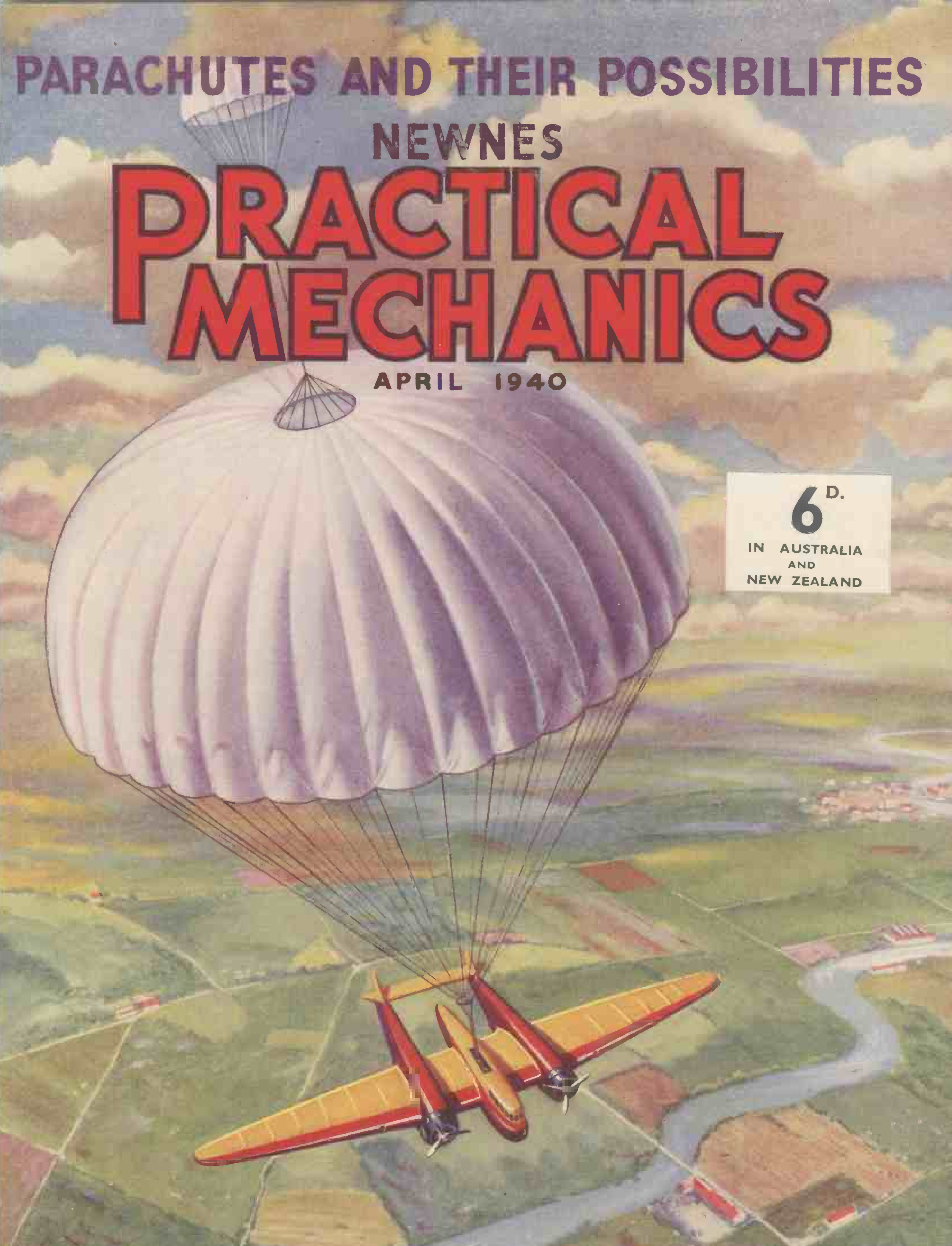
PARACHUTES AND THEIR POSSIBILITIES

NEWNES

PRACTICAL MECHANICS

APRIL 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. APRIL, 1940. No. 79

FAIR COMMENT

By the Editor

The Call to Engineers

FOR many years I have preached the doctrine that the future of this country depends to a large extent upon engineers. I deplored the fact that after the last war the engineering trades which had done so much to bring it to successful conclusion, was cast off like an old boot by the Government, which destroyed the incentive for young men to serve apprenticeships. Disarmament was the order of the day.

Mine was a voice crying in the wilderness, but I cannot refrain from pointing out now how right I was. Young men found it comparatively easy at the age of fifteen to obtain a blind alley occupation at 30s. or so a week, and so they deserted the chance of becoming an apprentice at a much smaller financial reward but with a much richer accretion of experience. Over twenty years have passed since the bells and the bunting proclaimed the victory of the Allies.

Overnight engineering establishments working at top pressure for the Government found themselves with the order to stop work. They had been prevented from following their peacetime programme of manufacturing articles for home consumption and for export. Thus, they were without Government orders, without a peacetime programme, and they had lost the valuable goodwill which they had created before the war started.

Fresh Markets

IN the twenty years which have elapsed they have developed fresh markets, only to find that history repeats itself, but with this important difference—there is a great shortage of skilled engineers. Many of those who after the last war deserted engineering because of its uncertainty have returned to it, but the country now needs tens of thousands of skilled men, and training centres all over the country are doing their best to supply the demands. It takes a number of years to train an engineer, but I have no doubt that these training centres will be able to supply men for some of the lesser skilled occupations.

Now we have the lessons of the last war upon which to go, and the young man not of military age who is now at that halcyon period of life when he leaves school behind him, and is upon the threshold of his career, may find it profitable to reflect that this country will not, as it did the last time, desert engineering. In any case, for many years to come the engineering and the building trades will be working at top pressure because of the boom which will inevitably follow the war. We are concentrating every nerve upon winning it, and thus we must neglect the manufacture of things not essential to its prosecution. A young man may therefore consider the prospects of engineering as a career as being particularly bright. This is especially so when we remember that during the past quarter of a century many new branches of engineering have sprung up as a result of the introduction of new materials, such as plastics, and new methods of manufacture.

Aptitude

THERE should be excellent opportunities for the individual with the necessary aptitude. Aptitude is, of course, required in engineering. An interest of mechanical things is one of the first requirements. Study of such subjects as mathematics, machine drawing, machine design, manufacturing processes, and machine-shop practice are necessary essentials. Thus, whilst the practical training is being acquired evening classes and/or postal tuition will lift the individual beyond the ranks of the practician.

The practical side of engineering offers equally good prospects to the man skilled in the use of tools, both hand and machine. Not every individual wishes to become a designer or a draughtsman. The skilled turner, the toolmaker, the man able to do all branches of milling, precision grinding, planing and shaping, will be in great demand for the next ten years.

The country to-day realises only too well that it must depend for the successful issue of the war upon the soldier and the engineer. I therefore invite those of my readers now in process of picking a career to give careful consideration of the prospects I have outlined.

"Practical Engineering"

OUR new weekly companion journal, *Practical Engineering*, which is published every Thursday at 4d., has been most enthusiastically received by the engineering industry and its personnel. If you are interested in engineering you should place an order for its regular delivery every Thursday morning.

New Books

NEW books recently published from this office include: "Newnes' Short-wave Manual," 5s. (by post, 5s. 6d.); "Motor Car Principles and Practice," 3s. 6d. (by post, 3s. 10d.); "Dictionary of Metals and Their Alloys," 5s. (by post, 5s. 6d.); and "Model Boat Building," 3s. 6d. (by post, 3s. 10d.).

In connection with our companion weekly, *Practical Engineering*, there has been a special offer of the 256-page Engineers' Manual for 3s. 6d., and six coupons cut from consecutive issues of *Practical Engineering*. It is not too late to reserve a copy.

This volume, which would cost at least 10s. 6d. in the ordinary way, is packed with the facts, figures and formulæ needed daily by engineers.

The Principles of

Interesting Particulars Lifebelts of

Our artist's impression of a combined "pilot" chute, and main parachute fully inflated after being released from a twin-engined monoplane

FOR a century or more air travellers and explorers have toyed with practical parachutes of one description or another, but it is only since the beginning of the Great War that the parachute as an almost hundred per cent. safety device for emergency use in the air has been forthcoming.

It was Leonardo da Vinci, that fertile and many-sided Italian genius, who first seems to have been struck with the idea of the parachute in what we may relatively call modern times, although it is very probable that this air safety-device was known, at least in principle, by the ancient Chinese technicians. Says the famous Leonardo, writing about the year 1500, "If a man have a dome of fabric above him and suspend himself thereby, he shall be able to make safe descent to the ground from a height."

But the versatile da Vinci, although he undoubtedly mentioned that which we now term the parachute in his writings, never seems to have had the courage of his convictions in this particular instance, for he did not put into practice his notion of the parachute, preferring, it would appear, to remain content with a vague theorising in this direction.

The First Parachute

The first parachute ever made is held to have been constructed by another Italian, one Fante Veranzio, sometime in the 18th century, and Veranzio is said to have descended to earth safely by it after throwing himself from a tall tower. Apart from the fact that this parachute consisted of a rectangular piece of canvas attached to a wide frame, we have no further particulars of its origin or use.

