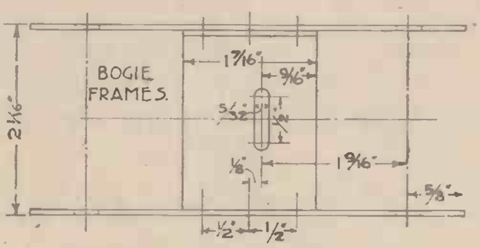


Fig. 7.—Bogie frames and stretcher plate

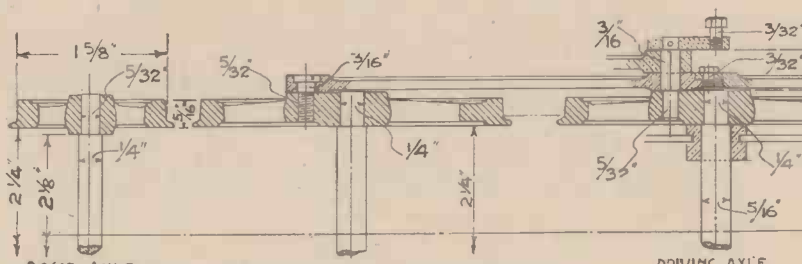


Fig. 5.—Half sectional plan of wheels and coupling rod

Trailing Outside Frames

Details of the trailing outside frames are given in Figs. 6 and 8. These are fitted with dummy springs and hornblocks, and then fixed to the main frames. The six footplate supporting brackets are cut from 3/16 in. flat brass, drilled for lightness, and fixed to the main frames by set screws.

The displacement-type lubricator, with steam feed, is attached to the front buffer beam by countersunk screws. The position of this fitting is shown in Fig. 10. The lubricator is built up out of 1 in. diam. mandrel drawn brass tube with disc ends, and is fitted with a 1/2 in. diameter filler, No. 1 drain cock, No. 0 union cock, and No. 0 plain union for steam feed.

Bogie Frames

Details of the bogie frames are given in Fig. 7. These are cut out of 1/16 in. planished steel plate, and the stretcher is also made of 1/16 in. steel.

The "life guards" (see Fig. 4) are cut from 1/16 in. steel plate, and after being filed to shape are fixed to the front end of the main frames by the same screws which hold the buffer beams to the frames.

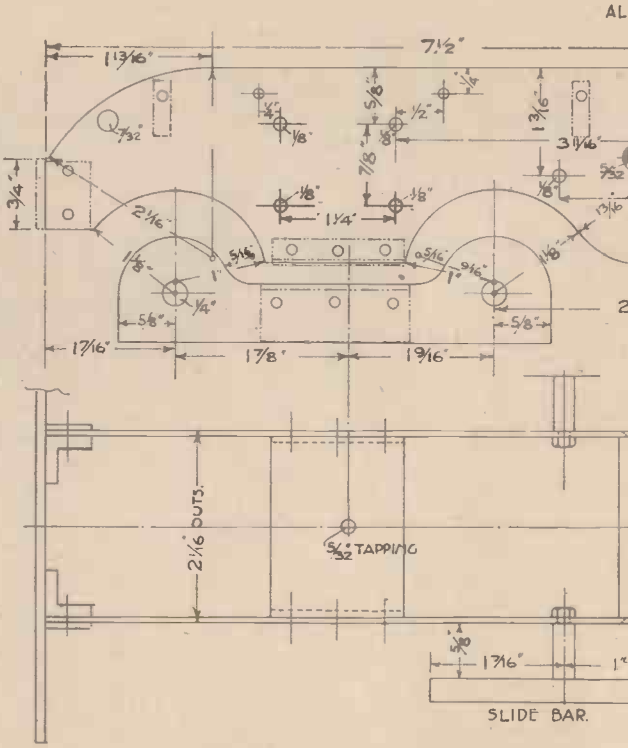
The bogie frame swivels on a 5/32 in. steel pin screwed to the frame stretcher and held by lock nuts. A slot is cut in the bogie stretcher plate to allow of the necessary lateral play. Three hexagon screws hold the frame to the stretcher plate on each side.

Wheels

The wheels are turned from castings of cast iron, and are forced on to turned steel axles which are shouldered down at the ends. The space between the shoulders on the driving-wheel axles is exactly 2 1/4 in., as indicated in Fig. 5. The crank-pin and pins for the coupling rods are forced in and riveted, the driving crank-pins being extended for the connecting rods and eccentric cranks.

Fixing Hornblocks to Tender Frame

Mark the position of the holes on each hornblock, as indicated in Fig. 8. For the tender there are eight pairs of blocks, with four holes in each. Clamp



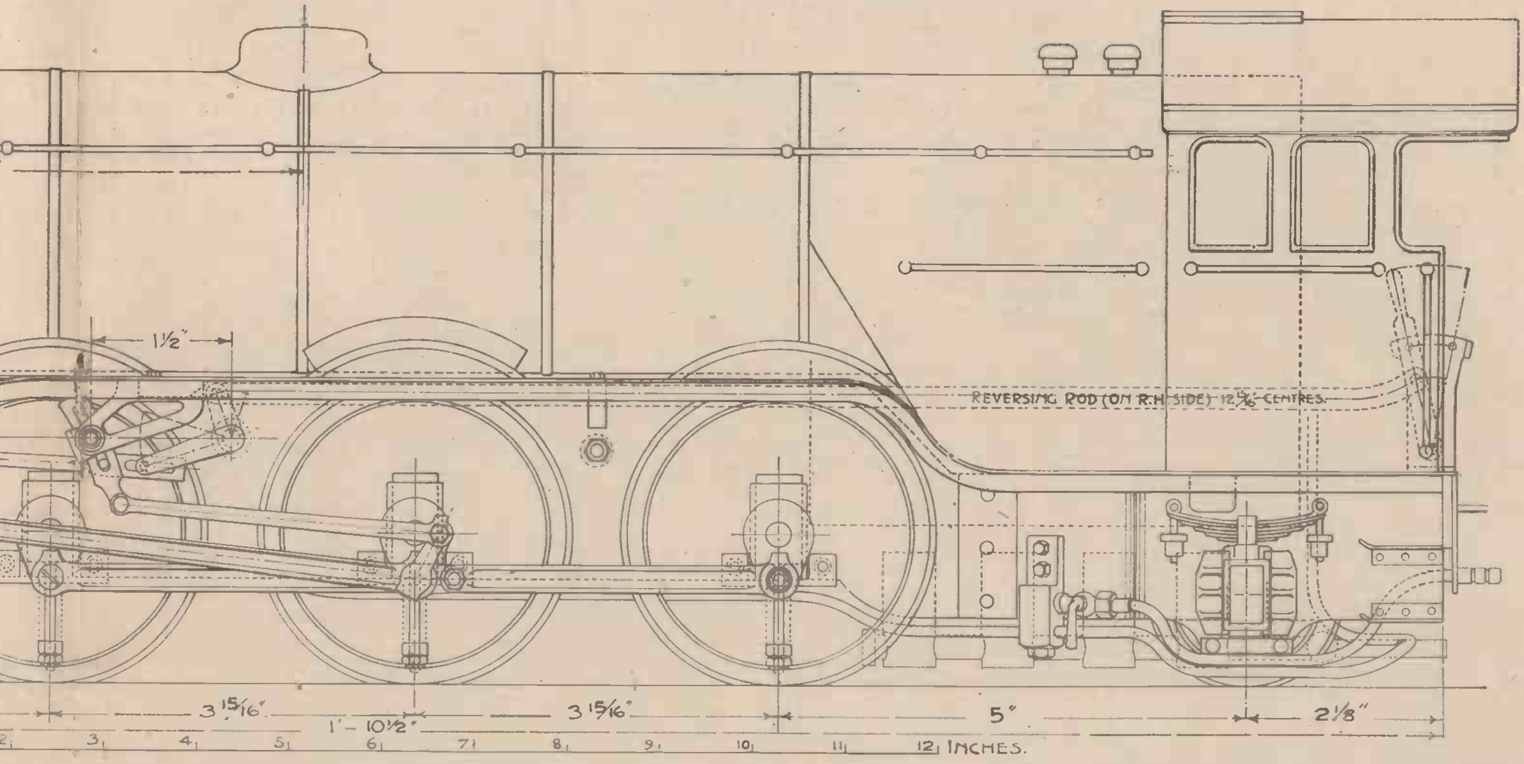
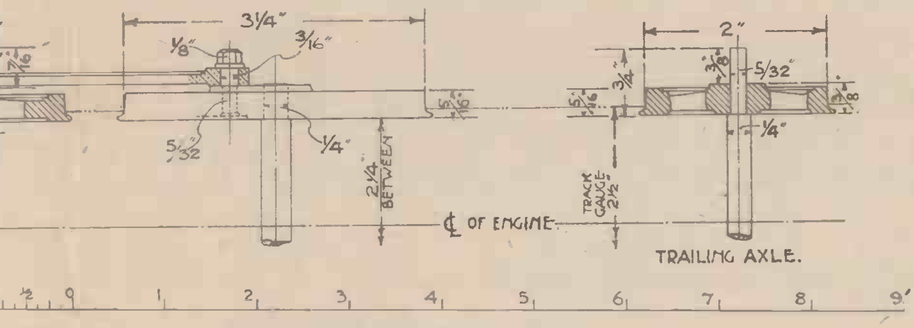


Fig. 4.—Side elevation of the 2½ in. gauge model "Flying Scotsman"



L HOLES DRILLED 3/32" EXCEPT WHERE FIGURED OTHERWISE.

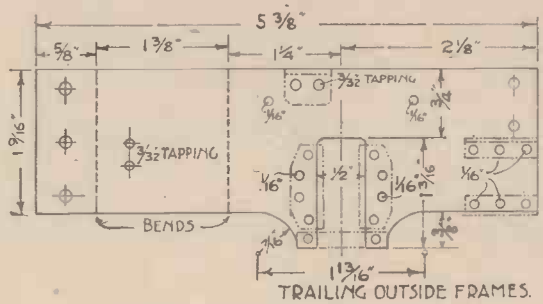


Fig. 8.—Detail of outside trailing frames

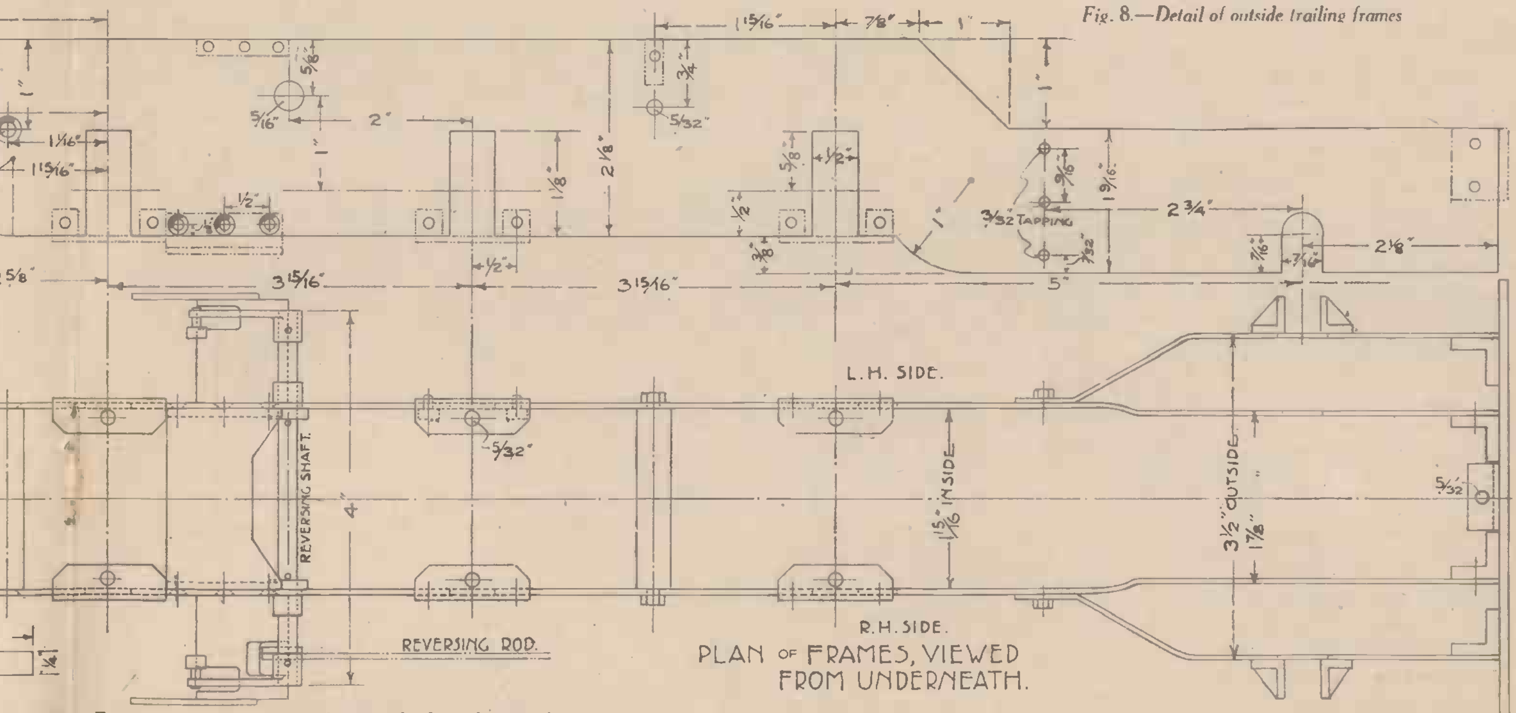


Fig. 6.—Side elevation and inverted plan of main frames

Fig. 9.—The main frames, showing one of the cylinders being fitted

the horn blocks in the correct position on to the tender frame and, drill through with a No. 51 twist drill. The hornblocks are rivetted to the frames with 1/16th copper rivets. The block must be carefully positioned, before rivetting, by means of a template of the axle box. For this a piece $\frac{3}{8}$ in. accurately machined brass or steel can be used.

SPECIFICATION

The chief items of the specification are as follows:—

Main frames, $\frac{1}{16}$ in. planished steel plate.
Hornblocks and axle boxes of gunmetal.
Underslung spiral springs for driving wheels.
Wheels and axles—cast iron wheels forced on steel axles.
Cylinders ($\frac{5}{8}$ in. bore by 1 in. stroke) gunmetal castings. D-slide valves.
Boiler and tubes—copper.
Valve gear—Walschaert.
Reversing gear—lever type.
Footplates—planished steel.
Fittings—water gauge, steam pressure gauge with syphon, steam valve, blower valve, check valve, safety valve, dome and chimney.
Full list of parts and blueprints will be given next month.

At this stage the dummy spring castings can be cleaned up. Lay them on a flat surface and centre punch the holes for the fixing screws, which are central over the axle boxes. Countersunk screws are used, the spring castings being drilled and tapped on the eye of the spring, and then fixed with the countersunk screws from the back.

The keeps, which are 1 in. long, are cut from $\frac{3}{16}$ in. by $\frac{1}{16}$ in. brass strip, the ends being drilled $\frac{3}{32}$ in. clearance holes, and corresponding holes are tapped in the frames. Two $\frac{3}{32}$ in. holes are drilled in each end to take the fixing screws for the buffer beam.

Buffer Beams

The buffer beam castings can now be cleaned and the buffer centres set out, with the aid of a rule and dividers. Clamp the tender frame to the buffer beam, and drill and tap for $\frac{3}{32}$ in. screws. Drill $\frac{3}{32}$ in. clearance holes in the buffer beams and the lugs. The tender frames are now ready to receive the bottom footplate, which is of $\frac{1}{32}$ in. sheet brass, and measures $13\frac{3}{8}$ in. by $4\frac{7}{8}$ in. Lay the frames square on the footplate, using it as a template. Clamp it in position, and secure with screws and nuts, the nuts on the underside so that the body of the tender can be removed from the frame, if necessary. The heads of the screws are soldered in place to make the joints water-tight.