Towards the end of the 18th century, soon after the invention of the gas-filled balloon, a number of different parachutists made their appearance. The famous aeronaut, Blanchard, for instance, experimented by casting animals out of balloons which had reached great heights, each animal having a parachute device attached to it. And finally, we read, Blanchard plucked up sufficient courage to throw himself out of his balloon, and to rely for his safe descent upon a crude parachute device of his own construction.

The Pioneer, Garnerin

The first really successful parachutist of all history was a certain Andre Jacques Garnerin, who, on October 22, 1797, rose from a park at Monceau, near Paris, on a parachute attached to a balloon. At a height of 2,000 feet, he cut the cord which attached his parachute to the balloon. The balloon instantly shot upwards, and Garnerin, equally as suddenly, shot downwards. This intrepid pioneer, however, despite the fact that he was made very dizzy and sick by his violent pendulum-like movements as he sailed downwards through the air, landed safely, and was given a great reception by the admiring spectators who had witnessed his historical performance.

It is interesting to record Garnerin as being the first parachutist to descend upon English soil, a feat which he accomplished on September 21, 1802, in the presence of a large concourse of people.

During the 19th century, parachute descents were, for the most part, made in connection with fairs and outdoor displays, and it has only been since the introduction of the aeroplane that the parachute has come in for the amount of scientific attention which it obviously has richly deserved.

Most of the early parachutes were of the now familiar "umbrella" type, which, so far as European history is concerned, originated in the theoretical "dome" of Leonardo da Vinci at the beginning of the 16th century. Such parachutes, however, had two great faults—that of "pumping," or violently oscillating in a vertically upward and downward direction, and, also, that of "swinging," the unfortunate parachutist being compelled to undergo a rapid to-and-fro swinging movement as he descended to the ground.

By careful attention to design, these great drawbacks have now totally disappeared from the characteristics of the modern parachute, which, in reasonably good weather, descends to the ground, after having once opened out, with almost unbelievable sweetness and steadiness.

The early parachutes, however, oscillated violently as a result of their tendency to turn upside down. Modern parachutes invariably have a small aperture at their apex which enables the air imprisoned in

Parachutes

Concerning the Modern the Air

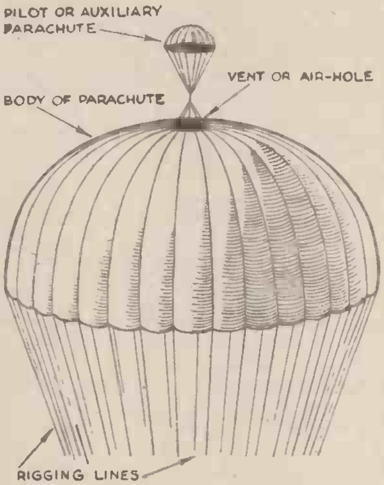


Diagram showing the main body of a modern parachute with the "pilot chute" above it

the parachute to escape upwards. It was the French astronomer, Lalande, who first suggested this innovation which was found to exert an enormous steadying effect upon the parachute in descent and which has been consistently adopted ever since.

In view of the fact that the early parachute invariably tended to turn upside down, an Englishman named Cocking designed a parachute which was similar in form to an umbrella turned inside out, the "point" of the parachute being downwards. The edges of the parachute had a tubular metal rim. This parachute showed no tendency to turn over in the air, but, unfortunately, its rim proved a tragically weak part, for it collapsed in the air, and as a result Cocking hurtled some thousands of feet to his death.

Stability of Modern Parachutes

The stability, and the surety of the modern parachute, obtains mainly as a result of the enormous amount of attention which has, during the last quarter of a century, been paid to the details of its design and construction.

Modern parachutes are of two types. One of these is attached by a line to the aeroplane, and it automatically opens after it has fallen a short distance. This particular type of parachute, however, is not without danger, for if the aircraft to which it is permanently attached meets with sudden disaster, it may not always be possible for the user to get the parachute sufficiently far away from the plane for it to escape being entangled, or burned, or otherwise destroyed.

For this main reason, the second type of parachute has now become the more popular for all Service usages. This is the "free" type of parachute which is normally carried in a carefully folded and compacted condition within a pack which forms the seat cushion, or backrest used by the occupant of the 'plane. The parachute is attached to the air-traveller by means of shoulder and thigh straps, and it is brought into operation by the voluntary pulling of a metal ring attached to a rip cord which opens up the parachute pack and so allows the "body" or fabric of the parachute to unfold itself.

Technique of Parachute Descent

The technique of the parachute descent is not a difficult one for anyone to get into, although, naturally enough, the first descent (provided it is not made under circumstances of dire emergency) calls for the presence of a certain amount of confidence and courage. Having the parachute pack firmly strapped in position, the user either jumps or steps into space from the travelling 'plane. After (but not before) the decisive jump or step into space has been made, the parachutist pulls the substantial metal ring attached to the rip cord. In practice, this rip cord release is normally made within a second or two of leaving the 'plane. Within about one and a half seconds of this action being carried out, the parachute opens fully, allowing the user of it to descend gently and steadily to the earth's surface. As a precaution against bad weather, when, under such conditions, the parachutist, after making contact with the ground, might possibly be picked up again by a gust of wind and dragged violently along the ground, a quick-release device is usually incorporated into the parachute harness, whereby the parachutist, having safely reached the ground, may almost instantly detach himself from the main body of the parachute, leaving the latter free to be blown away by the wind.

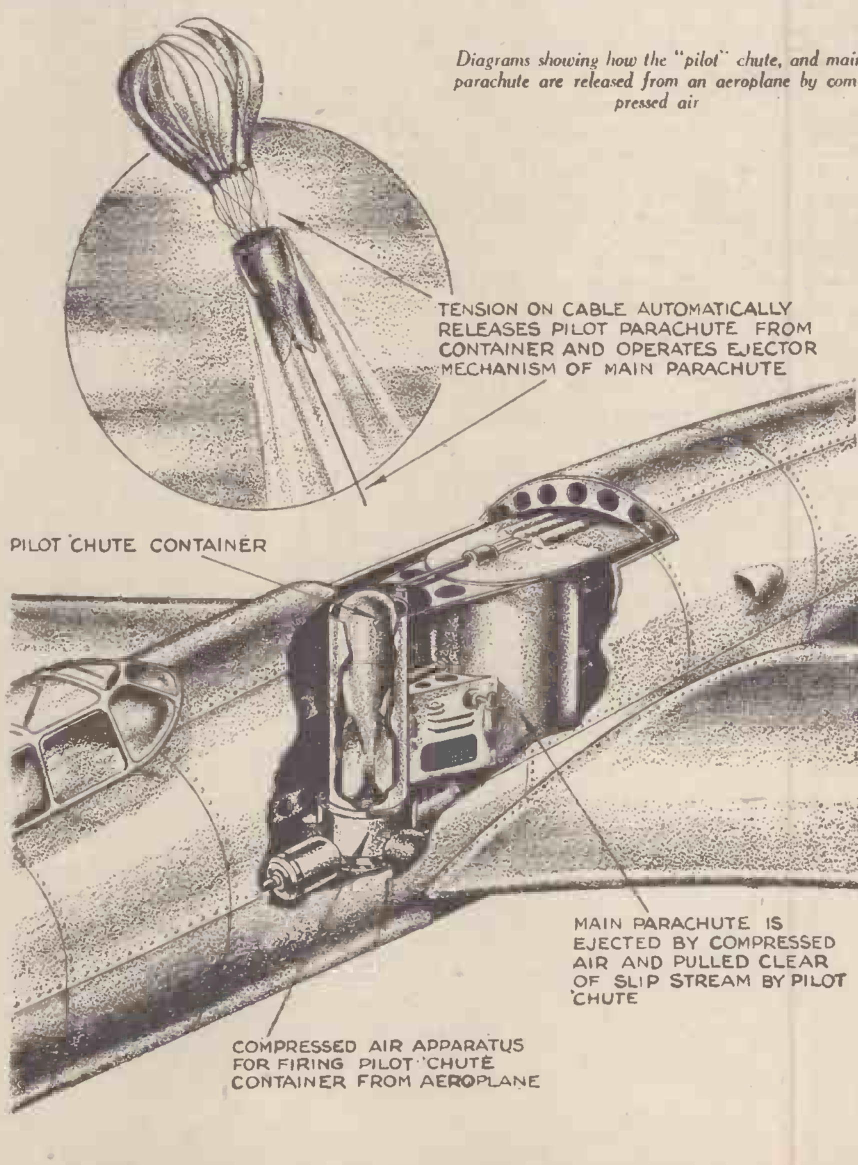
There is no mystery concerning the almost incredible safety of the modern parachute. Based on the original Irvin "free" parachute, the modern parachute, or "air-lifebelt," as it has come to be called, contains within its compacted assembly a small or auxiliary parachute which is released immediately upon the pulling of the rip cord of the pack. This auxiliary or pilot parachute shoots out and, instantly unfolding itself, serves to pull out the main body of the parachute, from whose edges are suspended the rigging lines attached to the man-carrying harness of the device.

Irvin Type of Parachute

The average Irvin type of parachute has an opened-out diameter of about 24 feet, and it weighs, with its harness, some 18 lbs. Its rate of falling (with a passenger of about 12 stones) is of the order of 16 feet per second. Military-type parachutes are often smaller and they permit of more rapid descents, which, in drastic circumstances, are naturally essential.

Usually, the parachutist of average weight comes to earth without feeling any more shock than that experienced after jumping off a six-feet wall.