Tender Wheels

These are turned on rim and face, and have outside journals to receive the axle boxes. The journals are turned from $\frac{1}{4}$ in. steel rod to $\frac{3}{16}$ in. diameter, and the wheels forced on.

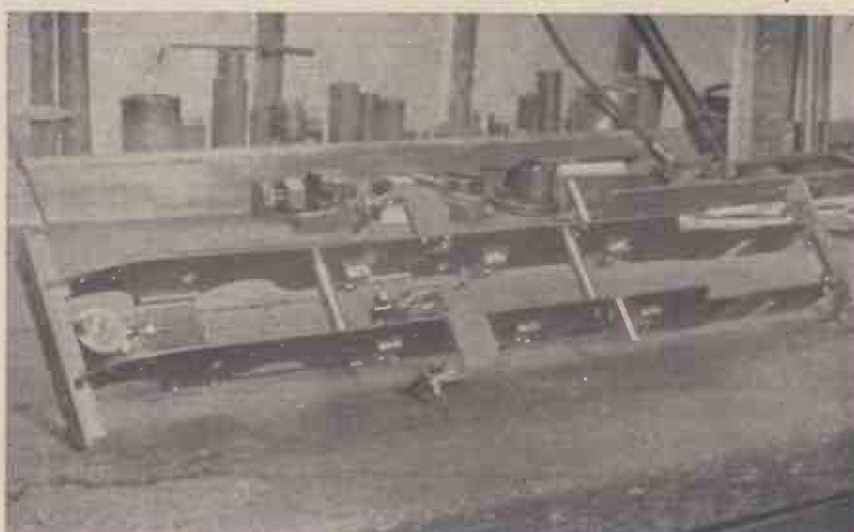


Fig. 10.—The finished main frames with buffer beams and displacement lubricator in position

(To be continued)

Fig. 11.—Engine main frames, tender frames, horn blocks, and dummy springs

A Low-

By Major

The Design of the Model has been Looks very Well in the Air. It

A front view of the model

THE number of successful low-wing petrol models that have been produced is very small indeed. By successful, I mean models that fly regularly and with stability.

The high-wing model is generally chosen because it is so easy to produce even a poorly designed example that will be reasonably stable.

Many people are heard to declare that the low-wing model will not glide. Actually this assertion is not in accord with the facts, and is usually made by people who have either never made a low-wing model or who have only tried one, and have not obtained sufficient experience of the type.

A low-wing model can actually be an excellent glider, and anyone who doubts this should remember the "Klem" full-sized aeroplane. It is a beautiful "floater" and has a very flat glide. Incidentally, it also has the reputation of being of the simplest fixed-wing aeroplanes in the world. To obtain such a reputation means that it is exceptionally stable and foolproof—anyone who has flown a "Klem Swallow" will bear this out.

It may be recalled that many of the most successful early post-War (1914-18) rubber-driven models of high performance were low-wings. This type won many of the S.M.A.E. competitions.

Perfectly Stable

I have always been interested in low-wings, and have built many rubber and quite a few petrol low-wings. As a result I have found that if certain rules are followed, the low-wing is perfectly stable, and can be flown in rough weather. It is actually easier to get a good glide after power than in the case of a high-wing, because the thrust line can be arranged directly through the centre of resistance of the main plane.

The thrust does not then tend to pull the nose up around the centre of resistance as in the case of the high-wing and parasol, and so cause a stall, unless counteracted by down thrust or some such method. This point will be dealt with later.

For rubber-driven models, where an acute climb is required, on limited power, to gain height for soaring, the high-wing has its points; but for the petrol model that merely requires steady flying, the low-wing is safer.

There are two difficulties in the design of a successful low-wing model that must be overcome, and both are extremely simple but so often neglected. The first is that lateral stability must be assured by a greater dihedral angle and careful weight distribution, so that the forward side area is well above the C.G. This extra dihedral forward must be balanced by the correct amount of side area aft.

The second difficulty to be overcome is that the downward and then upward sweeps of disturbed air which follow behind the wing should not interfere with the tailplane and fin. This can be overcome by keeping the fuselage long, so that the upward disturbance clears the tailplane.

It is also important that the trailing edge of the wing shall blend in with the lines of the fuselage, in order to prevent buffeting of the tailplane. The model to be described complies with these simple rules, and has been kept ruggedly simple and practical, and yet looks very well in the air. Nowhere has looks been allowed to interfere with the dictates of practical performance, however.

Not only is the model stable, but it has been found to be more stable than the average good high-wing model. This is no exaggeration, but is an actual fact.

The photographs give a general idea of the model with its rounded top to the fuselage.

They show its keen but simple lines combined with general dihedral angle of the wings.

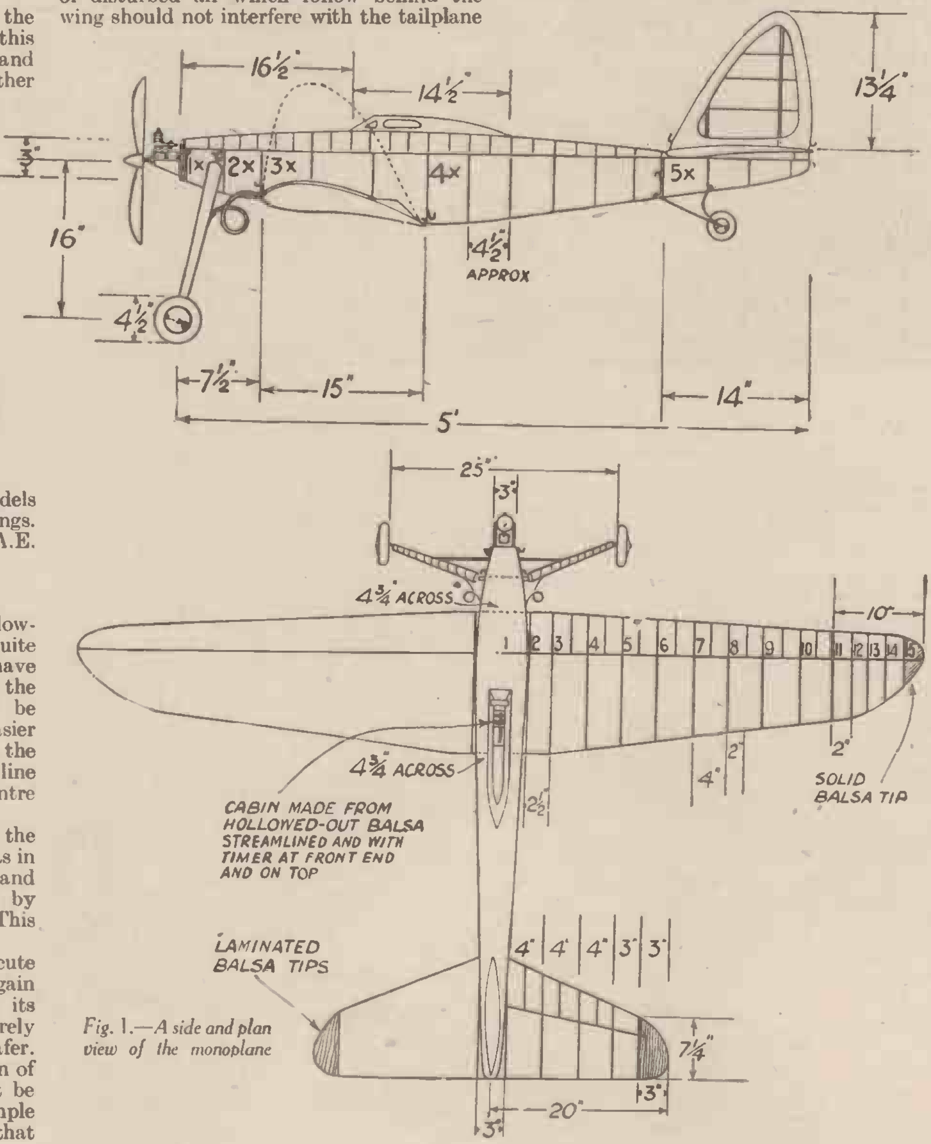


Fig. 1.—A side and plan view of the monoplane

Wing Petrol Monoplane

C. E. Bowden

kept Simple and Practical and is Perfectly Stable in Flight.

The model has a wing span of 8 ft. and maximum chord of 16 in., length 5ft. 3 in., and a weight of 6$\frac{3}{4}$ lb. It has been flown frequently with a 9 c.c. Brown, and also with a 9 c.c. Ohlsson engine, or from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. maximum revs.

One photograph shows the model in flight, and also gives a good idea of its flat gliding angle. Unfortunately, these photographs were taken during dull weather last winter and, therefore, suffer in clarity.

Simple and Novel Method of Construction

The fuselage has been made up on the same simple and easily constructed method that was designed for the little "Kub." Details of the "Kub" were published in my book, *Petrol Engines and Model Aeroplanes*, and a replica of the model in the hands of Mr. Jefferies won the 1937 Sir John Shelley Cup, which proves the practicability of the constructional methods. There are a number of replicas of the "Kub" flying about successfully. Let us examine the fuselage first.

(*Above*) *The model in flight and* (*left*) *a rear view of the model*

The Fuselage

Fig. 1 is a general arrangement drawn plan and side elevation of the model. A scaled-up full-size drawing should be made upon cheap drawing paper, unless the builder wishes to keep his plans, when a better but thin paper should be used. It is necessary to draw up the fuselage full size, side elevation and plan on one piece of paper.

From this and Fig. 2, dimensions of the five three-ply formers can be obtained, and the formers cut from $\frac{1}{8}$ in. three-ply except No. 1 nosepiece former, which is cut from $\frac{1}{4}$ in. three-ply. All formers are fretted out for lightness, and these formers make jigs to keep the fuselage true whilst building.

As the tops of the formers are measured from a straight top line from the fuselage, if the formers are accurately cut and the fuselage sides correctly shaped, the correct angle of incidence of the low-wing will be automatically obtained. The formers also take the shocks, and stubs of detachable wings and tail-retaining hooks, engine and undercarriage.

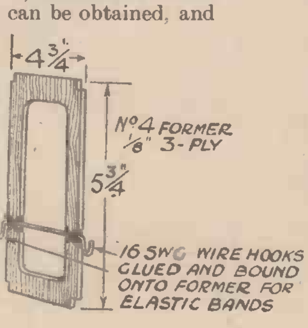
Fuselage Sides

Wire hooks, as shown, are bound with thread and glued to the formers. Hooks should be of 16 s.w.g. wire (see Fig. 2). The two sides of the fuselage are cut from $\frac{1}{16}$ in. sheet balsa of light weight to the side elevation shape of the fuselage.

On to the inside of these two side sheets of balsa, $\frac{3}{16}$ in. by $\frac{3}{16}$ in. lightweight balsa longerons and uprights are glued, and temporarily pinned by ordinary steel pins until the cellulose glue is dry. The pins are then withdrawn and the constructor has two sides strictly formed with longerons and uprights complete.

The above operation may be done on a floor by laying the sheet balsa sides on the floor and pinning the longerons on the inside and along the outline of the sheet balsa. Plenty of glue should be used, as the whole idea is to form a strong balsa box fuselage, and due to the method of construction no birch or spruce longerons, etc., are required; although the fuselage is actually stronger, though lighter, when finished, than a normal spruce fuselage, and certainly infinitely stronger than normal-type balsa fuselage, however much-strutting is indulged in.

Labour is also reduced, so that the fuselage can be made in three evenings. The first is spent in cutting the three-ply main corners and bindings on hooks, etc. On the second the two sides are formed, and on the third evening the top and bottom are added, and the whole is covered with silk, and doped. Black or red copying paper is used to transfer the fuselage side outlined to the $\frac{1}{16}$ in. sheet balsa sides. These are then cut to shape by a balsa cutting knife, or old razor blade.



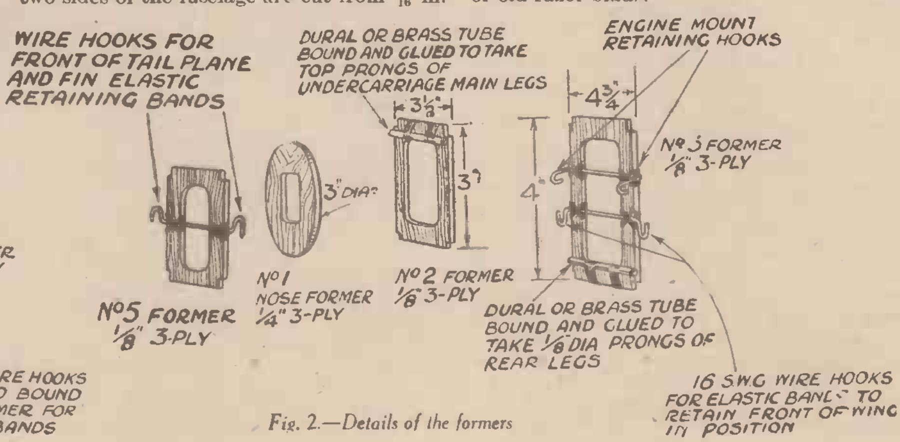


Fig. 2.—Details of the formers

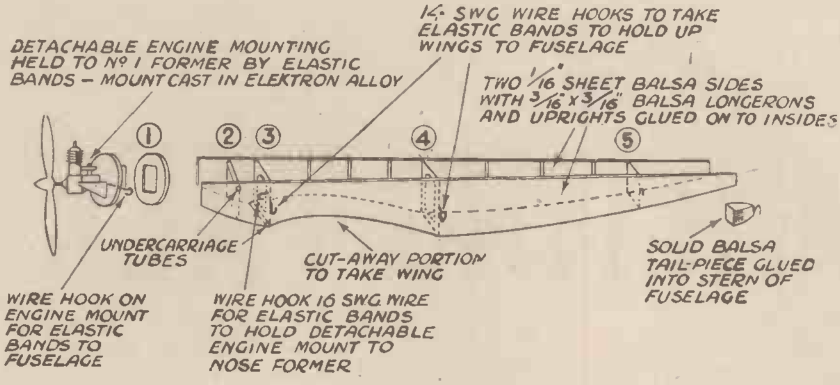


Fig. 3.—Method of assembling the fuselage

Fitting the Formers

Three-ply formers Nos. 2, 3, 4 and 5 (see Fig. 3) are now glued between the two sides where shown on the drawing, Fig. 2. Pins keep in position until dry. See Fig. 3, which gives a general idea of the fuselage as it now appears.

Now pull nose inwards a little at each side so that No. 1 circular nose former, which is made from ⅛ in. three-ply, can be glued on to the ends of each side. Pins will keep in position until glue is dry. A solid balsa tail-piece is next glued in at the stern, and that will finish off the fuselage to a streamline end.

The Engine Mounting

The engine is mounted on a detachable mounting that is held up to No. 1 former by elastic bands from the wire hooks on the mounting to wire hooks from No. 3 former. This mounting is a safety device that I started in this country, and adopt on all my models.

The fact that the mount is held to the fuselage by elastic bands prevents damage to both engine crankshaft and fuselage, in the event of any normal crash. Only a very exceptional blow will cause damage, because the elastic breaks first, and thus acts as an effective shock absorber.

Alteration of thrust line is also quickly made by packing where necessary with slips of wood, during the preliminary tests. These wooden packings can be permanently kept in position by silk and glue, when finally found to be correct. Furthermore, with this system the engine can be taken out in a few seconds for attention and repairs.

The mountings are cast in the very light but strong alloy electron. The reader can make up his own pattern or obtain a casting from the firm that deals with electron castings, or can now obtain standard castings for "Brown" or "Ohlsson" engines.

Finishing of the Fuselage

To carry on with the fuselage construction after this digression, glue a floor of 1 mm. 3-ply from No. 1 nose former to No. 4 former. This 1 mm. 3-ply floor will take the coil and condenser strapped down to it inside the fuselage between Nos. 2 and 3 formers, and will form a strong bottom to the cutaway portion, the shape of the wing section. The detachable wing fits up into it.

The cut-away portion is illustrated in the sketch showing the completed fuselage with wing and tail detached. Cross pieces of 3/16 in. by 3/16 in. balsa should now be glued in top and bottom.

The remainder of the floor can be glued on from No. 4 former up to the tailpiece. This covering is of 1/16 in. sheet light balsa.

Two brass or duralumin tubes to take 18 s.w.g. wire are now pushed through the sides of the fuselage where shown, and glued up to the cross-pieces. A little balsa plastic wood is stuck against these tubes inside the fuselage, where they pierce the fuselage sides, to strengthen and take the loads caused by the tail wheel undercarriage fittings.

Coil and Condenser

The coil and condenser, as already mentioned, have been strapped to the floor by thread and glue. Two battery leads for the flash lamp flight battery are led through the bottom of the floor and have spring clips attached. The 4-volt 4 oz. rectangular flash-lamp battery used for flight purposes, is slung below this floor and outside the fuselage.

The battery is kept in position by rubber bands. This battery position may be criticised by some, but its advantages far outweigh any other considerations. It is at once got at to change, and to examine after each flight. In fact, it saves a peck of trouble in this position, and in a crash cannot damage the inside of the fuselage by becoming detached, and charging through the side of the fuselage.

All types of position for the battery have been tried on different models, but it has been found that the outside slung position is best. The weight is also kept low for a low-wing model. If desired, a balsa stream-lined fairing can be added in the form of a dummy "Lamblin" type radiator. In actual practice it hardly shows.

Lead out other necessary wires through holes in the floor to the engine.

The next operation is to cover the whole of the top of the fuselage box with 1/16 in. sheet balsa. Now glue on ⅛ in. balsa sheet half ovals as shown, along the top of the fuselage. On top of these half ovals, stringers of ⅛ in. by ⅛ in. balsa are glued on ½ in. apart.

Now cover this turtle-shaped top of the fuselage with 1/16 in. sheet balsa, using plenty of glue. A simple cabin as shown should be carved to a streamline shape from solid balsa, and hollowed out. It is then glued on top of the fuselage where shown.

In the top of this cabin the timer for control of flight duration is fitted. Two detachable plugs and sockets are fitted into the cabin side to take the detachable leads for the ground starting battery. Wires are threaded through the fuselage up to the timer.

The nose now receives attention and strengthening. The circular nose former should have plenty of balsa plastic wood moulded by the fingers as a fairing to lead the circular nose former into the rectangular sides and bottom of the fuselage.

This plastic wood, when dry, makes an immensely strong nose. A little plastic wood is also worked inside behind the nose former to help strengthen it up inside; also around the undercarriage tubes where they emerge through the fuselage.

Now carefully sandpaper the fuselage down until quite smooth. Then cover the whole fuselage with very thin jap silk, using plenty of photopaste as an adhesive.

Covering the Fuselage

The whole fuselage should then be covered with one coat of full strength Clear Cellon Glider dope, as used on full-sized aircraft. You now have an immensely strong yet light fuselage, and if you require it coloured a coloured paint or dope should be added as an extra afterwards. Remember that colour adds a lot of weight, but provided too much is not added it makes little difference to a large model like the "Gull."

(To be continued)

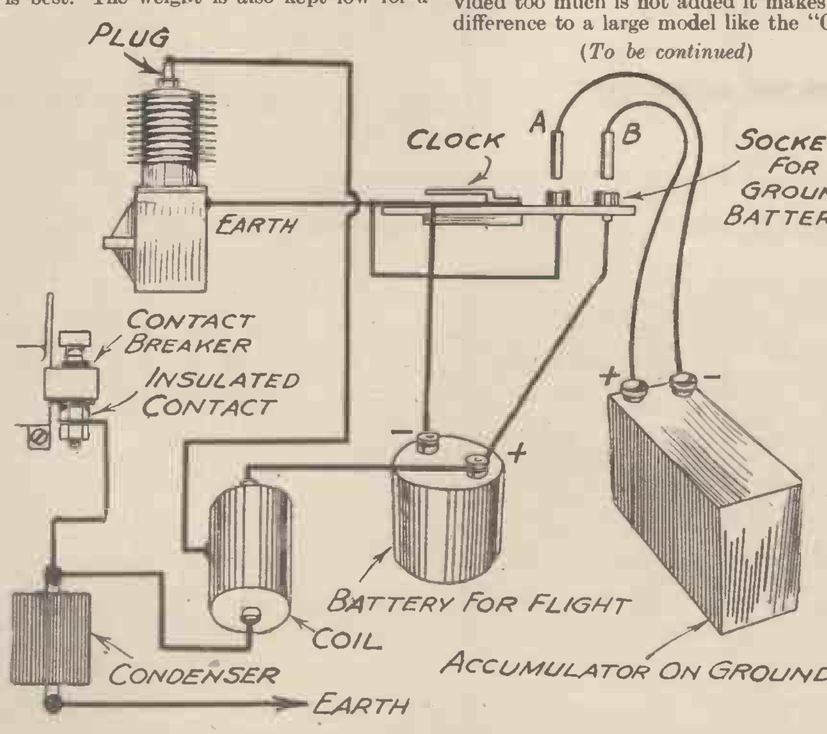


Fig. 4.—Wiring diagram of the ignition system

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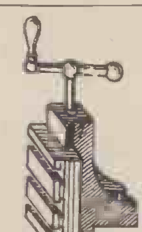

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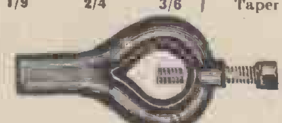

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A DICTIONARY OF

Metals and Their Alloys

(*Continued from page 188 of last month's 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

Cartridge Brass.—Composition : copper, 70%; zinc, 30%. This composition represents the extreme limit of solubility of zinc in copper. The alloy is more brittle than copper and cannot be rolled when hot.

Case-Hardening.—This consists in impregnating the surface of steel with carbon so that this portion may be hardened by quenching, while the interior remains tough and soft. The steel, as it were, is contained in a hardened "case." There are several ways of case-hardening steel, one of the best known being to pack the steel objects into mixture of animal charcoal and barium carbonate and to heat them in a furnace to about 900°C. for a period of time depending upon the depth of "casing" required.

Cassiopeium.—A name for Lutecium, proposed by Auer von Welsbach in 1906. It is now obsolete.

Cast Brass.—A very common brass. It may contain up to 75% of copper, but an average composition is 2 parts of copper to 1 of zinc. It often contains a very small amount of lead. It is often known as "Common Brass."

Cast Iron.—See **Pig Iron.**

Cast Steel.—This term was originally applied only to crucible steels. Nowadays, however, it is applied to cheaper steels.

Cathode Copper. — Electrolytically - refined copper which has been deposited on the cathode of the electrolytic bath of acidified copper sulphate solution. Such copper is usually melted up again in a furnace before being marketed as "electrolytic copper."

Causul Metal.—A special grade of alloy cast iron containing nickel, copper and chromium. Similar to "Ni-Resist" (which see).

Cementation Steel.—Steel which has been made by the "cementation" process in which bars of wrought iron are packed into a sealed furnace together with charcoal. The resulting material is termed "blister steel" (which see).

Cement Copper.—See **Copper Precipitate.**

Cementite.—This is a carbide of iron. Fe_3C, which is a hard constituent of cast iron.

Ceralumin.—A British aluminium alloy. Brinell Hardness (when heat-treated) 130-140. Tensile strength 40,000 lb. per sq. in. Contains : silicon, 1.2%; copper, 2.5%; magnesium, 0.8%; iron, 1.2%; nickel, 1.5%; remainder aluminium.

Cerium.—Metallic element. Chemical symbol, Ce; At. No. 58; At. Wt. 140; M.P. 623°C.; Sp. Grav. 6.73; Sp. Ht. .04479.

The metal was first isolated by Mosander in 1826 from a mineral which had been named "ceria" in commemoration of the discovery of the planet, Ceres (the name being that of the old goddess of tillage and corn) in 1801.

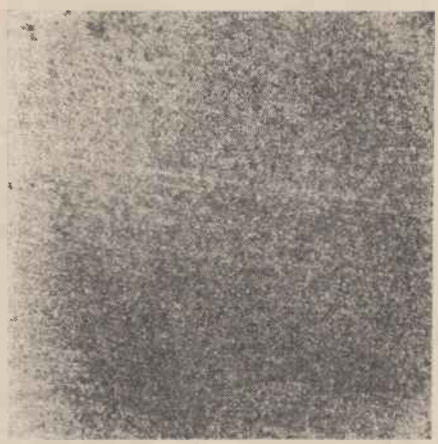
Chief ores : Cerite, and Monazite.

Cerium, when pure, is a steel-grey metal, ductile and malleable. In moist air, it is superficially oxidised. Cerium is a strongly "pyrophoric" or spark-emitting metal, both in the pure state and in the form of some of its alloys. On this account it has been greatly used in recent years in petrol-lighters and other similar sparking devices. Its salts are employed in the gas-mantle industry, and, to a small extent, in photography.

Charpy's Alloy.—Anti-friction metal. Composition : tin, 83 parts; copper, 11.5 parts; antimony, 5.5 parts.

China Silver.—A silvery-white metal containing : copper, 65.24 parts; tin, 19.52 parts; nickel, 13 parts; silver, 2.05 parts.

Chinese Bronze.—Also known as *Shaku-do.* A bronze employed for art metalwork.



High-grade chrome Steel. Here the crystalline structure is exceedingly fine, thus imparting to the metal very high stress-resisting properties

Varies in composition. The following are typical :—

	I	II
Copper	94.61%	95.77%
Silver	1.55%	.08%
Lead	.11%	—
Gold	3.73%	4.15%

A similar alloy, known as *Shibu-ichi* contains :

Copper	66.31%
Silver	33.17%
Iron	.52%

(With sometimes a trace of gold).

The gold in these alloys is important, since it enables them to acquire a very beautiful patina when used for art metalwork.

Japanese bronzes have a very similar composition.

Chinese Silver.—An imitation silver used in the jewellery trade. Composition : Copper, 58%; zinc, 17.5%; nickel, 11.5%; cobalt, 11%; silver, 2%.

Chisel Steel.—A carbon steel containing 1% of carbon. It is readily forged. Used for chisel-making, large punches, miners' drills, etc.

Christophle Metal.—An ornamental copper-nickel alloy. Similar to China Silver, which see.

Chrome-Aluminium Steel.—A type of steel used sometimes on the Continent on account of its resistance to scaling. Has been used for the tubes of locomotive superheaters, etc. Contains about 6% of chromium and from 1 to 1.5% of aluminium.

Chromel.—A chemically-resistant pure nickel-chromium alloy. It is also heat-resistant and is sometimes used for making electric fire elements. Composition : nickel, 80%; chromium, 20%.

Chrome-Molybdenum Steel.—Steels of this type are resistant to oxidation. They have mostly been developed on the Continent. An average chrome-molybdenum steel contains from 1 to 1.5% of chromium and about .5% of molybdenum.

Chrome-Nickel.—A nickel-chromium alloy containing about 23% nickel and 73% chromium. Used in the manufacture of chrome-nickel steels.

Chrome-Nickel Steel.—See **Chrome Steel.**

Chrome Steel.—Chromium, when alloyed with steel, acts especially as a hardening agent. Hence chromium or chrome steels are characterised by their very great hardness. Indeed, steel containing about 1% of carbon and from 2.5 to 4% of chromium is so hard that it cannot be worked with ordinary hardened steel tools. It is, therefore, more or less perfectly drill-proof.

Combined with nickel or vanadium, chromium steel gives the strongest and the best-wearing of the commercial steels, chrome nickel and chrome-vanadium steels being tough, yet machinable. Hence such steels are used for gears and for the crankshafts of internal-combustion engines and for other engineering components which are continuously subjected to heavy service.

Simple chrome steels are used whenever extreme hardness (without machinability) is required. Thus high-quality files are made from chrome-steel containing about 1.3% of carbon and .5% of chromium. Chromium steels are also used for bearing balls and races, for projectiles and shells.

Steels containing more than 12% of chromium are highly resistant to corrosion. They constitute the now very much used "Stainless Steels."

Chrome Vanadium Steel.—See **Vanadium Steel.**

Chromium.—Metallic element. Chemical symbol, Cr; At. No. 24; At. Wt. 52; M.P. 1520°C.; B.P. 2200°C.; Sp. Grav. 6.9 Sp. Ht. .12. Discovered in 1797 by L. N. Vauquelin, who named it "chromium" (from the Greek *chroma*, colour) on account of the coloured salts which it gives rise to.

Chief ores : Chrome Iron ore or Chromite, $Cr_2O_3.FeO$; Chrome ochre Cr_2O_3.

Chromium is a steely-grey metal having a pronounced bluish cast, particularly when plated. It is very hard and somewhat brittle. Unacted upon by air at ordinary temperatures. Soluble in mineral acids except nitric acid, in which liquid it assumes the so-called "passive" or inert condition. As a plating metal, chromium is now universally employed and has practically superseded nickel. Chromium is of great technical importance in metallurgy on account of its hardening effect on steel. Steel containing from 2½ to 4 % of chromium is so hard as to be almost drill-proof. The various alloys of chromium and steel are not only hard but also chemically resistant, as, for example, the now well-known stainless and "chemical" steels.

In the pure metallic state chromium has no uses, it being too hard, brittle and difficult to work.

Chromium Bronzes.—These are copper-tin alloys containing chromium and iron. They are corrosion-resistant and have been used as bearing metals.

Chromium Steel.—See **Chrome Steel**.

Chrysochalk.—Name given to an imitation-gold alloy similar to Mannheim gold. Used in cheap jewellery. Average composition: copper, 90.5; zinc, 7.9; lead, 1.6 parts. It has a fine golden colour, but it gradually tarnishes on exposure to air.

Chrysorin.—An imitation gold. In reality, a variety of brass. Average composition: copper, 66.6; zinc, 33.4.

The name is derived from the Greek, *chrysos*, gold.

Clamer's Alloy.—A general-purpose white bearing or anti-friction metal. Composition: tin, 5%; copper, 64%; lead, 30%, nickel, 1%.

Clerk's Alloy.—An imitation silver. Composition: copper, 75%; nickel, 14.5%; zinc, 7.5%; tin, 1.5%; cobalt, 1.5%.

Cliche Metal.—An alloy sometimes used for preparing cloth-printing rollers, engraving plates, etc. Composition: tin, 48; lead, 32.5; bismuth, 9; antimony, 10.5 parts.

Clock-Case Metal.—A type of brass used for clock bezels and other ornamental purposes. Has a smooth surface and takes lacquer well. Compositions: copper, 68%; zinc, 32%.

Coarse Solder.—See **Plumber's Solder.**

Cobalt.—Metallic element. Chemical symbol, Co; At. No. 27; At. Wt. 59; M.P. 1467°C.; Sp. Grav. 8.5; Sp. Ht. .107; Coef. Exp. .0000124; Therm. Cond. (Silver=100) 17.2; Elec. Cond. at 0°C. (Mercury=1) 9.685.

Chief ores: Cobaltite or Cobalt glance, CoAsS; Smaltite, $CoAs_2$. Also frequently contained in nickel ores.