Provided that the rip cord is pulled a second or two after leaving the 'plane, the average "dead drop" of the parachute user is only about 60 to 80 feet before the



Diagrams showing how the "pilot" chute, and main parachute are released from an aeroplane by compressed air parachute fully opens out and almost imperceptibly arrests this headlong descent. From this instant the parachutist drifts gently to the ground, and, for the greater part, the sensation of doing so is much akin to that of floating upon a perfectly calm sea. There is no apprehension, no nervousness in this scientific and orderly descent to Mother Earth. Sometimes, however, in the presence of strong winds, the parachutist has to guard against his being deposited upon a housetop or on to the uppermost branches of a clump of tall trees. This he does by certain springing movements of his body, akin to jumping, which serve to enable him to avoid such unwanted and, indeed, dangerous "high" landing places.

After a beginner has made his initial parachute descent, he finds all subsequent "jumpings-off" to be amazingly easy, and inconsequential affairs. It is, indeed, as easy to release oneself backwards into space from a travelling aeroplane as it is to step off backwards from a slowly moving 'bus. Some parachute users prefer actually to dive out of the 'plane. Others crouch down and jump off almost on all fours, whilst others still prefer to drop out of the 'plane head downwards. This latter position of descent enables the skilled parachutist to observe the apparently upwards-rising earth during his descent and to judge the opportune time for releasing his rip cord.

The Delayed Drop

It is a curious fact that if a man dives head foremost from a 'plane at great altitudes without at once pulling the rip cord of his parachute, he often tends to turn slow somersaults during the lengthy "dead drop" which he may elect to make. One British parachutist met, some years ago, a tragic and an untimely death in consequence of the slow somersults which he performed during the course of an ultra-delayed drop of this description which he made, it being surmised that he delayed too long the pulling of his rip cord.

The "delayed drop" technique of parachute descent is one in which practised parachutists can become exceedingly expert. This "delayed drop," of course, consists of stepping or jumping overboard from an aeroplane at a great altitude, and in purposely refraining from pulling the rip cord of the parachute until a "dead" fall of one, two or even more thousand feet have been made.

The fact that a man can fall freely through space for several thousand feet without experiencing breathlessness or impairment of mental faculties successfully demolished once and for all the very common and age-old theory that the downwards rush from a height deprives a falling individual of his senses.

After a "dead-dropping" parachutist has fallen about 1,600 feet under the earth's force of gravity the air resistance set up by his downwards-hurtling body tends to neutralise the gravitational attraction for the man's body. This results in a steadying of the downwards speed of falling, and in a checking of a continual tendency to any decided increase in this speed. As a result of these forces, it is found that a parachutist falling freely from a very high altitude attains a maximum "dead drop" speed of some 250 miles per hour, and that this speed is not appreciably increased before the falling individual pulls the rip cord of his parachute, and so brings his precipitious descent to a conclusion.

American parachutists practising the "delayed" or "dead drop" method, sometimes strap to their wrists large watches having very prominent seconds hands. Such a watch the parachutist would hold before his eye during the "delayed" part of his descent to earth and thereby count the seconds accurately before he pulled his rip cord.

There are thinking and experienced aeroplane technicians who still hold the opinion that the parachute is, as yet, only in its infancy. Such a device, they say, must, at some future time, necessarily be universally available, not merely for aeroplane pilot and passenger safety, but, also, in many cases, for the safety of the aeroplane itself. In other words, these experts visualise a time when every aircraft, no matter of what particular type it may be, will carry its own parachute by means of which it would be enabled to descend gradually to the ground, with or without passengers and crew, in a case of necessity.

Experimental Uses

That such opinions are well founded ones, is proved by the fact that on one occasion at Los Angeles, in America, an entire small aeroplane has actually been brought safely down to earth by this means, the 'plane being a "Curtis," weighing some 1,800 lbs.

Needless to say, there are great difficulties to be overcome before this principle of providing for the safe descent of an aeroplane in an emergency by means of a parachute device can be made essentially practicable, such difficulties being mainly concerned with the enormous size of the parachute required to support such a great weight. Nevertheless, it does seem possible that some modification of the parachute principle may ultimately be forthcoming whereby parachutes of reasonable dimensions may be made capable of supporting very greatly increased loads and, also, given a certain degree of steering power which they nowadays, of course, decidedly lack.

A "powered parachute" embodying a small motor and a steering device is by no means a too optimistic dream of the future. Nor, again, is one which might be available for long-distance travel.

But at the present time, however, the parachute, as its name (derived from the French) implies, must remain a device whereby we "prepare to fall." As such, this "airman's lifebelt" has saved thousands of lives, and has rendered to air-travellers the possibility of an emergency descent downwards through space rather an interesting one, than an otherwise inevitably fatal headlong hurl to earth.

Making an Anemometer

Constructional Details of a Simple Wind-gauge

AN anemometer, or wind measurer, is easily made, but at the same time is a most fascinating piece of apparatus. Four semi-circular cups form a kind of horizontal windmill which spins slowly or rapidly, according to the velocity of the wind. By means of a worm and pinion gear a pointer moves over a graduated scale, from which can easily be found the speed of the wind in miles per hour.

The cups are beaten out of circular pieces of sheet copper, exactly 4.71 in. in diameter, and when finished must be exactly 3 in. in diameter. If you do metal work this is a simple task. If not, you can get them made quite cheaply.

The Four Arms

These are made of $\frac{3}{16}$ in. diameter brass rod, 11⅞ in. long. The vertical spindle consists of a piece of ¼ in. dia. steel rod. The boss A is 1¼ in. diameter and ½ in. deep. Run a thread on the end of the rod and tap the hole in the centre of the boss. Tap four holes ½ in. deep *exactly at right angles*, to take the threaded ends of the four arms. Solder the cups firmly in position as shown. Screw the arm firmly into the boss and screw this tightly down on the spindle.

The worm wheel is fixed securely to the spindle by its set-screws (see Fig. 2). The bottom spindle is pointed and runs in a hollowed bearing block of steel, B. A collar and set-screw, C, keep the spindle in place. The pinion has 56 teeth, and is fixed firmly by its set-screw to a spindle D, which runs in bearings in the two brass strips E.E.

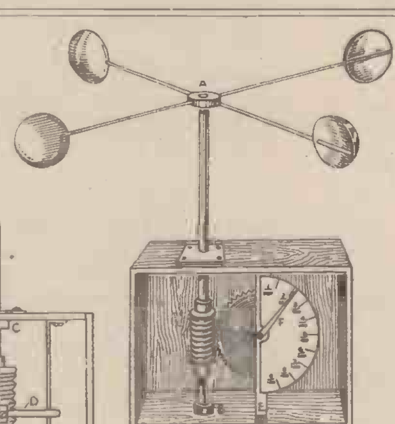
A dial of cardboard, graduated into twenty equal parts and numbered 1/100, 2/100, up to 20/100 is glued to the front strip. The front strip and half the dial is shown in Fig. 1.

A pointer, F, is soldered to the front end of the pinion spindle.

The Box

This is about 6 in. long, 3 in. deep and 4 in. high. It should be firmly screwed together. A sheet of glass forms the front, through which the dial is read. The bearing in the top of the box is formed by screwing a piece of sheet brass on and boring a hole just large enough to allow the spindle to revolve freely. The hole in the wood should be a little larger to allow perfect clearance.

If made exactly to these dimensions, fifty-six revolutions of the cups, i.e. one revolution of the pinion and pointer, equal 1/5 of a mile. Each division on the dial is thus 1/100 of a mile.



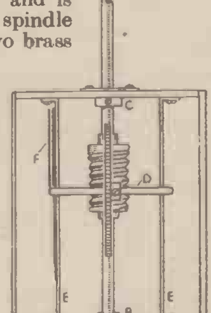
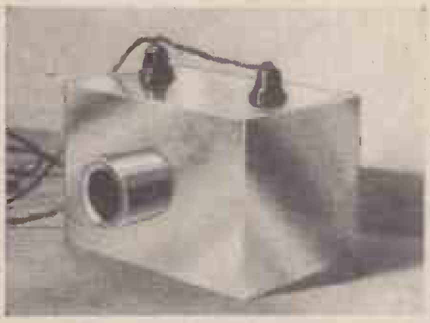


Fig 1 (above).—View of the completed anemometer
Fig. 2.—The spindle and worm wheel

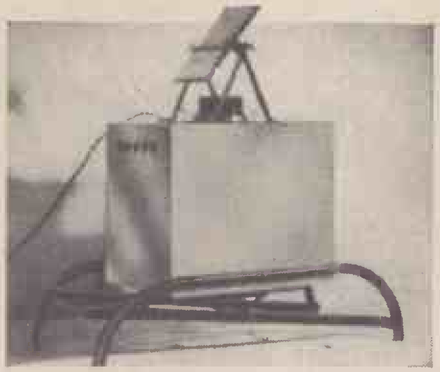
When the wind is blowing, watch the pointer and note carefully how many divisions it passes in one minute, or five minutes. Suppose it moves from 0 to 10/100 in one minute. This means a speed of 1/10 miles in one minute or six miles per hour. If the pointer does four complete revolutions in one minute, this is 4/5 of a mile per minute, which is forty-eight miles per hour.

Simple Episcopes

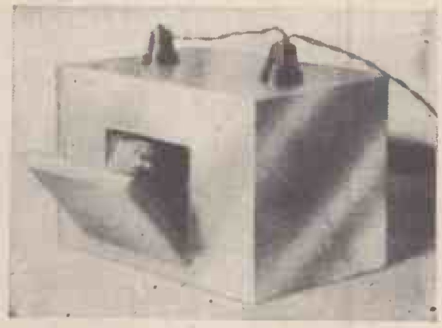
Constructional Details of Two Easily-made Projectors



Front view of a simple episcope



Side view of an improved episcope



Rear view of simple episcope showing the hinged door

AN episcope is a projector for showing images of ordinary pictures on a screen, and its operation is exactly the reverse of an ordinary camera. The device consists simply of a lens and a box, and as the light reflected from a small picture is thrown on to a much greater screen area, a strong light is needed.

Lenses

The lenses can be cheap magnifying glasses. such as may be obtained for 6d. Both episcopes here described use these lenses.

Having decided upon the maximum width of picture to be used (say 6 in.) and the corresponding screen size (about 3 ft.), a test of the lens may be made as follows. A window bar 3 ft. long is focused on a piece of paper, and (at the right distance from the window) an image 6 in. long is formed. The distance between paper and lens (*d*, Fig. 1.) gives the correct lens position in the episcope (Fig. 2).

For the lenses used, d=8 in. approximately, the episcope box is 6 in. by 10 in. It may be a converted biscuit tin, or built up. The curved parts act as reflectors for the two bulbs, which should be placed at the centres of curvature as shown. The holders are fixed in the top of the box and holes 1 in. diameter are needed. An old centre-bit will make these easily, using a block of wood on the other side of the tin to steady it for cutting.

A hole 6 in. square is made in the back of the box and covered from inside by a thin piece of glass. This is held by tin clips soldered inside. A square "door," covered with felt, holds the picture against the glass, and the holder is hinged at the bottom, a clip holding it shut (Fig. 3).

Underside of improved episcope showing the swivelling platform for holding the picture to be projected

Lens Tube

The lens tube is a cocoa tin minus the lid; a hole being made in the bottom, leaving a ledge which supports the lens. Soldered tin clips will hold it in. The hole in the tin, and the hole for the lens tube, are too large for the brace and bit, so a simple tool can be made as shown, out of two nails, and a piece of wood. One nail acts as a cutter and is sharpened with a file. It is best to make the hole in the episcope on the small side, and then expand it by revolving a suitable piece of metal in it, until the lens tube just fits. The lip on the hole makes the tube much steadier.

In use, it will be found that the picture must be inserted upside down, but even then print is reversed and unreadable. This difficulty may be overcome by using a transparent screen, as shown in Fig. 3. Quite adequate illumination may be obtained by using two 60-watt bulbs.

(*Continued on page 335*)

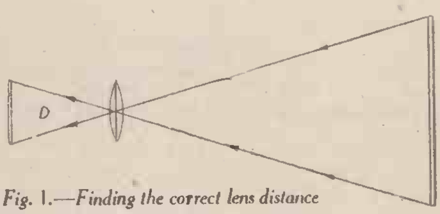


Fig. 1.—Finding the correct lens distance

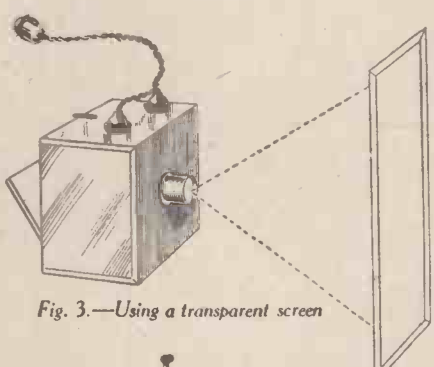


Fig. 3.—Using a transparent screen

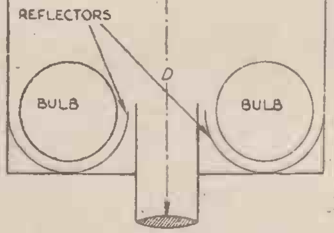


Fig. 2.—Sectional plan view of the simple episcope

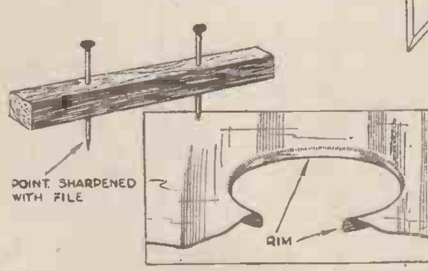


Fig. 4.—Simple tool for cutting the large hole in the tin casing

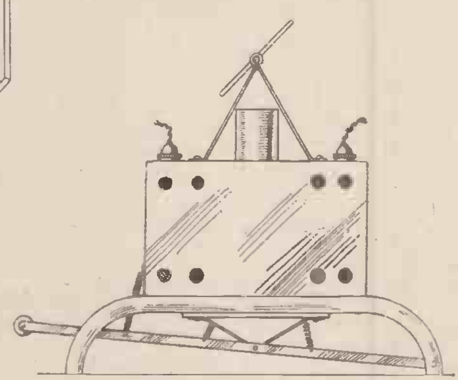


Fig. 5.—Side view of an improved episcope

Modern Explosives

How Nitrogen, the 'Explosive Element,' makes Modern Warfare possible

At practice with an anti-tank gun, somewhere in England

TO a large extent, present-day warfare is carried out not only by armed forces on land, on sea and in the air, but, also, between the chemical factories of the nations. For, without the chemical factories of modern times, there could be no supplies of high-power explosives, and without the latter a nation would be as powerless in the hands of its enemies as is a mouse within the paws of a cat.

When we reflect upon the fact that a century ago, the only explosive material known was ordinary gunpowder, and when we realise the enormous degree of damage which present-day explosives are able to effect, the tremendous strides which have been made in the science of explosives within the last hundred years is borne forcibly upon us.

Gunpowder

Although gunpowder, which is a mixture of sulphur, charcoal and saltpetre, was known to the Chinese in ancient times, it was, as far as we can ascertain nowadays, first used in battle by the English at Crécy in the year 1346. From that historic fight right up to the battles of Victorian days, gunpowder has been the main support of both victor and vanquished. And yet, strictly speaking, gunpowder can hardly be called a true explosive, for, when ignited in the open, it simply burns away rapidly and more or less harmlessly. When, however, it is fired in an enclosed space, it explodes with some force, although, of course, the energy of detonating gunpowder is relatively feeble compared with the tremendous amount of energy released by the detonation of any modern explosive.

It is a very curious fact that the element, nitrogen, which the chemistry books (speaking, of course, of the free nitrogen existing in the air) tell us is an inert and lazy element, is contained in all modern explosives which are of any use. In fact, we may call nitrogen *the* explosive element, for, without doubt, it is the nitrogen in explosives which underlies their characteristic action in almost instantaneously releasing tremendous stores of destructive and uncontrollable energy.

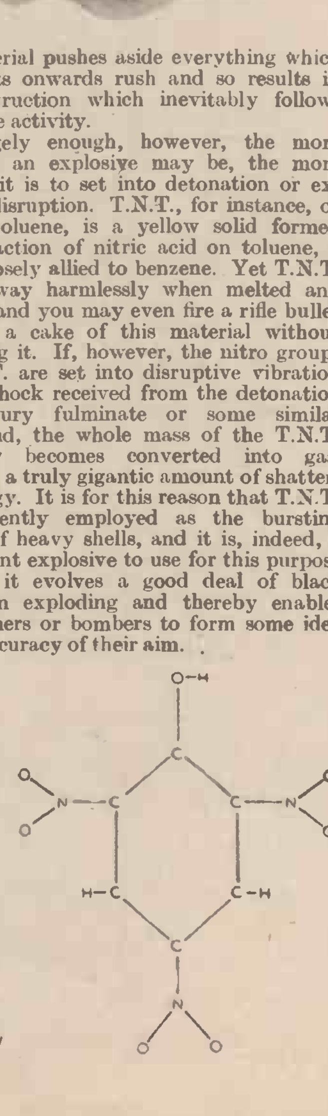
Gunpowder contains nitrogen, this element occurring in the potassium nitrate (saltpetre) which is an essential ingredient of the powder. Actually, the active agent in gunpowder, and, indeed, in all modern explosives is the nitrogen atom in combination with two atoms of oxygen, or, as this characteristic configuration of atoms is called, the "*nitro group*," which chemists represent by the symbol—NO_2.

Mercury Fulminate

In actual essentials, all that any modern explosive consists of is a complex and convenient assemblage of millions of these "nitro groups," which, normally, are fairly stable and harmless chemical entities. If, however, the atoms in these nitro groups receive a sudden, sharp disturbance, say, from the detonation of a grain or two of mercury fulminate, the component atoms of the groups are set into a condition of unrestrained vibration. With such energy do they vibrate that they instantly fly asunder, dragging after them the carbon and hydrogen atoms which comprise the remainder of the explosive. Thus what was originally a perfectly solid body becomes instantly converted into a heated gas, or, rather, a mixture of gases, whose combined volume is many thousands of times as great as that of the original solid. The molecular energy, that is to say, the energy of the flying molecules of the exploding substance is so great that it is practicably unrestrainable. The enormous volume of gas which has been suddenly generated by the exploding material pushes aside everything which resists its onwards rush and so results in the destruction which inevitably follows explosive activity.