Cobalt was first recognised as an element by Brandt in 1735. Its name is derived from the German, *Kobold*, a goblin or sprite, because the old German miners considered cobalt ores to be useless and, indeed, injurious to other metals.

Cobalt is a hard white metal, similar to nickel in appearance, but having a slight bluish cast. It is malleable, ductile and feebly magnetic, properties which it shares in common with nickel. It oxidises very slowly in moist air, and is acted upon in the ordinary way by the common acids. Cobalt in thin films is said to have the property of absorbing hydrogen. In all its chemical properties, cobalt is very closely related to nickel. In the metallic form, cobalt has not many uses, but its various chemical compounds, particularly the insoluble pigments which it gives rise to, are of considerable importance.

Cobalt Chrome Steel.—An alloy steel having a high resistance to pitting and high-temperature deformation. Sometimes used for the valves of internal-combustion engines. Composition: iron, 80%; chromium, 13.3%; cobalt, 3.7%; carbon, 1.5%; molybdenum, 0.7%; silicon, 0.4%; manganese, 0.4%.

Cobalt-Chromium Steels.—At one time employed for the exhaust valves of motor engines, their great hardness preventing scoring. Their mechanical properties, however, fall off with high temperatures, and they have now largely been replaced by the chromium steels.

Cobalt Steels.—These were first investigated by Sir Robert Hadfield in 1891. They may contain up to 35% of cobalt. They are characterised by their great magnetic permeability, for which reason they are employed as magnet steels.

Coffin Metal.—A lead-tin alloy used for making metal coffins. Approximate composition: lead, 45 parts; tin, 40 parts; copper, 15 parts.

Coinage Bronze.—This usually contains: copper, 95%; tin, 4%; zinc, 1%. It is hard and slow wearing under ordinary conditions.

Coinage Copper.—This usually contains: copper, 95%; tin, 4%; zinc, 1%, although these proportions vary from time to time.

Coinage Metals.—These comprise copper, silver and gold, and, to a certain extent, nickel. Platinum has, also, rarely been used for coinage purposes.

These metals (and/or their special alloys) are employed for coinage purposes because they are sufficiently plastic under pressure to be "struck" with dies, they are tough and not easily broken, they do not readily corrode in air or water, and because, if necessary, they can be hardened by admixture with other metals to meet the hard wear of ordinary coinage.

Coinage Silver.—In the pre-war days, this contained: silver, 92.5%; copper, 7.2%; lead, .2%; gold, .1%.

"Cold Short."—See **"Short."**

Colorado Silver.—A nickel silver. Composition: copper, 57%; nickel, 25%; zinc, 18%.

Columbium.—Metallic element. Chemical symbol, Cb; At. No. 41; At. Wt. 93.5; M.P. 1950°C.

Occurs in the rare mineral Columbite or Tantalite.

Discovered in 1844 by H. Rose and called by him "Niobium" (from Niobe, the mythological daughter of Tantalus) since the metal is very similar in properties of tantalum. Of more recent date, the metal has been re-named Columbium (from Columbus, the discoverer of America) in view of its chief sources of ore being situated in America. In many chemical and other reference books, however, the name "Niobium" is still perpetuated.

Columbium is still a rare element. It is a steel-grey, hard, difficultly fusible metal which is resistant to acids and resembles tantalum, its related metal, in appearance and properties. So far the metal has not been put to any use, but, doubtless, were it more plentiful, it would function well as a lamp filament metal.

Columnar Fracture.—Name used to describe the appearance of the fractured surfaces of some metals, the metal breaking across into rectangular "fingers" or pieces resembling lump starch. Tin shows this type of fracture when heated to near its melting point and then struck sharply with a mallet.

Common Brass.—Another name for Cast Brass (which see).

Common Pewter.—See **English Pewter.**

Common Solder.—M.P. 220°C. Composition: tin, 50%; lead, 50%. This alloy constitutes the ordinary solder of the workshop.

Complex Steels.—See **Quaternary Steels.**

Composition.—An alloying ingredient for gold used in the jewellery trade. Jeweller's *composition* consists of brass containing 2 parts copper to 1 of zinc. Zinc and copper in gold harden the metal.

Conchoidal Fracture.—Term referring to the characteristic appearance of the broken surfaces of certain varieties of metals, the metal fracturing with a convex or concave surface having shell-like markings. Certain types of hard steels possess this type of fracture. It denotes hardness and brittleness in a metal. (From the Latin, *concha*, a shell.)

Conductivity.—The power of metals and alloys of transmitting heat and electricity. Hence the terms, "Thermal Conductivity," "Electrical Conductivity." The electrical conductivity of a metal is practical equal to its thermal or heat conductivity, and in both these instances the presence of even a very small amount of impurity in the metal will diminish its conductivity. The electrical conductivity of a metal is much decreased by rise in temperature. Of all metals, silver has the highest thermal and electrical conductivities.

The following table shows the relative conducting powers of a number of well-known metals:

	Thermal Conductivity.	*Electrical Conductivity.*
Silver ..	1000	1000
Copper ..	748	941
Gold ..	548	730
Aluminium	—	511
Zinc ..	—	266
Platinum ..	94	166
Iron ..	101	155
Nickel ..	—	120
Tin	154	114
Lead ..	79	76
Bismuth ..	18	11

Conductivity Bronzes.—Copper alloys containing elements such as tin, silicon and aluminium. Although they have a lesser conductivity than pure copper, they are characterised by great strength and are, therefore, used instead of pure copper for some purposes for which a maximum copper conductivity is not a paramount necessity.

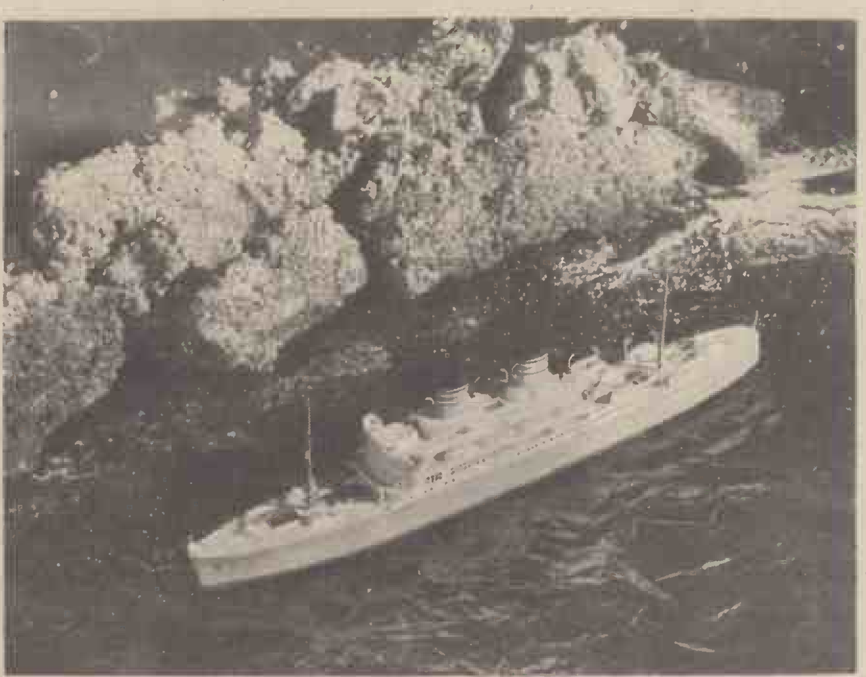
Constantan.—An electrical high-resistance alloy used for winding resistance coils, etc. Composition: nickel, 40%; copper, 60%. Also used as a thermo-couple alloy.

Cooperite.—A nickel-zirconium alloy, similar to Stellite (which see) but lighter and cheaper.

Cooper's Gold.—An imitation gold containing platinum. Is never used now, but was employed fairly extensively in the days of relatively inexpensive platinum. Composition: copper, 12; platinum, 3 parts. The alloy makes an excellent imitation gold.

(To be continued)

"MOTILUS" PEEPS INTO THE MODEL WORLD



A realistic model of the German Africa liner "Windhuk"

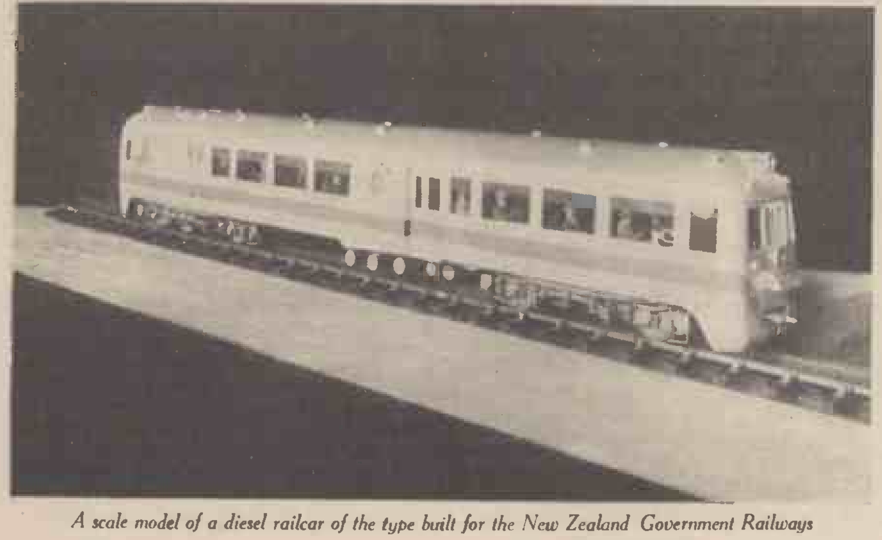
The Latest News from Model-Land

THE first illustration on this page is of a very topical subject. The vessel you will recognise as the German Africa liner *Windhuk*, which before the war was plying regularly between Hamburg, Southampton and South Africa, with her sister ship the *Pretoria*. You may think the vessel was photographed here when she was coming down Channel past the rocky coast of Cornwall, but no, this photo is of a 6-in. waterline miniature of her, with scenery supplied by ordinary gas coke and sea of crumpled cellophane, together with a sprinkling of ground rice and salt! What possibilities this picture suggests to the model maker and enthusiastic photographer (like me!). These table-top shots are just the thing for the black-out, and I have always found that model making and photography—whether still or cine—went hand in hand. It is even more useful if you make your own models because little waterline ships do not require a workshop and do not take up enough space to upset the household!

Model Railway

This is the sort of railway every boy would like to possess and it does belong to one lucky boy, Peter Stephens, who lives at Muswell Hill. It is of handy size, 5 ft. by 5 ft., and is permanently built on a sheet of $\frac{3}{8}$ in. plywood, backed by 2 in. by 1 in. wood round the edges. For use it is placed on the table, and when finished with it can be taken off and stood against the wall—a neat idea. At present, his father tells me, the layout is only half completed owing to the usual schoolboy problem, lack of funds! But eventually he intends to run a double line through the station in the top left-hand corner, and to add a goods shunting line to the main station in the centre, with a siding alongside the platform in the lower left-hand corner. All points in the layout are electrically operated from a signal box (just off the right-hand corner), and all the stations are home made from 2 in. by 1 in. wood faced with 3-ply. The tunnel and bridge are also constructed of 3-ply, and the whole layout is painted in attractive colours.

An attractive model railway layout



A scale model of a diesel railcar of the type built for the New Zealand Government Railways

A cameraman making shots of the hull of the model " Dominion Monarch "

A Model Railcar

Next I show a scale model of a diesel railcar, of the type built for the New Zealand Government Railways by the Vulcan Foundry Ltd., of Newton-le-Willows. The model is the work of Bassett-Lowke, and is now on exhibition in the New Zealand Railways Department of the Centennial Exhibition at Wellington, New Zealand, which opened in November last. It was built for the makers. The scale is ½ in. to 1 ft. and with a gauge of 1¾ in. (gauge 1); current is supplied—24 volts D.C.—by means of a raised centre rail. The photograph shows quite a large amount of the external detail, which has been most faithfully modelled, including ventilators, headlight and marker lights, footstep recesses, door handles and grab rails. You will also see replicas of the token pick-up gear fitted on each corner of the model, which is finished in the standard colouring of the New Zealand railways—aluminium and green. The model is fitted with a whistling device which is operated from the track side.

An innovation is created by the modelling of figures inside—passengers embodying the New Zealand types, and exquisitely finished. This question of model figures has raised quite a controversy in its time. I know a man who would love to cover the model liners in Cockspur Street with crowds and crowds of cruising passengers. Bathing in the pool, playing deck quoits and generally making whoopee—and all the officers and crew at their proper stations. I wonder if some enterprising publicity manager of a shipping or railway company will ever try this out. I do not think it has yet been done.

Model Making Film

Among the many short films being shown to-day on industries and hobbies, model making does not seem to have received a very big share of space on the silver screen, but to-day has seen a step forward. The company of Palfreeman Film Productions have been specialising in Northampton and its industries, and besides making films of shoemaking, etc. have made a special one on model making, ship building and railway making and here is seen Cameraman A. C. Carter making shots of the hull of the model *Dominion Monarch*, while the upper-structure work was in progress. By the time this appears in print some of my readers may quite possibly have seen the actual film as it appears very shortly in cinemas all over the country.

Novel Cigarette Box

Cigarette smokers have no doubt seen many novel table containers for cigarettes, but here I venture to prophesy is something quite new—the conversion of a model ship's funnel into a cigarette case. In this instance it is ⅛ in. to the foot model of the forward funnel of the *Winchester Castle* before she was converted to a single funnel. The funnel is mounted on a wood base with the lining of the funnel built up to accommodate the cigarettes correctly. For ship-lovers this is a novelty which should appeal greatly to hosts, when the cigarettes are to be passed round a nautical " crowd."

A novel cigarette box which resembles a funnel

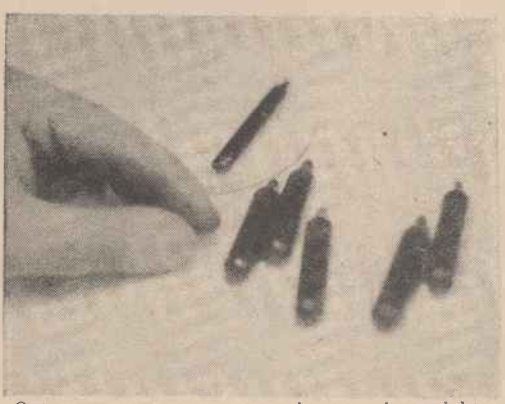
Converting Motor Car Dynamos to A.C. Motors

(*Continued from page* 203)

perform, and one method is shown here. The heating unit is mounted on the same base as the motor, and is connected in series with it. It has been found that with the larger types of motor, when fan-cooled, the maximum permissible current for continuous running is 2 amperes. Wire should be removed from the heater until the motor is operating satisfactorily. Suitable resistance units can easily be made in the following way. Obtain an old bayonet cap lamp and remove all glass and connecting wires, and to the contacts solder stout bare copper wires of about No. 16 gauge. Obtain some plastic fire cement and mould it into a small inverted cone with the cap at the apex; hollow out the base, leaving walls about ¼ in. Cut a wide spiral from the cap down to the base, and then back, starting and finishing at the copper leads. Small knobs of cement should be made at the points where the wire turns back, and also at the leads. When dry, a heating spiral should be wound on the former and the length adjusted as before; the wire should just glow in the dark; the connections should be made to small nuts and bolts passed through eyes in the copper wire (see Fig. 5).