Strangely enough, however, the more powerful an explosive may be, the more difficult it is to set into detonation or explosive disruption. T.N.T., for instance, or tri-nitrotoluene, is a yellow solid formed by the action of nitric acid on toluene, a liquid closely allied to benzene. Yet T.N.T. burns away harmlessly when melted and lighted, and you may even fire a rifle bullet through a cake of this material without exploding it. If, however, the nitro groups in T.N.T. are set into disruptive vibration by the shock received from the detonation of mercury fulminate or some similar compound, the whole mass of the T.N.T. instantly becomes converted into gas, releasing a truly gigantic amount of shattering energy. It is for this reason that T.N.T. is frequently employed as the bursting charge of heavy shells, and it is, indeed, a convenient explosive to use for this purpose because it evolves a good deal of black smoke in exploding and thereby enables the gunners or bombers to form some idea of the accuracy of their aim.

The chemical representation of the molecule of picric acid, the sudden disruption of the atoms of which is attended with the liberation of tremendous energy



Nitrogen Chloride

Just as T.N.T., and its related modern explosives, are so relatively stable that you would be taking little chances if you carried them about in your coat pocket, there are, at the opposite end of the scale a number of materials which are so sensitive that they explode, sometimes, almost of their own accord. One of these latter materials is nitrogen chloride, a heavy yellow oil. Nitrogen chloride sometimes explodes with extreme violence when even a speck of dust falls upon it, whilst to shake a quantity of this oil is, one may be sure, practically tantamount to suicide. For this reason, nitrogen chloride cannot be used as a commercial or military explosive, it being incapable of handling.

The same applies, to a lesser extent, to nitrogen iodide, a yellow-brown powder, which can be made easily enough in the laboratory.

Combinations of certain metals with nitrogen and oxygen, known as the "fulminates," are considerably more stable than the above compounds. By dint of great care and constant supervision they can be manufactured commercially, and the fulminate of mercury in particular has long been used as the detonating agent in the percussion caps of ordinary rifle cartridges as well as in the detonators of shells, mines and bombs. Mercury fulminate detonates violently on the slightest blow, and, as we have already seen, this short, sharp shock is sufficient to set up the prodigious energy-release of the explosive substance upon which it is made to act.

Gun-Cotton

The first explosive material to be discovered — apart, of course, from gunpowder, was gun-cotton, this being made by the chemist Schönbein, of Bâle, Switzerland, in 1845. Schönbein, by treating ordinary cotton with nitric and sulphuric acids, found, in effect, a method of taking the nitro groups out of potassium nitrate (the constituent of gunpowder) and hitching them on to the molecule of cotton.

Now, although gun-cotton, when ignited, simply flares up more or less harmlessly, leaving nothing behind, it explodes with tremendous force when detonated with mercury fulminate. And, unlike gunpowder, exploding gun-cotton is smokeless. It was found not to foul the gun, and in this respect alone, its discovery represented a tremendous advance upon the historic gunpowder.

In the year following the introduction of gun-cotton, an Italian chemist, Ascanio Sobrero, by name, discovered nitro-glycerine, which he made by acting on ordinary glycerine with a mixture of nitric and sulphuric acids in much the same manner as the chemists, Schönbein had acted with these acids on cotton the year previously. Sobrero called the product which he obtained "Pyroglycerine" and he hardly recognised it as an explosive. Indeed, it was only developed for the latter purpose in 1863 by Alfred Nobel, of Sweden, who found that the material, which he termed "nitro-glycerine," could be detonated by means of small charges of gunpowder.

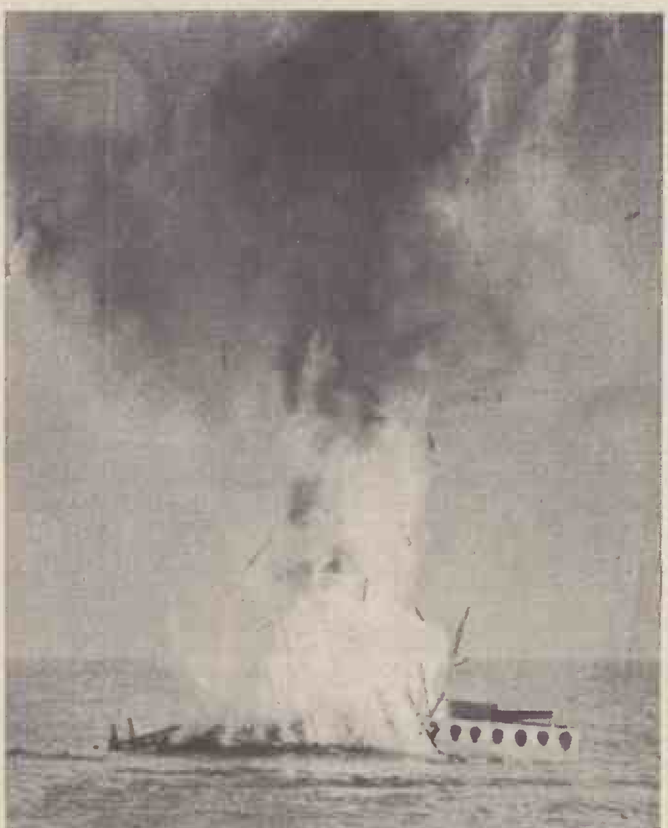
Dynamite

Nobel found that he could absorb nitro-glycerine into a very porous variety of mineral earth called "kieselguhr," and the resulting product which he obtained he termed "dynamite." At the beginning, dynamite had to be exploded for rock blasting by charges of gunpowder, but it was not long before mercury fulminate was more successfully employed for this purpose.

Nitro-glycerine is a yellow oil which, when pure, is fairly stable. You can, for instance, extinguish a lighted match in the liquid, but if it is subjected to any strong shocks it "goes off" with disastrous results, the cause being, of course, the disrupting activities of the nitro groups which each molecule of nitro-glycerine contains.

To Alfred Nobel, also, occurred the idea of dissolving gun-cotton in nitro-glycerine, and thereby getting a sort of double explosive. Nobel made millions out of this simple idea, for, subsequently a combination of nitro-glycerine and gun-cotton appeared on the market as "cordite" which was (and is) employed as the propellant charge of rifle cartridges and light shells. It is, perhaps, a curious twist of Fate which made Nobel bequeath a proportion of his vast fortune to the establishment of a Peace Prize, and to the founding of international prizes in medicine, literature and the arts, for, having brought into being the means of destroying mankind, he seems, before his death, to have made every endeavour to neutralise the possible future implications of his life's work. Unfortunately, however, as we are all only too well aware, Nobel's posthumous aims have not met with the world-success they deserve.

It was Alfred Nobel, too, who, by combining a form of gun-cotton (di-nitro-cellulose) with nitro-glycerine, invented "Blasting Gelatine," an explosive much more powerful than dynamite, and one which has been much used for commercial rock blasting.



This picture shows the devastating effect of a target being blown up by a charge of T.N.T. during mine-laying tests at sea

"Turpenite"

About this period, also, a Monsieur Turpin, patented a method of filling shells with picric acid, a compound which had long been known and which, on account of its yellow colour, had actually been used as a dye. Thus the explosive, "Turpenite" came into being, an explosive which is one of the main stand-bys of modern artillery practice.

Now picric acid is made by treating carbolic acid (or phenol) with nitric acid, and its chemical name is "tri-nitro-phenol." Hence, once again, we see the reason why picric acid (under its many names of "Turpenite," "Melinite," "Lyddite," etc.) is so powerful an explosive, for each molecule of picric acid has three nitro groups attached on to it, these nitro groups disrupting the molecule with enormous force when detonated with mercury fulminate or some similar compound.

Although modern warfare has been, within our generation, enormously mechanised in every possible manner, science has (perhaps fortunately) produced no fundamentally new explosives, although, naturally enough, every nation in the world possesses its own special explosive mixtures, the secrets of whose recipes are jealously guarded.

No one, however, has ever discovered a more efficient substitute for the nitrogen atom, as it exists in the NO_2 groups, for the building up of a synthetic explosive agent. It seems likely indeed, that we have more or less reached the limit of our power in the field of scientific explosives depending upon molecular action, for, as we have already noted in our reference to nitrogen chloride, if a more powerful and a more sensitive explosive material than, say, T.N.T. or picric acid were to be discovered, it would very probably be too sensitive to handle.

Frightful as the effects of modern explosives may often be, it must be realised, however, that, compared with the possible explosives of the future our present-day explosive materials may appear as relatively harmless as gunpowder is to a detonating charge of T.N.T. For all our modern explosives derive their shattering effects by means of the flying asunder of groups of atoms.

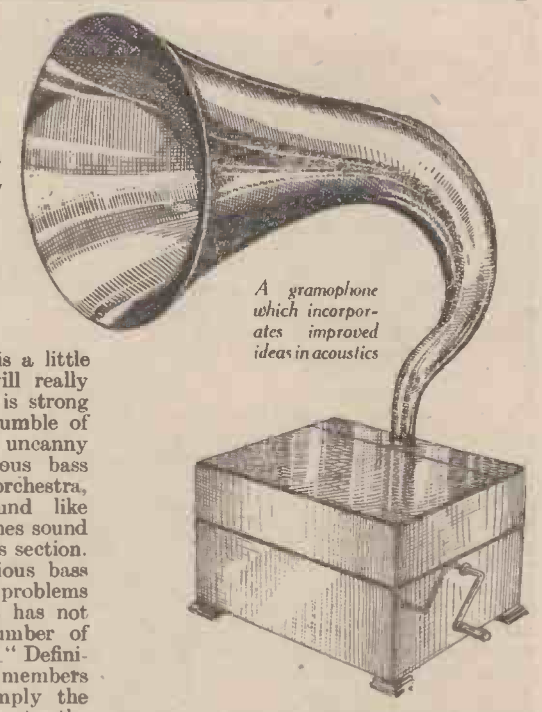
Atomic Power

One day, however, some genius will hit upon the much sought for secret of atomic power. Then will come the ability to release the vast stores of the energy which is contained in atoms. We are told that, in such times, a handful of sand will provide enough energy to drive a mammoth liner across the Atlantic. Explosively released, however, such energy could be made to exert almost unimaginable devasting effects, by comparison with which the disrupting of a present-day explosive would be little more than the firing of a toy cannon.

Let us hope, however, that by the time the inevitable knowledge of atomic power is attained, mankind will have long realised the utter wastefulness of warfare, and its far-reaching devastation of civilisation. If not, it will, under such circumstances, face a drear and dreadful prospect, for a nation possessed of the secret of the Atomic Explosive could readily render itself the material conqueror of the world.

Improving the Gramophone

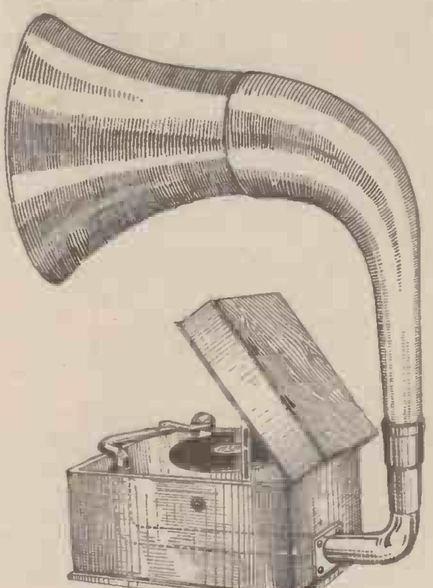
What the Modern Gramophone is Capable of Doing for the Intelligent User



A gramophone which incorporates improved ideas in acoustics

THERE are still quite a number of people who regard the gramophone as a mere toy, and often these people possess an antique instrument incapable of reproducing, with fidelity, the recorded frequencies obtainable to-day.

The introduction of electrical recording in 1925 created a whole set of new problems for the engineers; in those days gramophones had very short horns, quite adequate to pass the frequencies of accoustical records, but incapable of reproducing the new electrical recordings. In 1923 there was formed a body known as "The Expert Committee"; these gentlemen were all amateurs, one being an expert on sound-boxes, another on horns, etc., and by exchanging ideas, and constant experiment, the hand-made accoustical gramophone of to-day was born.



The "Expert" Senior Gramophone

"Wilson Formula"

A formula was devised known as the "Wilson Formula," and roughly speaking this consisted of a very long small bore tapering tone-arm leading into a tapering conduit at the end of which the horn was inserted. At first, these horns were straight, and about five feet long, but owing to considerations of space, and appearance, it became necessary to devise a horn which did not project so much into the room; the result was the "Expert" horn made by Mr. E. M. Ginn.

As will be seen from the illustration an excellent compromise has been affected without materially affecting the results obtained. In the "Expert Senior" the accoustical length is something over ten feet from the needle point to the "bell" of the horn. Until one has actually heard one of these machines in use it is a little difficult to convey what they will really do with a good record; the bass is strong and firm, and not just a deep rumble of nebulous quality. It has an uncanny facility for separating the various bass instruments used in a modern orchestra, thus, double basses really sound like stringed instruments, and trombones sound as though they belong to the brass section. This "splitting up" of the various bass instruments was one of the biggest problems confronting the engineers, and it has not yet been solved by quite a number of commercial radiogram makers. "Definition" was a word often used by members of the Expert Committee to imply the ability of a reproducer to separate the various instruments, and bring them out individually with equal clarity, and at approximately the same volume. Owing to the fact that all instruments used in an orchestra have a certain resonance it was necessary to make the gramophone horn of a material which was not in sympathy with any particular instrument's resonance period.

Papier Mâché Horns

In this respect papier mâché was found to be ideal; this material, when made up, was found to possess a number of advantages, thus, it was easily "worked" to the desired shape, it was immensely strong, and finally, being accoustically "dead" it did not favour any particular instrument.

The soundbox was a problem in itself, and to this day I believe there is only one man who really understands the fundamental principles of soundboxes—Mr. W. S. Wild, of Clapham, was the "box" man on the Expert Committee, and it was he who pioneered the small diaphragm, the sprung stylus-bar, and believed in what he called "mass inertia." Briefly, this meant that the "box" should weigh anything up to sixteen ounces, the reason for this was to keep the "box" steady, and allow the stylus-bar to waggle as much as possible, aided by the springs and gasket-rubbers. He claims, and rightly, that the ordinary commercial "box" with pivoted stylus-bar is incapable of being tuned to concert pitch, as the stylus-bar not being sprung, but pivoted, could not "waggle" to the extent that the "wild" box stylus-bar does.

The illustration of E. M. G. Mark XA shows how this firm have tried to make the instrument more compact and the results on this and the Expert machine are very fine. The latter model seems to concentrate on a deeper bass with good definition, and a very commanding body of tone, the XA is particularly good for definition above all else; the bass does not seem so strong, but in my opinion the general clarity of the machine as a whole is slightly superior to the "Expert." The cost of either model is roughly £25. For best results, the use of fibre needles is advised.

Rawlplug Electric Hammer

THE RAWLPLUG CO. have just put on the market an efficient electric hammer suitable for boring holes in such hard materials as concrete, brick, stone, etc. It can also be used for hacking, pointing and chase cutting.

The new Rawlplug Electric Hammer, suitable for either A.C. or D.C. supply

It is compact, and is wired for either A.C. or D.C. supply. Power consumption is approximately 170 watts. This works out at about one-sixth of a penny per hour, assuming power at 1d. per unit. Motor speed is approximately 4,500 revs. per minute.

Two blows per revolution are delivered by a patented mechanism consisting of two steel balls rotating inside a cylindrical rotor under control of a special type of cam, which practically eliminates vibration. The number of blows is 3,000 per minute.

There is no danger of the toolholder being shot out as it is locked in position in the hammer, and held clear from it until the drill is presented to the surface. A rubber shield prevents debris from entering the toolholder guide.

The hammer is driven by an electric motor having two V-section canvas-backed rubber belts giving minimum slip and wear. This flexible drive prevents undue shocks to the motor shaft.

The hammer is supplied with 9 ft. of 3-core tough rubber flexible cable, special Rawldrills sizes 6-14, Ejector and Tommy Bar and costs £7 10s.

Inside the engine room of a British submarine

The Principles of the Submarine—Part 3

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

The Engine Room is the Heart of a Submarine, and here are Installed the Powerful Diesel Engines and Electric Motors which propel the Craft

IT has been said that the submarine owes its existence to the invention of the diesel engine and the electric storage battery. The truth of this remark lies in the facts that an electric motor driven from charged accumulators does not depend upon the consumption of oxygen for its operation, and that a diesel engine when made to drive an electric motor converts the latter into a dynamo which re-charges the batteries.

A heat engine in operation requires a large and continuous supply of oxygen, and it is evident that a vessel propelled under water by such an engine would be obliged to rise to the surface at frequent intervals in order to replenish from the atmosphere the inroads made on its cargo of air by engine and crew. On the other hand, the supply of electricity contained in storage batteries is not inexhaustible, and a boat depending solely upon an electric motor for its propulsion could comfortably remain submerged for lengthy periods, but might conceivably find itself stranded in mid-ocean by the premature consumption of its store of electricity. Since the submarine torpedo-boat has to navigate under two very different conditions—on the surface and submerged—it is supplied, therefore, with two different sets of motive powers to meet with the special requirements of these conditions. When in the submerged state it is driven by its electric motors, air being scarce and precious, and when on the surface by its diesel engines, where the supply of air is abundant. Although these two motive powers may operate independently, they may be coupled to advantage when the boat is on the surface, for here the mechanical work produced by the diesel engine is shared between the propulsion of the boat through the water and the driving of the generator which re-charges the storage batteries.

The Engine

A diesel engine is a device for producing mechanical force by burning a fuel in an enclosed space. The enclosed space lies in between the sealed end of a hollow cylinder and the crown of a piston which slides closely but smoothly within the confines of the cylinder. These remarks, however, are true of all internal combustion engines, but the special characteristic of the diesel engine which distinguishes it from other heat engines in this class is its particular method of igniting the mixture of air and fuel. The ordinary petrol engine relies upon a spark generated by an auxiliary apparatus for the ignition of the fuel air mixture; but in the diesel engine the swift compression into a small space of the air already present in the cylinder is sufficient to heat that air up to the point of spontaneous combustion with the admixture of fuel. Physics offers a ready explanation of this fact in terms of the molecular theory of gases. According to this principle the temperature of a gas is determined by the velocities of its constituent molecules, so that the problem of raising the temperature of a gas is solved by giving its molecules greater speeds. One method of doing this is to reduce the volume of the gas suddenly without giving its molecules any time to transfer their energy to their surroundings, obliging them, therefore, to move in a state of greater agitation, the external manifestation of which is a rise in temperature.