Nothing has been said about cooling arrangements, and with all these machines a fan is necessary. It may be dispensed with in the very small machines, but in the large ones it is essential. Cut a disc from stout sheet iron, and make six radial cuts to form the blades of a fan, and drill to fit the armature shaft. The end plate, which does not contain the brush gear, is drilled with several large holes for ventilation purposes and these should be filed into slots and be as big as possible without materially weakening the structure. It should project beyond the fan for a distance of ½ in., and besides being a precautionary measure, it increases the cooling of the fan. The cover for the bush gear may be used as a fan guard, since on some machines this is just a simple strip of metal. Figs. 1 and 2 show a completed machine adapted for grinding, and one ready for rewinding.

Chemistry for Beginners



Owing to its corrosive nature, pure bromine is best sealed in a number of small glass tubes, in which condition it is best stored for future use

No. 11.—Simple Experiments with Bromine and Iodine. Together with some Notes on Fluorine, the Unruly Element

To a large extent, bromine and iodine are chemical twins. Yet, despite their great similarity in chemical properties, they differ widely in appearance. Iodine, for example, is the well-known bluish-black shining solid, whose solution in alcohol, known as "tincture of Iodine," is familiar to all. Bromine, on the other hand, is a red, fuming liquid, and, incidentally, it is the only element, apart from mercury or quicksilver, which is liquid at ordinary temperatures.

Although bromine never occurs free in Nature, it is present in the form of its potassium, sodium and magnesium salts in many spring waters and, also, in sea water. The waters of the Atlantic and Pacific oceans are said to contain about 0.008 per cent. of magnesium bromide, and it is, indeed, from sea water that the bromine of modern times is very largely obtained.

Bromine, of course, is nowadays a highly important commodity. Apart from its utilisation in the form of potassium bromide which is employed both in medicine and in photography, much bromine is used in the manufacture of petrol "doping" compounds, dyestuffs and synthetic drugs.

Remarkable Liquid

This remarkable liquid element was first discovered by A. J. Ballard in 1826 whilst he was studying the crystallisation of mineral salt from the water of the marshes near Montpellier, in France. The discoverer first called the new element "muride," but very soon afterwards changed its name to "bromine," a word which he coined from the Greek *bromos*, meaning "a smell."

Bromine, true to its name, has, indeed, a powerful, suffocating smell, although, when inhaled in very small quantities the odour of the element is not unpleasant. But, owing to the fact that bromine vapour attacks the nose and eyes, all experiments with this material should take place out of doors, or, at least, in a current of air in order that the experimenter may not inhale any great quantity of the vapour.

To make bromine is not a difficult task. For us, it is best manufactured on the small scale by heating gently a quantity of potassium bromine (plus one quarter of its weight of manganese dioxide) with concentrated sulphuric acid. The heating may take place in an ordinary retort, or, if that piece of apparatus is not available, an ordinary flask provided with a delivery tube may be used, the delivery tube dipping down into a well-corked bottle (which should be immersed in cold water), the latter bottle also being provided with an escape tube for any small amount of bromine vapour which may escape complete condensation. This latter apparatus is shown in the illustration given on page 230, but in the photograph (for the sake of greater clarity) the water bath which should surround the condensing bottle has been omitted.

Sealed in Tubes

Bromine is a dark red liquid. It boils at 59°C. and it fumes strongly in air. Owing to the fact that the fumes of bromine attack the corks of bottles, and, also, cause even glass stoppers to stick, it is best to seal bromine up in small glass tubes, breaking each tube as the contained bromine is required for further experiment.

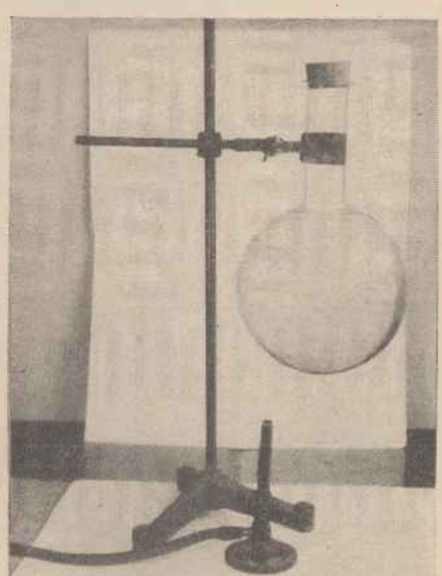
iodine. This well-known substance was first discovered in 1812 by B. Courtis, a Parisian manufacturer of saltpetre. Courtis found that by warming an extract of kelp, or burnt seaweed, with sulphuric acid he obtained a "vapour of a superb violet colour." This vapour condensed to blue-black glistening particles in Courtis' receiving apparatus, and it was not long before the material was recognised to constitute a new element, which, in view of the brilliant violet nature of its vapour, was given the name of "iodine," from the Greek word, *ioeides*, "violet."

It is well worth while inspecting the beautiful violet colour of iodine vapour, for once seen, it is not likely to be forgotten. This may readily be accomplished by heating a few iodine crystals at the bottom of a large dry flask. The crystals will immediately vapourise and will fill the flask with the characteristic violet vapour of the element.

Practical Experiments for the Home Worker

Bromine combines directly with many elements, forming bromides. Thus, it will combine with sulphur, antimony, lead, phosphorus, etc., forming compounds which have many varying uses. For many years a material known as "bromum solidificatum" was sold as a disinfectant. This comprised merely bromine absorbed in fuller's earth or kieselguhr.

Let us now examine, for a moment, the properties of bromine's twin element—



By heating a few crystals of iodine in a large flask, the beautiful and characteristic violet vapour of the element may readily be discerned

To make iodine in quantity, our best plan is to heat potassium iodide (plus a little manganese dioxide) with concentrated sulphuric acid in a retort, the entire reaction being analagous to the making of bromine by heating potassium bromide with concentrated sulphuric acid and manganese dioxide. Free iodine will at once be disengaged, and it will condense in the well-cooled receiver of the retort.

Iodine

At ordinary temperatures, iodine is a dark bluish-black crystalline solid. It is soluble in most organic liquids, such as alcohol, ether, acetone, benzene, but it is not very soluble in water. If, however, the water contains some dissolved potassium iodide, then iodine will dissolve to a much greater extent in it.

Iodine is slowly volatile at ordinary temperatures. Placed on a sheet of paper in a warm room a crystal of iodine will disappear in a few days, thereby proving its volatility.

Like its related element, bromine, iodine will combine directly with many elements such as phosphorus, sulphur, mercury, etc., forming iodides, although the energy of its combination is very much less than that of bromine.

By rubbing up 2 parts of mercury with 2.5 parts of iodine (wetted with methylated spirit) in a mortar, red murcuric iodide will be formed. This material (which is poisonous) has a rather curious property. When heated it turns yellow, but if allowed to cool, without being disturbed, it remains yellow. If, however, the mercuric iodide is struck, shaken, stretched or in any way subjected to frictional interference, it immediately reverts to its original red colour.

When solutions of soluble iodide or bromides (as, for instance, those of potassium iodide or bromide) are added to solutions of salts of the heavy metals, a characteristically-coloured precipitate of the metallic iodide or bromide is produced. Thus, potassium bromide solution added to silver nitrate solution gives a pale yellow precipitate of silver bromide, whilst potassium iodide solution added to silver nitrate solution precipitates full-yellow silver iodide.

Iodine from Seaweed

Iodine, as we have already noted, is contained in seaweed. On an industrial scale, the seaweed, as it is flung up on the west coasts of Scotland, Ireland and France, is carefully collected and slowly burned at the lowest possible temperature. The ash resulting from this process is called "kelp" in Scotland and Ireland and "varec" in France. From this "kelp" the iodine is extracted by means of chemical actions similar to the ones described. By careful burning of the kelp, it is possible to extract from 25 to 30 lbs. of iodine from a ton of good-class seaweed.

When iodine is brought into contact with starch, it gives rise to a brilliant blue colouration. What this colouring matter consists of is at present unknown, but it is a significant fact that this "blue" reaction is sufficiently delicate to reveal the presence of as little as 0.0000001 gram of iodine. Only free iodine gives rise to this blue colouration. Iodides do not give this reaction. Hence the formation of the blue colouring matter in contact with starch solution is definitely and conclusively indicative of the presence of free iodine.

Quite an interesting experiment may be effected by taking advantage of the different solubilities of iodine. If we pour into a long glass cylinder a quantity of carbon bisulphide, water and ether, the liquids, all being non-miscible, will arrange themselves in the cylinder in separate layers, carbon bisulphide being bottommost. A few crystals of iodine are now dropped into the cylinder and the latter shaken and afterwards allowed to remain undisturbed. The carbon bisulphide layer will be found to be coloured violet, the water yellow and the ether brown by the dissolved iodine.

Both bromine and iodine very closely resemble chlorine (described in Article No. 5 of this series) in chemical properties. Just as chlorine gas combines with hydrogen to form hydrogen chloride or hydrochloric acid, HCl, so, also, bromine combines with hydrogen to form hydrogen bromide (hydrobromic acid), HBr, and iodine produces hydrogen iodide (hydriodic acid), HI.

Hydrogen Bromide

We cannot very well produce hydrogen bromide or iodide by heating sodium (or potassium) bromide or iodide with sulphuric acid, thus imitating the method of generating hydrogen chloride by heating common salt with sulphuric acid), although, by substituting phosphoric acid, in these experiments with bromides and iodides we may get a fair yield of hydrogen bromide and hydrogen iodide gases.

Hydrogen bromide is best made by dropping bromine on to a quantity of moist red phosphorus contained in a flask. Volumes of hydrogen bromide—a colourless gas, similar in smell and properties to hydrochloric acid—will be liberated, and this, if required, may be led into cold water, thereby giving rise to a solution of the gas in water which is usually known as hydrobromic acid.

Hydrogen iodide is best prepared by placing a mixture of equal quantities of iodine and red phosphorus in a *dry* flask, and by dropping water slowly on to the mixture. Hydrogen iodide gas will, under these conditions, be formed abundantly, and it may, as in the case of hydrogen bromide, be led into water, in which liquid it will readily dissolve, forming hydriodic acid. This acid will fairly rapidly turn brown owing to the liberation of free iodine as a result of atmospheric oxidation.

Hydrochloric, hydrobromic and hydriodic acids are all very similar in chemical properties, hydrochloric acid being the most powerful and hydriodic acid the least potent. Many metals are dissolved directly by hydrochloric acid, but, usually, only hydroxides and carbonates are dissolved in hydrobromic and hydriodic acids, forming bromides and iodides respectively.

Sulphur Bromides

Various sulphur bromides and sulphur iodides may be made by heating sulphur with bromine or iodine, and the same is true of phosphorus, also. If phosphorus is experimented with, the red variety only should be used, since yellow phosphorus reacts too violently with iodine and bromine.

Just as iodine and chlorine are slightly soluble in water, so, also, is the red element, bromine. One hundred parts of water dissolve (at ordinary temperatures) about three parts of bromine water, the resulting reddish liquid being known as "bromine water."

Preparing bromine by heating a mixture of potash bromide, manganese dioxide and concentrated sulphur. The bromine distils over as a heavy red vapour condenses in the bottle

Into the many uses of bromine and iodine in synthetical organic chemistry we cannot propose to enter. It is of interest, however, to compare the different reactivities of chlorine, bromine and iodine in respect of their affinity for hydrogen. A mixture of equal parts of chlorine and hydrogen will violently explode under the influence of sunlight, forming hydrogen chloride. Hydrogen and bromine only combine slowly when exposed to light, whilst hydrogen and iodine do not readily combine at all unless specially persuaded to do so by catalytic means, as, for instance, by being passed over platinum black.

The term "halogen," or "salt-producing element" has been fully explained in article No. 5 of this series. We have now dealt with three of the four halogen elements, to wit chlorine, bromine and iodine. Hence it merely remains for us to take note of the fourth halogen, which is, of course, the highly-reactive fluorine, the element which is frequently epitomised as the "unruly" one, since it combines with almost every other element and is only maintained in its free and uncombined state with the very greatest difficulty.

Fluorine

Fluorine is the element contained in fluorspar, which mineral consists of calcium fluoride (CaF_2). For many years the existence of the element was known before it was first prepared. The excessive difficulty of preparing fluorine gas was due to the fact that immediately the gas was liberated from its compounds, it attacked and combined with some other material in its immediate vicinity, thus rendering it impossible to prepare in the pure state.

After many experimenters through the decades of the last century had signally failed to liberate this the most active of all the chemical elements in its uncombined state, the problem was finally solved in 1886 by H. Moissan, the French chemist (of "synthetic diamond" fame). Moissan electrolysed a solution of potassium fluoride in anhydrous hydrofluoric acid, using an all-platinum apparatus for the purpose. As a result, fluorine gas was disengaged at the positive electrode, and it was led into all-platinum vessels, showing itself to be a canary-yellow gas, entirely devoid of the characteristic greenish hue possessed by chlorine.

So chemically energetic did the free fluorine show itself to be that it even attacked the all-platinum apparatus, making it necessary to substitute one comprising a platinum-iridium alloy. At a later date, however, a copper apparatus was employed, it being found that although the fluorine attacked the copper at once, forming a film of copper fluoride on the walls of the vessel, this film inhibited further rapid action.

Such, in brief, is the history of fluorine, the "unruly element." Few modern chemists have ever seen it or are likely to see it, for fluorine still remains to-day one of the rarest of chemical curiosities. Fluorine gas attacks almost everything, entering into violent combination with all substances, yet, strangely enough, fluorine does not combine with oxygen, there being no known oxides of the element.

Like chlorine, bromine and iodine, fluorine combines with hydrogen to form hydrogen fluoride which, in the pure state, in a colourless, fuming liquid, boiling at 19.5°C.—i.e., just above ordinary room temperatures. So energetically does fluorine combine with hydrogen, that the two gases unite together with a violent explosion even in the dark, forming cloudy fumes of hydrogen fluoride gas, HF.

"Hydrofluoric Acid"

The "hydrofluoric acid" which is sold commercially in lead or rubber bottles (on account of its property of dissolving glass) is an aqueous solution of the pure hydrogen fluoride. It may be prepared by distilling powdered calcium fluoride (fluorspar) with concentrated hydrochloric acid. The operation is not without some danger, since even the aqueous acid and its vapour are extremely corrosive, and are apt to produce sores on the skin which are difficult to heal. An all-metal apparatus must be used for the purpose—one of lead is to be preferred—and, naturally enough, the entire operation must be conducted out of doors.

Owing to the fact that hydrofluoric acid rapidly attacks and dissolves glass, it is much used for etching purposes and for producing designs upon glass. It is, however, possible to etch glass with hydrofluoric acid without producing the latter in any quantity.

BORING BARS

Some Important Points to Consider when Boring Cylinders are Here Detailed

WHEN boring cylinders bolted to the lathe saddle, and using a boring bar between centres, there are some considerations which should be taken into account. It may be well to set them out here. The main desideratum is stiffness in the bar and in its support on the lathe head and tailstock centres.

This can best be obtained by using the largest diameter of bar that the work will allow, because, by using a big diameter, the bar is stiffened against spring and the overhang length of the cutting tool between the edge and the tool support in the bar is reduced. Spring is the enemy to be faced up to in this class of work. A springing bar may cut a varying diameter along the bore. It will do this because, as the tool blunts, it may attempt to ride the surfaces being cut and so cut a smaller diameter.

Furthermore, the cored hole (if it is a cored casting) may be anything but concentric to its outside surface, and the cutter may be required to cut a deeper cut at one side than the other, or cut deeper at the top than at the bottom, or vice versa. If this happens, the result will not be a true cylinder. It is well to remind the turner that the centring of the casting on the lathe saddle should be done from the outside. The centre of the cored hole should not be taken as a guide, since cores have a habit of shifting in the sand mould and the hole cannot be relied upon to be concentric with the outside of the cylinder wall.