Dr. Diesel

In thermodynamics such a compression is described as adiabatic, and the first successful application of this principle was made by Dr. Diesel in the design of a heat engine in which the drive of a piston into a cylinder adiabatically compressed and heated the air in the cylinder to an extent which rendered it immediately combustible with the fuel present. The combustion of the fuel air mixture takes place when the piston is almost at the end of its compression stroke, the gases then being contained in a least volume. The process of combustion is a chemical reaction between the fuel, an organic compound, rich in carbon and hydrogen, and the oxygen of the air in the cylinder, enabling the carbon and hydrogen to satisfy their chemical affinities for oxygen by forming a host of gaseous compounds which require considerable space for their existence. The lack of immediate space between cylinder head and piston crown at the moment of their generation causes them to exert great pressure on the piston, which is thereby driven down the cylinder, and by harnessing this continued drive to a crankshaft by means of a connecting rod a source of mechanical power is made available.

These major principles have been recognised and applied in practice since their first demonstration by Diesel fifty years ago, but the existence of the diesel engine in its modern form has been made possible only through the continued perseverance in the solution of subsidiary problems concerned with the preparation and admission of fuel and combustion air, the scavenging of burnt gases, the lubrication and cooling of the engine's moving parts, and the manufacture of metals and alloys most suited to this type of heat engine.

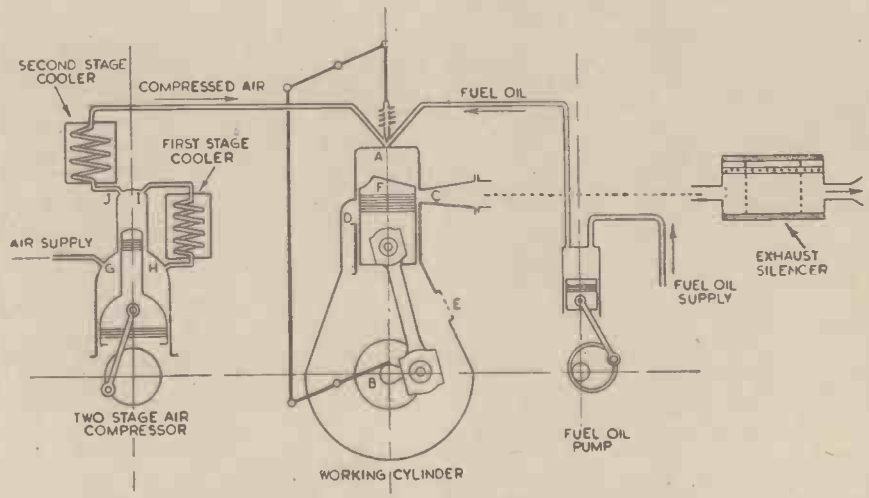


Fig. 8.—Working diagram of two-stroke port scavenging crankcase compression Diesel engine

Operating Principle

The operating principle of the diesel engine is illustrated in Fig. 8. When the piston in the working cylinder is almost at the end of its compression stroke a small quantity of fuel oil is suddenly sprayed into the air compressed between cylinder head and piston through a valve A in the cylinder head. Access to the cylinder is gained when the vertical needle in this valve is lifted for a short time by the action of a cam B on the crankshaft, and the oil is then blown in under the combined pressures of air delivered from the two-stage compressor and of the oil itself fed from the supply pump. The form of the valve nozzle causes the oil spray to divide into fine particles which lace the air and spontaneously ignite in it, since the adiabatic compression of the air in the cylinder has already raised its temperature above the flash-point of the oil. As the piston moves down in its power stroke and approaches the bottom of the cylinder, an exhaust port C is uncovered a fraction of a second before the scavenging port D, and a blast of air which has been drawn into the crankcase through a breather valve E during the piston's upward stroke and compressed in the crankcase by the down-stroke of the piston, passes into the cylinder through the air port D' and sweeps out the mixture of spent gases, leaving a supply of fresh air in the cylinder ready for compression in the next upward stroke. The form of the piston crown is designed to make the air blast swirl upwards into the cylinder to promote efficient scavenging of the waste gases, and a sufficient quantity of fresh air for the next combustion is provided by the tail of this blast added to the supply of air delivered through the needle valve with its burden of fuel oil.

Air from the Compressor

The air from the compressor must be cool when it reaches the needle valve in order to avoid premature combustion with the fuel before the mixture is blown into the working cylinder, and since its sudden contraction in the compressor cylinders causes its temperature to rise, necessary steps must be taken to cool it before it reaches the spray valve. This is done in the two-stage compressor by taking the air to its final pressure in two distinct steps and cooling it after each step. Air is drawn into the valve G into the lower part of the cylinder by the suction stroke of the piston, and compressed by the upstroke to a critical pressure which forces it through the valve H into the water-cooled spiral of the first stage cooler. The suction stroke of the upper part of the piston draws the cooled air into the narrow part of the cylinder, where it is compressed to its final pressure and delivered through the valve J and the second stage cooler to the head of the working cylinder of the engine. A third piston and cylinder pumps fuel oil from the storage tank and supplies it at the required pressure to the needle valve in the working cylinder head. The crankshafts of both air compressor and fuel pump are geared to the shaft of the working cylinder in order to deliver under pressure air and oil at the moment the needle valve opens to give access to the combustion cylinder.

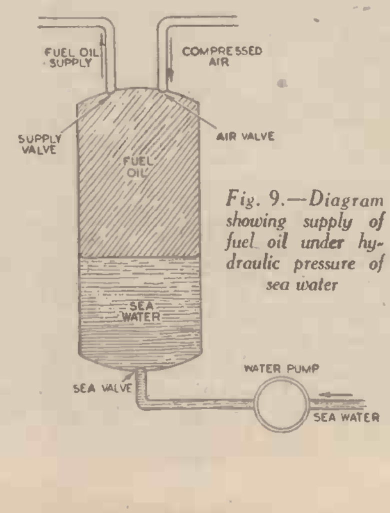


Fig. 9.—Diagram showing supply of fuel oil under hydraulic pressure of sea water

Silent Exhaust

A desirable quality in any heat engine is a silent exhaust, and in a submarine it is especially important to make the discharge of waste gases as noiseless as possible when the boat is surface cruising under the motive power of its diesel engines. This is arranged (see Fig. 8) by receiving the spent gases into a broad, water-jacketed chamber containing baffle plates spaced at intervals across its axis, and a perforated water tube mounted above the plates to pass along the length of the chamber. The curtain of water shed by this tube cools and condenses the exhaust gases and makes their impact on the outside air less forceful and consequently less noisy.

The highly specialised nature of the submarine as a sea-going craft makes it necessary to equip it with equally specialised mechanism. In principle any heat engine could be used to propel a boat on the surface of the sea, but the Diesel engine is chosen for this purpose in submarines because it satisfies the special requirements of this type of boat to a greater degree than any other kind of heat engine. The main requirements of the submarine engine are safety of operation, high speed of revolution, swift reversibility, and high economic value in weight, space and fuel consumption. All of these factors, with the exception of weight economy, are offered by the diesel engine. and the continued endeavours of metallurgical research and engine design are being directed towards the remedy of this single defect.

Highly Suitable

The compact structure of the diesel engine makes it highly suitable for operation in the confined spaces of the submarine's engine room, where space for air and movement are not over-abundant. For a given output of horsepower, the diesel engine occupies only about one quarter of the space required by the power plant in a coal-burning ship, and not quite one half of the space needed in an oil-burning vessel, while the fuel consumed by the diesel engine is hardly more than one third of the amount needed in a marine steam engine developing the same horsepower. The diesel engine's method of burning the fuel by the heat generated by the adiabatic compression of the air in the cylinder has a greater margin of safety in an enclosed boat than the method of the steam boiler or electric spark, particularly as the submarine's atmosphere is always liable to contain a mixture of oxygen and hydrogen evolved from the storage batteries which could be exploded by a spark. The main defect of the diesel engine from the point of view of usage in a submarine is its heaviness

Soap-Making At Home

A quantity of soap made from kitchen grease. The soap is shown " in the crude," i.e. before pressing and refining

An Article of Practical Interest, Showing How Serviceable Soaps May Be Prepared from Simple Materials

SOAP-MAKING is one of the several directions in which domestic scraps may be utilised. And, more than this, soap-making, although it has in our modern times climbed up to the status of a vast and mass-scale, technically-controlled industry, is an operation which can be carried out under home conditions with the minimum outlay in " plant." All that is required for the purpose are a few old pans and dishes and some type of gas or electric stove on which the various materials may be heated up.

Although soap-making on the small scale does not necessitate the possession of any chemical knowledge, the amateur who embarks upon this interesting, useful (and, maybe, in these days, profitable) occupation should at least have some idea of the nature of the process which he is controlling. For this reason, therefore, the following explanation of the nature of soap must be given, although, no doubt, readers who are well versed in chemical science will choose to skip over it.

Ordinary Soap

Ordinary soap consists of the sodium salt of one or more " fatty acids," these peculiar acids being so-called because they enter into the composition of all fats and most animal and vegetable oils. In most of these fats and oils, the fatty acid is combined with glycerine, the product being technically known as a " glyceride."