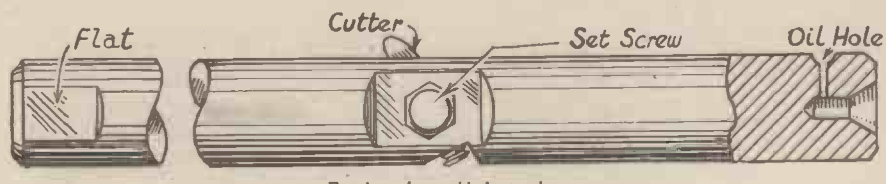


Fig. 1.—A suitable boring bar

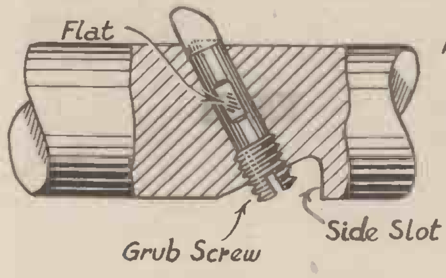


Fig. 2.—A sectional view of the bar showing the position of the cutter

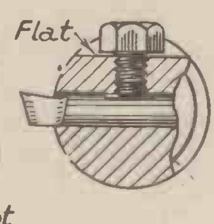
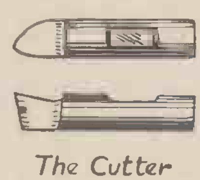


Fig. 3.—A transverse view of the bar with the cutter and pinch screw shown in position



Figs. 4 and 5.—Two views of the cutter

Setting Up

In setting up the work on the saddle, the position should be ascertained by using the two lathe centres as the datum line—the axial line. First block both ends of the cored hole with a strip of wood jammed in the ends of the bore. Use a surface plate and a scribing block, and locate the casting by the outside of the body—not the flanges—of the cylinder. Pack it up on the plate so that the centre of the casting—not the core—is the same at both ends. Set the scribing block to the centre of the outside walls of the casting, and scribe a line across each end parallel with the surface plate. The lathe bed or a drilling machine bed may be used as a surface plate.

Now turn the casting over a quarter turn and again level so that the outside surfaces are parallel with the surface plate and, with the scribing block set at half their height, scribe lines parallel with the surface across the two ends on the wooden plugged core holes. The point where the two lines intersect at each end will give us the axial centre of the casting. It may not be the axial centre of the cored hole, but that does not matter.

Now bolt the casting down on the lathe saddle by one or two straps and bolts, and pack up and move sideways until the two points of intersection of the scribed lines—one at each end—align with the points of the head and tailstock centres. It is important that these should be dead in line with each other, or the hole bored will be taper instead of parallel. The writer always checks this by chucking a length of scrap bar between the centres and taking a cut along with the lead screw sliding the saddle along.

It is important, for this test, that the cutting edge of the tool should stand exactly the same height from the bed as the lathe centres. If it is high or low the test will be inconclusive and many taper bores have been caused by disregarding this point. Now carefully measure each end of the test bar with the micrometer. If the ends agree, the centres are right for accurate boring by the boring bar. Do not remove the centres after this test.

The Bar

The best material for a boring bar is cast iron, because it has less spring than any other metal. A suitable bar is shown in Fig. 1. Its diameter should be about the diameter of the hole to be bored, less enough to allow the cutter to project $\frac{3}{16}$ in. for small work and $\frac{1}{4}$ in. for large work. The idea is to get as big a bar as the job will stand and as little unsupported length of cutter as possible.

The bar will be a casting made from a turned wooden pattern and it need not be machined except at the ends, to get a square face. A surface at an angle is filed to start the drilling of a hole at right angles to it and to recess the grub screw. The flat at the top (Fig. 3) provides room for the hexagon head of the set-screw without projecting farther than the cutter projects.

The ends of the bar should be centre-punched and bored in the lathe by feeding up to a drill held in a true-running chuck, the other end of the bar being located, and traversed up for cut, by the tailstock barrel and hand wheel.

These centres are important and should be of good diameter. The sectional end shows their proportions. There should be a good area of surface of lathe centre in contact with the taper hole, and a good clearance hole at the end of the taper for the nose of the lathe centre. The taper in the hole should exactly correspond with the taper on the centres. The centre hole on the bar which runs on the tailstock centre should be provided with means for lubrication, and this is best attained by drilling a hole $\frac{1}{8}$ in. diameter, as shown, through the side of the bar and into the clearance end of the central hole.

Making the Cutter

The cutter is best made of round cast steel $\frac{1}{4}$ in. or $\frac{5}{16}$ in. in diameter, according to the size of work to be done and the size of the bar. It is fitted in a hole of the same diameter bored at a slight angle, as shown in the sectional part of the bar (Fig. 2). A close fit is a very great advantage. At one end the $\frac{1}{4}$-in. or $\frac{5}{16}$-in. hole runs right out at the side of the bar so as to support the cutter right up to the end of the hole. At the other end it is tapped to take a grub screw by means of which the cutter can be held up to the cut and adjusted to the required diameter. This cutter has a flat on its top side. The flat should be $\frac{3}{16}$ in. wide. Against this is screwed a hardened hexagon-headed screw which holds the cutter firmly against rotating or pulling out.

The grub screw in the end of the cutter hole prevents the cutter getting back under the cut and, therefore, cutting under size. Both screws should be case hardened.

A transverse view of the bar at an angle with the cutter and pinch screw shown in position is seen in Fig. 3. Two views of the cutter in Figs. 4 and 5 show its shape. It should be hardened dead hard and then let down by heating the non-cutting end with a blow-pipe flame until the cutter edge assumes a golden-yellow-amber colour. It is then quenched.

Boring by Bar

If very accurate setting of the tool by micrometer is desired, the diameter of the bar at the part where the cutter goes through may be just turned to some standard diameter, such as 1 in. or $1\frac{1}{2}$ in. Then by measuring with the micrometer across from the cutter edge to the side of the bar and deducting half the bar diameter we get radius the tool will cut. Twice this will, of course, be the diameter of the hole the bar will bore.

"PRACTICAL MECHANICS" WIRELESS SUPPLEMENT

A 30/- THREE VALVER

An Efficient Receiver which is Available in a Partially Completed Form with Cabinet

Figs. 1 and 2.—A three-quarter rear view of the chassis showing the compact arrangement of the components. (Right) The completed receiver in the cabinet supplied with the parts

INEXPENSIVE receivers are always popular, and in an endeavour to pursue this policy further we have been looking round and have found a very useful nucleus for a three-valve receiver of novel design which readers may obtain for the low price of 10s., inclusive of cabinet. This particular item is in the form of surplus supplied by Electradix Radios, and consists of a small cabinet, panel and baseboard with three valve-holders ready wired. All wiring is completed, with the exception of two very slight modifications, and all that has to be done is to make these two modifications, wind a very simple coil and mount it, and the receiver is ready for use. The total cost, including three suitable valves, is just under 30s., and the receiver is then quite a useful piece of apparatus as it has one or two very novel points.

LIST OF COMPONENTS

One wired chassis and cabinet	Electradix
Four fixed resistances: 75,000 ohms, five 100,000 ohms, two at 1 megohms and one 2 megohms	Dubilier 1 watt type
One .0003-mfd. fixed condenser, wire-end or mica type	Dubilier or similar
One D.210, one L.210 and one P.220 valve	Hivac
One 9-volt G.B. battery	Exide
One 120-volt H.T. battery	Exide
One 2-volt L.T. accumulator	Exide
One coil—see text.	

Dealing first of all with the circuit, it will be seen from Fig. 1 that this is a standard R.C. coupled arrangement following the detector and two L.F. lines. A special switch is fitted on the panel by means of which the receiver may not only be switched on and off but the output stage may also be cut out, so that the receiver is automatically operated as a two-valver. In these days of economy this is, of course, a valuable point, as there are many occasions on which two valves will provide all the volume which is required. The reaction control is effected by means of a special moving plate type of condenser using the metal panel as one plate and a sheet of mica is supported to provide the dielectric. A threaded rod gives control over the moving plate and this operates most effectively in providing the reaction effects. The home-made coil has a suitable winding, of course, to ensure that reaction is smooth over the entire band.

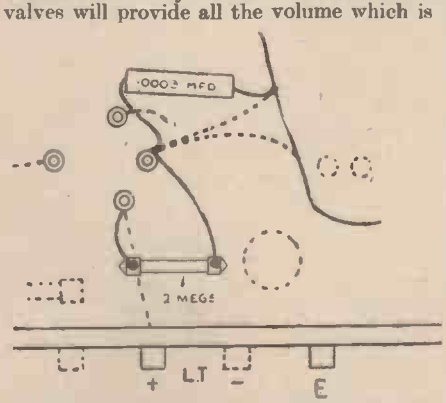


Fig. 3.—This diagram shows the modifications to the connections to the grid of the detector stage

Wiring Changes

As the receiver is supplied there is a variable resistance fitted which will not be needed with modern valves. There is a flexible lead connected to the plunger or moving element of this resistance, and to eliminate the device this flex lead should be cut off the plunger and the latter removed. The end of the flex lead should then be soldered to the lead joined to the top of the resistance.

The second alteration which has to be made to the wiring is the incorporation of a grid leak and condenser. It will be seen when the receiver is obtained, that two connections are made to the grid socket of the first valveholder and these must be unsoldered. A .0003 mfd. fixed condenser must then be connected to the grid socket and the other side of the condenser must be joined to the two wires which have been removed. The grid leak is then connected between the grid socket and the L.T. positive socket of the detector stage. These are the only alterations which have to be made and all that now remains is to fit suitable resistances in the four sets of clips provided and wind the coil when the receiver is ready for use. The resistances should have values of 75,000 ohms, 100,000 ohms, and two or one megohm each, and they are inserted as indicated in the wiring diagram.

The Coil

The coil is wound on a length of suitable former, that used by us being ordinary postal tubing with an overall diameter of 2¼ in. and a length of 3 in. A disc of wood should be cut to fit tightly in one end of the tube, and on this wooden disc five valve pins must be mounted to fit into the sockets provided on the baseboard. The exact measurements are given in Fig. 3. The valve pins are supplied by Messrs. Electradix and are attached to the wood by means of the nuts provided. The coil is wound with 26 S.W.G. enamelled wire and the full winding data is given in Fig. 4. Make quite certain that the two windings are in the same direction, and that the ends are connected to the correct pins. A 9-volt grid bias battery and a 120-volt H.T. battery are

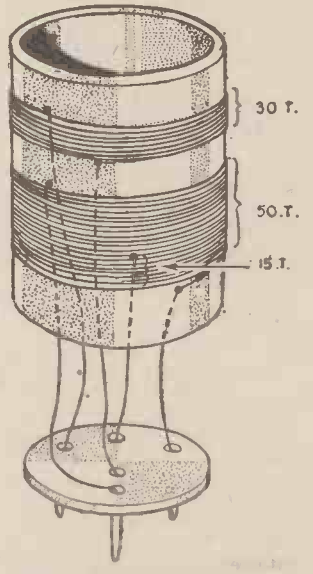


Fig. 4—The coil winding and connecting data

needed in addition to the usual 2-volt accumulator, and the batteries should be connected to the rear terminal strip with ordinary flex and plugs in the usual manner, the terminals being suitably marked. G.B. — 1 should be 1.5 volts, and G.B. — 2

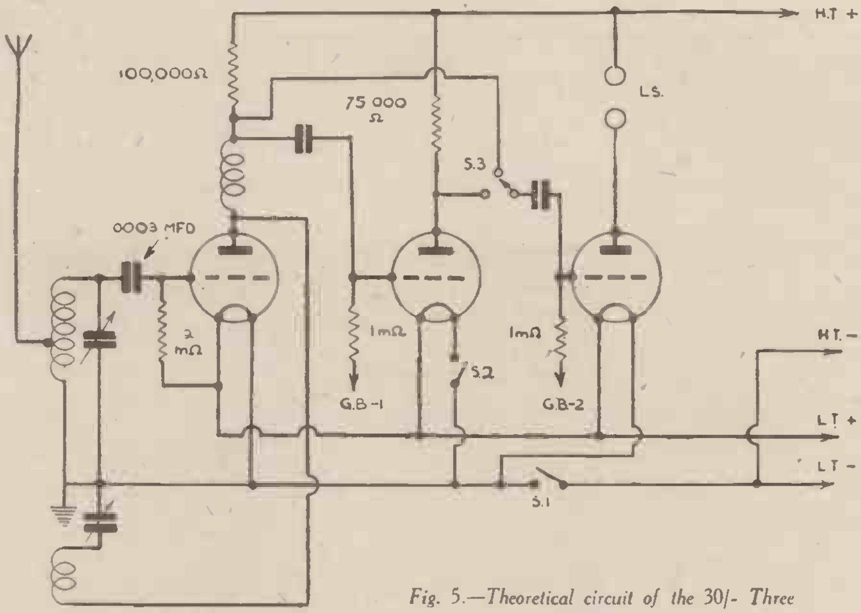


Fig. 5.—Theoretical circuit of the 30/- Three

4.5 volts, whilst the total 120 volts are employed for H.T. Connect the 'phones or a loudspeaker to the end pair of terminals, and use a medium type of aerial. A large aerial will, of course, introduce selectivity difficulties unless a series aerial condenser is used, whilst a small aerial will probably provide insufficient pick-up. For preliminary tests, whilst making certain that the coil is in order, it would probably be preferable to turn the right-hand control until it indicates 2, which means that the output valve is cut out of circuit. The tuning condenser should then be turned until the Home Service transmission is picked up (towards the top end of the scale). The reaction control should then be operated and it will be found that there is a gradual build-up in strength until oscillation sets in. The control should not, of course, be used so far advanced that signals are distorted, or that any substantial noise accompanies the signal, as in that case there is a risk of some interference being caused on receivers in the neighbourhood.

Always keep the reaction down as much as possible, consistent with good signal strength. When the right-hand switch is turned to indicate 3, all valves are in circuit and volume will be substantially increased. The H.T. and L.T. consumption will, of course, be correspondingly increased and, therefore, the extra valve will, as already mentioned, only be switched in as occasion demands.

"Everybody's Book of Electricity," by R. Barnard Way. Price 1s. 114 pages, fully illustrated. Percival Marshall & Co., Ltd., 60, Kingsway, W.C.2.

WHEN writing a textbook on electricity the author is faced with the poser that nobody as yet has been able to discover what electricity really is. Thus the reader has to be satisfied with a vague sort of description, and be content to know how to make it and what electricity can do for us when handled correctly.

In this book the author sets out to tell the reader a little about everything electrical, from simple electrical devices to electric trains, wireless, X-rays, etc. Although the book has only 118 pages and his descriptions are brief he covers his subject admirably in the small space available, and he helps the reader out with numerous diagrams.

"Marking-out for Machinists," by Captain Richard Twelvetrees, A.M.I.Mech.E. Price 1s. 6d. 80 pages, 51 illustrations. Percival Marshall & Co., Ltd., 60, Kingsway, W.C.2.

IN engineering practice the marking-out operations are entrusted to highly skilled mechanics and there is no such dimension as "near enough." In this textbook the author describes the ways and means for transferring given dimensions from mechanical drawings to the materials of construction so that the accuracy of the former may be reproduced in a tangible form. Captain Twelvetrees points out in his book that the marker-out has not recourse to a piece of rubber to correct his mistakes but that he is in the unhappy position of knowing that he has ruined the particular job he has on hand.

The author starts off by telling the reader how to prepare work for the marking-out table and the tools necessary for this delicate operation. He then goes on to show how errors in marking-out multiply and so through various chapters until finally finishing up with marking-out in the tool-room.

"British Railways To-day." By K. G. Fenelon. Price 2s. 6d. 187 pages with half-tone illustrations. Thomas Nelson & Sons, Ltd., 35, 36, Paternoster Row, E.C.4.

THE above book is the latest addition to the long list of Discussion Books published by the above company. These books are published from time to time so that the man-in-the-street may become acquainted with what is going on in the modern world. Recently, the railways have figured prominently in public discussion, and in this book the author has provided a summary of the historical evolution of the British railways to enable present conditions to be understood in the light of past history. Dr. Fenelon deals in non-technical language with the relations of the railways to the public, the State, the trader and the farmer. A number of half-tone plates are included in the book.

"You and Life." By Dr. Karl v. Frisch. Price 2s. 6d. 270 pages. Scientific Book Club, London.

IN this book the author introduces his subject by dealing with life, death and immortality and he introduces a number of clever analogies which make interesting reading. Under the heading of the organs of the body and their functions he tells us why running makes us hot and out of breath, why we do not bleed to death from a pin-prick and many other interesting things concerning the human body.

Other chapters in the book deal with Connection with the Outside World, Reproduction, Development, Inheritance and Evolution of Species in the Course of the Earth's History. A six-page index is also included at the back of the book.

"The Woodworker." Vol. XLIII., 1939. Price 6s. 6d. net. 408 pages. Evans Bros., Ltd., Montague House, Russell Square, London, W.C.1.

EVERYONE interested in woodwork will find much to interest them in this useful volume. It contains a wealth of ideas on making furniture of every description, of modern design, and includes practical articles on the uses of tools, the making of joints repair work, polishing, workshop practice, and numerous allied subjects. The book is well illustrated with line and half-tone illustrations.

MASTERS OF MECHANICS

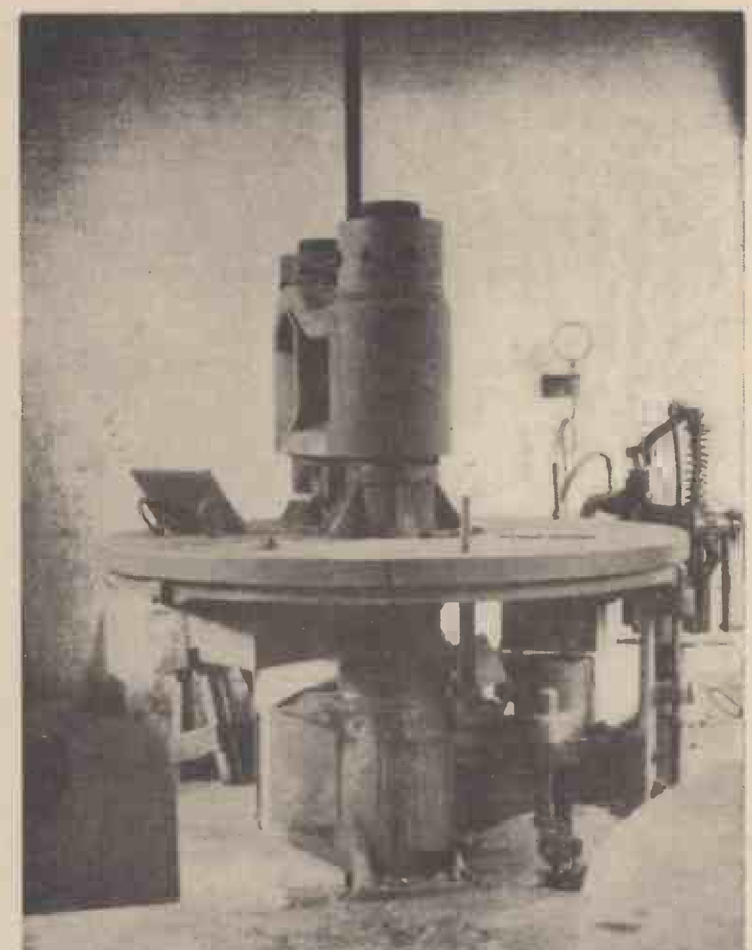
No. 53.—Joseph Bramah—His Work and His Success
Pioneer of Toolmaking and Inventor of the Hydraulic Press

MORE than sixty years before the early railways threw their network of lines across the face of Britain, there slowly trudged to London from Silkstone, in Yorkshire, a young carpenter just out of his term of apprenticeship, and Joseph Bramah by name.

It was a long and a weary walk to London in those days, a journey which led the determined traveller over miles and miles of badly made roads, up hills and down dales, through hundreds of villages and a handful of growing towns. But Joseph Bramah was a determined enough young man, and as he continued his daily journey towards the Metropolis he hummed a merry tune and shouldered his bag of roughly made tools more lightheartedly than ever as he thought of the continually decreasing numbers of miles which lay between him and that famous city of the world in which he had convinced himself his eventual fortune lay awaiting him.

A Curious Young Man

A curious young man was this "Joey" Bramah, as he had been known among his native hills of Yorkshire. We meet him here on his first journey to London at about the age of twenty-one. He has, as we have already noted, just been released from his apprenticeship to a Yorkshire carpenter, one Allott by name, who resided in the village of Stainborough, in the parish of Silkstone, Yorks, in which village "Joey" had first seen the light in the year 1748.



A modern hydraulic press used for the manufacture of cement tiles functions upon the principle first applied by Joseph Bramah

Bramah's father was a farm labourer, who afterwards rented a small farm of his own, on which "Joey" and his four younger brothers were all born and reared. All the Bramah lads received the smattering of an education in the local school, and all showed eventual signs of constructive abilities. In this latter direction, however, it was the eldest boy, "Joey," who exhibited the greatest degree of natural ingenuity and talent. Making friends with the neighbouring blacksmith, young Bramah succeeded in persuading that worthy to make for him a number of crude tools, such as chisels, files, and knives. With these, he began making mechanical models, and also a violin or two, and even, it seems, a violincello.

"Joey" Bramah might have remained for ever a farm hand had it not been for the fact that he severely injured his ankle whilst ploughing-up some acres of rough land. The accident laid him up in bed for some weeks, during which time he took to wood carving and similar pursuits in order to while away the time. Incidentally, too, he decided that his career in life lay in an occupation of a constructional nature and not in the traditional land work of his family.

Apprenticed to a Carpenter

And so it was that the eldest of the Bramah lads was "put to" the carpenter Allott as an apprentice. Here he distinguished himself. In addition to making window-frames, doors, ploughs and other "bread and butter" articles, he continued to indulge his 'cello making and his violin construction until he became quite famous among the rural community. The needs of such a community, however, could never be expected to coincide with the output capabilities of a budding genius which young "Joey" Bramah undoubtedly was. Hence it is that we meet him at the beginning of this review of his life's career slowly and yet cheerfully wending his way over the rough and winding road to London, to that city in which he felt sure existed every possible scope for his future energies and abilities.

The exact date of Bramah's first arrival in London is not known. It was probably some time in the summer of 1769 and it would appear that almost immediately upon his arrival in that city, the Yorkshire lad found work with a cabinet-maker in the East End of the Metropolis. This work, however, did not suit him. Before long, we find Joseph Bramah setting up for himself in a very small way as a cabinet-maker and mechanic, a business which he seems to have prospered in from his very commencement of it.

Then another very circumstantial accident befell Bramah. He stumbled on a long ladder, fell heavily, and landed himself in bed for another considerable period. But this period of enforced leisure was, as Bramah admitted afterwards, just what he wanted, for it gave him time to work out an invention or, rather, the details of an improvement on an invention which had been in his mind for some time.

Briefly, the circumstances were these: in London, at that period, the "water-closet" system of sanitation was being introduced for the first time. Bramah's work had been concerned with the installation of these articles, but he had seen many demerits in the details of such systems and he had vainly endeavoured to snatch a little leisure in which to work out for himself an improved system. The necessary leisure came to Bramah during his enforced "lay up" after his accident, and the eventual result of it was Bramah's first patent (taken out in 1783) for an improved water-closet system.

New Premises

The patent (and the business which resulted from it) was eminently successful. Bramah took over new premises for his works, engaged a number of workmen and even sent up to Yorkshire for the old blacksmith who had forged a few tools for him during his childhood days.

The above business having been firmly established, Bramah next turned his attention to locks, a subject which had interested him from his early youth.

The locks which were in use towards the end of the eighteenth century were of a very inefficient kind. They could easily be picked, despite the massive dimensions which they were often given, and thus the measure of protection which they afforded was very little.

Bramah seems to have given his mind to the solution of the problem of making a thief-proof lock in consequence of the great amount of mechanical and constructional work which was inherent in the task. With the most elementary of mechanical tools he succeeded in his aim, and eventually devised a lock operating on the now well-known "tumbler" principle. The Bramah lock was patented, and its inventor without more ado set himself to manufacture the lock commercially.

The large-scale production of Bramah's lock, however, necessitated the introduction —and, for the most part, the *invention*—of various machines and mechanical contrivances whereby the new locks could be turned out in commercial numbers. The locks were fitted with springs, sliders, barrels and levers, each of which components required the most careful machining for it to take its part in the functioning of the lock as a whole. However, in his usual indomitable manner, Bramah solved each problem of production as it presented itself, and, with the aid of his growing number of assistants, the lock was eventually marketed and became very successful.

Unpickable Lock

Throughout his long and useful career Bramah was very proud of his lock. In his shop in Piccadilly, London, he for years exhibited a notice to the effect that he would present £200 to anyone who could pick one of his patent locks. Many individuals tried to win the proffered reward, but they all failed, and the Bramah lock remained unassailed for a period of no less than 67 years until it was, at last, picked in 1851 by an individual named Hobbs. As, however, Hobbs took 16 days over the job of picking the lock and used specially made implements, it was quite evident that the Bramah lock, despite Hobbs' technical mastery over it, still remained inviolable in actual practice.

Having safely and successfully launched his patent lock upon the market, Bramah looked round for other fields of activity, and, as a result, hit upon the invention in connection with which his name is mainly remembered nowadays. This was, of course, the invention of the hydraulic press which Bramah at first called his "Hydrostatic Engine."

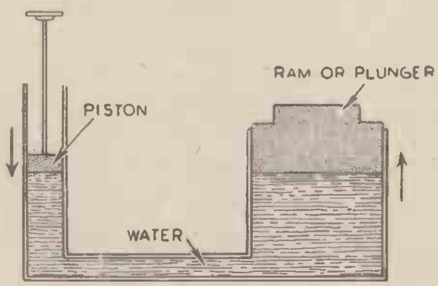
The principle of the hydraulic press will, no doubt, be familiar to readers of this article. This principle of pressure applied to a small column of water being transmitted by the liquid to a larger water column and thereby operating a solid piston, "plunger" or "ram" was by no means Bramah's own discovery. It had been known long before his time, but, on account of the many mechanical difficulties inherent in the construction of a "hydrostatic engine," the device had never come into actual being until Bramah himself took up the problem.

The Hydraulic Press

In the working out of his hydraulic press, Bramah came up against the formidable difficulty of effectively sealing the clearance which he had to allow between the solid plunger of his press and the cylinder within which it worked. He experimented with all sorts of packings, but they all allowed the water to leak upwards past the plunger under the great pressure which was generated within the system.

At last, however, the problem was solved by Henry Maudsley, Bramah's foreman, who himself eventually became a noted tool-maker. The idea occurred to Maudsley of making the pressure of the water itself in the plunger or "ram" cylinder give the necessary degree of water-tightness required. This Maudsley effected by means of a sort of flapping leather collar which fitted in a groove turned in the upper part of the ram cylinder. Under the internal pressure of the water in the cylinder, the leather flap of the collar was forced upwards between the ram and the cylinder, whilst during the subsequent descent of the ram under its own weight the leather collar allowed itself to be pushed harmlessly aside.

The Bramah hydraulic press took the industrial and the engineering world by storm. Its effectiveness, its essential simplicity and its operating economy appealed to every thinking engineer equally as greatly as did the vast scope which opened out for its use. The hydraulic press, therefore, was immediately successful, and although it has since been manufactured in almost numberless different detail forms, its working principle is still just the same as it was in the days of its first practical inventor, for, like the steam engine, it operates upon a fundamental and unassailable natural law.



Illustrating the principle of the hydraulic press which Bramah raised to the status of an engineering creation

It is interesting to note that the well-known pumping device known, nowadays, as the "beer engine," whereby a publican or barman raises from cellar casks the various liquors which are sold over the counter by him was the invention of Joseph Bramah. It was patented by this inventor in 1797, as also was an effective type of street fire-engine which operated upon a somewhat similar principle.

The Steam Engine

Bramah might have contributed much to steam-engine development had it not been or the legal villainies of James Watt, the falsely supposed "inventor" of this form of prime mover. Watt, and his equally scoundrelly partner, Matthew Boulton, of Soho Foundry, Birmingham, managed to obtain a strangehold upon English steam-engine development for a considerable number of years owing to a false and prejudiced legal interpretation of Watt's obscurely-worded "steam engine" patent. Having monopolised the whole field of steam-engine invention and development, Watt remained content in drawing monstrous royalties from users of his engines and in legally hounding and persecuting original steam-engine inventors who dared to pit their abilities against his legally favoured monopoly.

One of these original inventors whom Watt and his partisans succeeded in totally ruining was the Cornishman, Hornblower, a man who was as great an inventor of steam engines as Watt was a copyist of them. In the Watt-Hornblower trial of December, 1796, Bramah gave evidence on behalf of Hornblower who was being prosecuted for infringement. Bramah argued that the original Watt patent had no definite meaning, that it was absurd and inconsistent, that it could not be clearly understood and that many of Watt's methods arose from "monstrous stupidity." But Watt had powerful friends, and he won the day. Still, however, these remarks of the engineer Bramah are worthy of recording, for they show some of the contemporary expert opinions which were held on Watt's supposed invention towards the end of the eighteenth century.

After the Watt-Boulton monopoly had been forced eventually to give way, Bramah invented a few types of steam engines of his own, but he seems, in the main, to have left the subject of prime movers to the attention of others and to have specialised more or less in the fabrication of mechanical tools, whereby machinery parts and appliances could be made with great accuracy.

Several Inventions

In this direction, Bramah invented several varieties of mechanical planing, drilling and sawing machines both for wood and for metal. At Pimlico, near London, he established extensive shops for the commercial production of these mechanical appliances, and, naturally enough, as all successful manufacturers did at that time, he prospered exceedingly by them.

Bramah's prowess as a designer, inventor and manufacturer of tools and mechanical appliances became so widespread that it invaded official quarters, with the result that he was approached, in 1806, by the Bank of England with the request that he would invent a machine capable of numbering successively the various notes for which that organisation has long been famous. And so came into the world the nowadays much familiar "numbering machine" which prints or "stamps" numbers in consecutive succession upon any papers or documents on which it may be operated. Bramah's invention of the numbering machine not only saved the "Old Lady of Threadneedle Street" a lot of monotonous work, but it also put a better check upon her notes and therefore rendered forgeries easier to trace.

To list the different inventions of Bramah during his peculiarly active career would require more than a whole page of this magazine. A machine for turning out perfectly shaped quill writing pens by the hundreds was his, as was, also, a mode of building canal locks and bridges and a method of rooting up trees by means of the hydraulic press.

His Death

The end of this truly remarkable and energetic inventor came rather suddenly on December 9, 1814. He had a day or two previously been out superintending the installation of one of his tree-rooting hydraulic presses in the New Forest district of Hampshire. Catching a chill, he neglected it, whereupon the complaint speedily transferred itself into the pneumonia which brought about his decease.

Until comparatively recent times, the original farmstead at Stainborough, where he was born, remained in almost the same condition as when the great Bramah in his boyhood trod its verdant meadows and ploughed its brown fields.

Time, indeed, changes all things, and frequently enough annihilates even the most notable memories. But, in the hydraulic ram, which in its modern patterns can lift almost any conceivable load, the genius of "Joey" Bramah, former farm-lad of Stainborough, Yorks., still persists, and, indeed, is likely always to do so in this one of the most imperishable of man's engineering creations.

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.

Converting Car Dynamo to A.C. Motor

I HAVE a 12 v. Smith car dynamo, which I wish to convert into an A.C. motor to run off a supply of 250 volts 50 cycles.—G. C. (Leicestershire).

A MACHINE with a 13-slot armature 2¼ in. diameter and 1¾ in. long fitted with 26-part commutator, running in 2-pole fields at about 2,000 r.p.m., should be able to develop 1/6th h.p. as a D.C. motor, but if used on 50-cycle alternating circuits the power output will be rather lower, probably not more than 1/8th h.p. This will only be practicable if the fields are laminated, since a solid field casting would acquire a dangerously high temperature on alternating current due to eddy currents set up in the solid metal. As a commutator type motor with wound armature, running on A.C. the machine will need to be series wound to the following specification, to suit a 250-volt 50-cycle circuit :—

Armature.—13 coils each containing 60 turns of No. 30 S.W.G. 6-mil. d.c.c. copper, grouped two per slot, coil span from slot 1 to slot 6 inclusive.

Fields.—2 coils, each with 450 turns of No. 21 S.W.G. d.c.c. connected in series.

Brushes.—2 " Link C/4 " carbon, 3/8th in. square, set at an angle of 180 deg. The remaining two brush positions used when the machine was operating as a car dynamo will not be wanted now.

The full load current consumption on 250 volts A.C. would be from 1 to 1.2 amperes. (See also article on page 203.)

A Hard Alloy

WHAT metals combined would produce an alloy hard enough to resist blows or pressure without distorting, and yet have, if possible, practically no contraction in cooling, after being cast ? Melting temperature about the same as zinc.—A. L. (Bristol).

IT will be very difficult for you to produce an alloy which will fulfill the exacting conditions which you lay down, for, to begin with, no alloy melting around the temperature of melting zinc will come up to the extreme hardness of the alloy steels. Babbit metal is more or less useless for your purpose, being far too soft.

You might try an aluminium bronze, that is an alloy containing 10 per-cent. of aluminium and 90 per-cent. of copper. If the melting point of this is too high for your purpose try an alloy containing three parts of zinc and one part of alumium with or without the addition of about a quarter per-cent. of copper. Again, you might try one of the stereotype metals, as, for instance, an alloy consisting of lead 100 parts, antimony 20 parts, tin 3 parts. This metal is fairly hard, of medium-low melting point, and casts well with little shrinkage or contraction. It is not, however, dead hard, but you might increase its hardness by incorporating a little aluminium and/or copper with it. There are no actual alloys having all the requirements you outline, however.

One per-cent., or even less, of aluminium in zinc will harden the metal somewhat, but would not decrease the amount of contraction on cooling.

For your purpose we think that a stereotype metal such as the one mentioned above is the most likely to meet your needs.

Annealing Furnace

WHAT is the type of salts used for the salt bath annealing furnace used for annealing stainless steel ? The salts are heated in a pot to the correct annealing temperature, and the stainless steel articles immersed. As the temperature is fairly high, what is the pot or container made of to withstand the heat.—R. S. (Grimsby).

THERE are numerous systems of annealing steel and many of them are secret ones. Usually, however, small articles of stainless or other steels are packed into an iron box, the spaces between the articles being filled up with charcoal. The lid of the box is luted on and the whole is then placed in a furnace at the correct annealing temperature.

Other annealing salts are a mixture of dry lime and powdered charcoal, fused calcium chloride, borax and the various borates. In many instances, of course, the " dry " annealing of steel takes place in an ordinary furnace without the use of other materials.

A cast-iron container is often suitable for use in annealing processes, also a vessel of unglazed earthenware—" crucible earthenware."

Cyanogen Bromide

HOW do you prepare cyanogen bromide, and how can I obtain solid dry sodium azide ?—P. S. (Liverpool).

TO make cyanogen bromide (which, incidentally, is a highly poisonous substance) place two parts of mercury cyanide in a retort surrounded with ice and allow 1 part of bromine gradually to flow into the retort. Cyanogen bromide and mercury bromide are formed and much heat is evolved. After the reaction has been completed, warm the retort very gently. Cyanogen bromide will sublime and will collect in the receiver (which should also be surrounded with ice) in the form of needle-like crystals. It may be contaminated with bromine. If so, expose it to the air for a time in order to allow the bromine to evaporate.

You can only obtain sodium azide in a state of purity by carefully acting upon sodium oxide with hydrazoic acid. You will find the preparation of this and other similar salts detailed by Curtius in " Berichte " 23, p. 3,032. This publication which is in German, may possibly be referred to at your city reference library. There is no English translation available.

Salt Water Erosion

THE engine in my model cruiser is fitted with an aluminium sump which is being eaten away by the action of the salt water. Can I make a preparation that will arrest this trouble.—L. B. (Neath).

THERE is really no method of preventing the sea water from attacking the aluminium sump of your model cruiser. The only line of treatment you can take consists in applying either paint or varnish to the metal surface. This treatment will be found effective provided that it is renewed at frequent intervals, that is to say, whenever the paint or varnish " roughens " and loses its glossy surface.

Alternatively, you might try painting the metal with celluloid varnish (made by dissolving scrap celluloid in amyl or butyl acetate until a syrup-like solution is obtained). This should be painted on in three separate thin layers, allowing the first layer to dry thoroughly before applying the remaining ones. This varnish will be quite invisible and it is fairly resistant to sea water.

In order to eliminate the trouble altogether, it would, of course, be necessary for you to reconstruct your engine sump in some metal other than aluminium, which when pure is not very resistant to sea-water attack. There are several aluminium alloys which possess resistant properties, particulars of which can be obtained from The British Aluminium Co., Ltd., King William Street, London, E.C.4, or from Aluminium Corporation, Ltd., Buckingham Gate, London, S.W.1.

Self-Change Gear

I HAVE invented a new kind of self-change motor-car gearing which embodies a modified form of the annulus-planet and annulus brake as used in the Wilson's patent

gearbox. **Can I patent my idea without infringing on the rights of the Wilson's patent.—H. K. (Lancs).**

AS you have given insufficient particulars of your invention, it is not possible to give you any definite opinion as to whether your invention contains sufficient subject matter for a patent. If you desire a considered opinion as to whether your invention is covered by any existing patent, it will be necessary for you to obtain professional assistance, as the work involved in giving such an opinion is a relatively expensive matter.

If the invention contains patentable subject matter, and it is more useful than known constructions, it will be possible to obtain a patent for it. A patent *per se*, cannot infringe a prior patent, infringement can only take place when the invention covered by a subsequent patent is made, used, or sold.

Fluid Glass

I HAVE heard from several reliable sources of the existence of a coating substance called Fluid Glass, which among other uses renders wood, cork, and asbestos really watertight, and also to a very high degree fireproof. It takes about twelve to twenty-four hours to dry, and sets hard as glass. Could you give me any further information upon this subject? It would seem to be ideal for covering speed-boats, etc.—R. S. (E. Croydon).

WE think that the "fluid glass" is one of the many entirely imaginary chemical materials which are from time to time conjured up by the daily press in consequence of mistaken or misapplied reports. There is, however, a glass-like composition of a plastic nature which is manufactured by Imperial Chemical Industries, Ltd. (Millbank, London, S.W.1), but this is by no means fireproof. Also, sodium silicate solution is almost perfectly transparent and may be used for impregnating various materials and conferring fireproof properties upon them. This is sometimes termed "glass solution," but we have never heard the term "fluid glass" applied to it. When sodium silicate is treated with acid, it is decomposed into silica, which is semi-transparent and highly fireproof.

We think therefore, that for your experiments you might well try impregnating your material with sodium silicate (solution) and afterwards immersing the impregnated material in a bath of weak hydrochloric acid which would render it almost entirely fireproof. Concentrated solutions of sodium silicate are well known under the name of "waterglass." It is impossible, however, by means of sodium silicate treatment, to obtain a glass-like coating upon various surfaces which is, we presume, the end you aim at.

Several Ideas

I HAVE thought of several ideas which I think are rather novel (details enclosed), and would like your opinion on each.—J. W. (West Hartlepool).

MEANS of gripping paper on drawing-boards without the use of pins is not broadly novel. Many years ago drawing-boards were quite common in which a panel fitted with a frame, the top surface of the panel and frame being level. The panel was held in position by hinged battens at the back engaging slots in the frame. In another construction of drawing-board, the paper was stretched over the surface by a pair of wires or bars, one at each opposite edge of the board. These wires or bars normally engaged in recesses near the edges of the board, and were provided with cranked ends which were pivoted in the edges of the board. It may be possible to obtain a patent for the proposed construction, but in view of what is already known it would necessarily be of restricted scope, and therefore not be of any great commercial value.

It may be possible to obtain a patent for the improved means for mounting machines to obviate vibration if the idea is novel or the methods employed are novel. The broad idea of interposing resilient pads between the supports of a machine and the ground are, of course, quite old, but it is possible that the particular method proposed may be novel. Since insufficient particulars are given of the proposed method, it is not possible to express a more definite opinion on the invention.

The improved pulley is thought to be novel from personal knowledge, and forms fit subject matter for protection by Letters Patent. It is not thought, however, to be likely to have any commercial success as practically the same result can be achieved by self-aligning bearings at probably less cost.

The improved mouse-trap does not appear to be a practicable arrangement, or to have any commercial value.

The improved method of converting an ordinary dining-table into a billiard table is no longer novel. A very similar arrangement was marketed some twenty years ago, but it is not thought that it achieved any marked success, and it is thought to be no longer on the market.

There is nothing to prevent you from making and selling your inventions, and since you do not propose to employ any hands, the Factory Acts will not apply.

The actual stamp duty payable on filing an Application for Patent with a Provisional Specification is £1; and for filing an Application for Patent with a Complete Specification, £5. If professional assistance is required, which is most advisable, the costs are necessarily greater and depend largely on the intricacy of the invention.

Winding an A.C. Motor

I HAVE recently purchased a ¼-h.p. D.C. electric motor from which all windings have been removed. Is it possible to rewind this motor to use as a ¼-h.p. A.C. 230 v. 50 cycle ?—K. A. F. (Norwich).

YOU have not stated the dimensions of your armature, but if it is rated at ¼ h.p. on direct current it may safely be assumed that 1/6th h.p. will be as much as you can hope for on alternating current, and if the yoke ring is solid the machine will develop considerable heat. The fields should be laminated throughout, that is, both field poles and yoke ring, for use on A.C. It is quite customary to have twice as many bars in the commutator as slots in the armature, the coils being grouped two per slot. The winding recommended for 230 volts 50 cycles 1/6th h.p. at approximately 2,000 r.p.m. will be as follows :—

Armature.—30 coils, each containing 66 turns of No. 31 S.W.G. d.c.c. copper, connected to 30-part commutator, grouped two per slot in 15-slot armature core, and lap-connected, with span of 1-8 for the coils.

Fields.—2 coils, each containing 500 turns of No. 23 S.W.G. s.c.c. copper, in series with one another and with the armature.

Brushes.—Of "Link C/4" carbon 3/8th in. square.

"Sea-foam Candy"

CAN you describe in detail how "sea-foam candy" is made, and whether it is possible to make small quantities at home ?—G. B. (Derby).

THE confection which you name is one of a very large class whose essential constituents are sugar, gelatine and albumen, plus, of course, any flavouring or colouring-matter which may be thought necessary.

You can make such sweetmeats by stirring confectioner's or icing sugar into double its weight of a 3 or 4 per-cent. solution of cooking gelatine to which has been added a quantity of albumen or white of egg equalling approximately one-half of the weight of the gelatine solution used.

The gelatine solution is placed in a capacious vessel and it is kept cool as possible by being surrounded by another vessel containing cold water. After the albumen has been dissolved in the gelatine solution, the latter is then rapidly stirred (preferably by means of a mechanical stirrer) and the sugar is added bit by bit. A large quantity of white sugary foam will be formed, and this, as soon as it arrives at the right consistency, is rapidly broken away and placed for a few minutes in a low-temperature oven (temperature not exceeding 100 degrees C.) to "cook" and to stabilise itself.

It is possible to make small quantities of this material at home, and in place of a mechanical stirring apparatus, an ordinary revolving "egg-whisk" should suffice.

Divining Water

IS there a fairly simple method of divining water where it is known to exist, such as a galvo. and exploring loop hook-up ?—L. A. (Birmingham).

YOU cannot divine water satisfactorily by electrical means. The orthodox way of locating the presence of water is by careful consideration of the geological strata of the district, followed by careful boring.

There is, of course, the practice of "dowsing" or the use of the forked twig or "divining rod" to be considered, and this, in our actual experience, has often been highly successful. At the same time, there are many who consider the technique of this method to be utterly false. A galvanometer and an exploring loop will give no assistance in the search for underground water.

Driving an Air Pump

I WOULD like to make an induction motor to drive a small air pump ¾ in. bore, ¾ in. stroke, for use with an aquarium. Would you kindly supply details for both the induction and the synchronous type of motor, 230 volts ?—W. A. P. (London).

WE are afraid the necessary space required to give sufficient drawings and details of a small induction or synchronous motor to make the matter intelligible would not be available at present, as neither the construction nor the windings are a simple matter. The cost of stampings, wire and material generally would be far higher than the price of a small motor ready-made which can be picked up for a few shillings at most secondhand electrical shops. If you only want a cheap motor for aquarium aerating it is suggested that you apply to Messrs. Basset-Lowke & Co., Ltd., 112, High Holborn, W.C.1, and get particulars of the synchronous impulse-type motors they market for that purpose.

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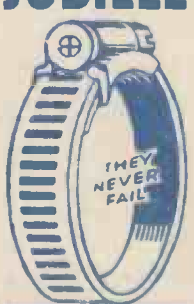

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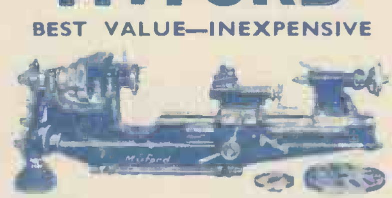

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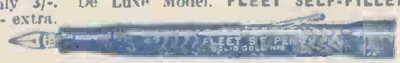

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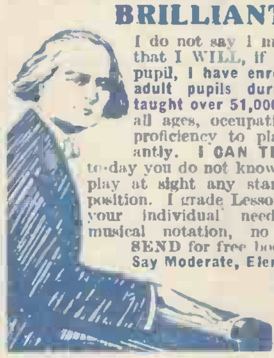

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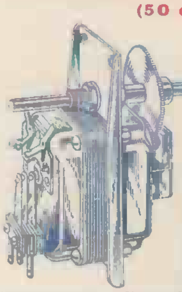

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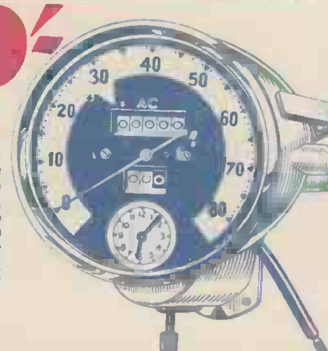

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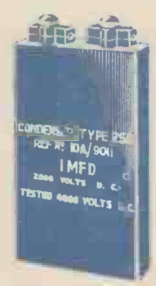

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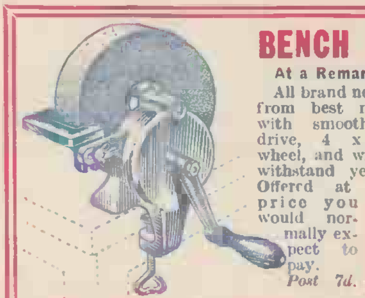

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