Now, the main constituents of fats are the glycerides of stearic and palmitic acids which glycerides are commonly known as " tristearin " and " tripalmitin " respectively. These glycerides are solid at ordinary temperatures, and they make up the bulk of most solid fats, such as lard, tallow, bone-fat, etc. There is, however, the glyceride of oleic acid (known frequently as " triolein ") which is liquid at ordinary temperatures. This glyceride constitutes the basis of the majority of animal and vegetable oils, such as olive oil.

When any of these glycerides (such as tristearin, tripalmitin or triolein) are heated up with caustic soda or caustic potash, there is formed a thick, frothy mass which contains free glycerine and the sodium or potassium salts of the various fatty acids which existed in the glycerides. These fatty acid salts constitute nothing more nor less than ordinary common soap. The sodium salts of the fatty acids are hard at ordinary temperatures and they constitute the hard soaps, whilst the potassium salts are semi-liquid and form the soft soaps.

Essentials of Soap-Making

Here, therefore, we have the essence—the " theory," if you like—of practical soap-making. In its essentials, the process of making soap consists in heating up animal or vegetable oils or fats with caustic soda or potash until all the natural glycerides contained in the oil or fat have been split up into glycerine and fatty acid, which latter will, of course, immediately combine with the caustic soda or potash present to form the resulting soap. This process, whereby the fat or oil is split up or decomposed by means of caustic soda or potash is known as " saponification " from the Latin, *sapo*, soap.

Showing the simple apparatus required to saponify oils and it consists merely of a vessel standing in a pan of water

It must be understood that only fats or oils containing these naturally-occurring glycerides can be saponified and converted into soap. Mineral oils, such as paraffin, creosote, petroleum, etc., do not contain glycerides, and hence they cannot be turned into soap. Naturally-occurring resins, however, contain much saponifiable matter and therefore all such materials can be utilised for certain types of soap-making.

The amateur who desires to embark upon the interesting task of soap production has many raw materials from which to choose. All fat-containing kitchen scraps, grease, etc., may be utilised for the purpose. Suet, tallow, lard, butcher's fats of all descriptions, the natural oils, such as olive and castor oil, raw linseed oil, cotton-seed, rape, cocoanut, cod-liver, whale, palm and a host of other vegetable and animal oils may all be used for soap production, although if these oils are used alone, the tendency will be for a soft soap to be produced.

The process of soap-making does not consist in heating up an undetermined quantity of fat or oil with a similarly undetermined quantity of caustic soda or potash, for, if this method were adopted, either the soda would be present in excess, in which instance, the product would be unusable, or the soda (or potash) would not be present in sufficient amount to completely saponify the fat or oil, and, in this instance, of course, the soap product would be contaminated with unsaponified fat which would also render it unusable.

Heating the Oil

In all practical soap-making operations, therefore, it is absolutely necessary to heat up the oil or fat with exactly the requisite quantity of caustic soda or potash which is necessary to saponify it completely.

In order to avoid the necessity of bringing in abstruse chemical calculations, the reader undertaking the task of soap-making may simply refer to the table accompanying this article, from which he can read at a glance the necessary amount of caustic soda (or caustic potash) which is required for the complete saponification of most of the well-known fats and oils. Using this table, the amateur soap-maker can turn out a very satisfactory and useful soap product at his very first attempt.

It should be noted that caustic soda or caustic potash are the saponifying materials employed. The beginner in soap-making, however, is advised to use caustic soda only, for not only is caustic potash more expensive, but it also gives rise to soaps which are naturally soft and pasty. Caustic soda (sodium hydroxide) *must* be employed. It will *not* suffice to use ordinary household or washing soda, which, being sodium carbonate, is a different material from caustic soda. Caustic soda, however, can readily be obtained from most large paint stores, and from any dealers in chemical supplies. Let us now follow the course of a typical soap-making process.

The Process

Suppose we are utilising ordinary tallow for our purpose, this we shall find on reference to the Saponification Table printed with this article needs exactly 14 per cent. of caustic soda to saponify it. We therefore weigh out a known quantity of tallow, place it into a glass beaker or other suitable vessel, and add to it exactly 14 per cent. of its weight of solid caustic soda dissolved in a little water in order to make up a strong solution of the soda.

The tallow and the caustic soda are now heated up in a pan of boiling water, the heating being effected gradually for two or three hours. During this time, the mixture is well stirred, and it will froth up and will form a thick, homogeneous mass. When no further change takes place, the vessel containing the mixture should be removed from the pan of water and some common salt well stirred into it. This will precipitate a thick curd which will comprise the required soap, whilst the liquid part of the mass will now consist mainly of a solution of salt in glycerine.

The curd, after cooling, should be filtered off through muslin or similar cloth and then pressed into suitable shapes.

If caustic potash has been used in the above process in place of caustic soda, salt should not be added at the final stage, and, on cooling, a jelly-like mass of soft soap will be produced. If, however, salt is added in this latter instance, a portion of the potassium soap will be converted into the sodium soap and thus the normally-produced soft soap will be hardened up considerably.

In the above process we have, in a nutshell, as it were, the main essentials of soap-making. Although the soap product obtained as above may be completely suitable for rough uses, such as floor scrubbing, etc., it will certainly not suffice for average toilet purposes, since it will be devoid of attractive appearance and will also be entirely innocent of any pleasant odour. Moreover, it may still carry traces of salt and glycerine which will render it unpleasant for toilet use.

Toilet Soap

There are many ways and means of converting this "soap base" into refined and toilet soaps or into soaps for special purposes. First of all, the soap may be dissolved completely in hot water and again "salted out" by means of the simple process of throwing salt into the solution. It should again be filtered off, pressed and dried. A much purer product may then be obtained by this simple means. The purified soap may again be dissolved in water or it may be very carefully melted, and into this dissolved or melted product may be incorporated a suitable aniline dye and/or a few drops of perfume mixture.

Not all dyes are suitable for soap colouring, since many of them fade under the influence of the slight amount of alkali which all soaps contain. The reader, however, will find suitable soap-colouring dyes tabulated in a convenient form on this page.

Now, with regard to the perfuming of the soap. The exact composition of the perfumes of many of the proprietary soaps is maintained a well-guarded secret, but the amateur may take it as a general rule that almost any pleasant-smelling essential oil will suffice for soap perfuming. In the ordinary household soaps, oils of spike, lavender, mirbane, lemongrass, sassafras, pine and citronella are commonly used, but in most instances "compound" or mixed perfumes are actually employed. Here, for instance, are some actual formulæ of soap perfume of the compound type :—

Fat or Oil Used	Percentage of Caustic Soda	Percentage of Caustic Potash
Kitchen Fat, Grease, etc. (average) ...	14.0	19.5
Tallow, Lard, Suet, etc. ...	14.3	19.8
Wool Fat ...	7.3	10.25
Cottonseed Oil	14.2	19.9
Raw Linseed Oil	13.7	19.0
Castor Oil ...	13.2	18.5
Olive Oil ...	14.3	20.0
Rape Oil ...	12.5	17.4
Cocoanut Oil ...	18.6	26.0
Palm Oil ...	17.8	24.8
Lard Oil ...	14.8	20.7
Bone Fat ...	13.9	19.5
Cod-Liver Oil ...	13.5	18.5
Whale Oil ...	14.0	19.7
Resin (average)	13.0	18.0

Table showing the exact percentage of caustic soda or potash which is required to saponify completely various fats and oils used in soap-making. The percentage solid of caustic soda or potash is calculated on the weight of the fat or oil used

Colour	Dye
Red	Cloth Red
Green	Cynaine Green
Violet	Acid Violet
Golden Yellow	Metanil
Heliotrope	Violamine
Blue	Alizarine Blue
Lemon	Fluorescein
Amber	Bismarck Brown
Salmon Pink	Rhodamine 6G Extra
Pink	Rhodamine B Extra
Canary Yellow	Fast Light Yellow

List of dyes specially suitable for soap-making. Others may also be used, but they may not be alkali-fast

Rose Perfume

Oil of Rose	2¾	parts
Oil of Geranium	2½	..
Oil of Cinnamon	1	

Elder-Flower Perfume

Oil of Bergamot	9½	parts
Oil of Lavender	2¼	,,
Oil of Thyme	2¼	,,
Oil of Cloves	1	,,
Oil of Cassia	¼	,,
Oil of Almonds	¼	,,

Flower Perfume

Oil of Citronella	9	parts
Oil of Lemon	4½	,,
Oil of Cassia	2¼	..

Complicated Formulae

Many of the more complicated formulæ for soap-perfumes contain as many as thirty different ingredients. There would, however, be little use in burdening this straightforward article with such complexities, for every amateur will find himself able to make up suitable perfumes from whatever oils he may have available. In all cases, however, only a few drops of the perfume should be added to each purified "melt" of soap.

Using a hard soap base, such as the one above mentioned, it is easily possible to manufacture any number of medicated and "special" soaps. By adding to the soap base small quantities of disinfectants and antiseptic substances, such as carbolic acid, coal tar, beechwood creosote, the various disinfectant soaps may be prepared. Sulphur soap is made by adding finely powdered sulphur to the soap "mix." Boracic soap is prepared by re-dissolving the purified soap in a solution of borax.

Fine sand and various abrasives may be incorporated with the soap base, thereby producing special types of cleaning and scouring soaps. "Mottled" soap consists of common hard soap through the mass of which has been disseminated particles of ultramine blue.

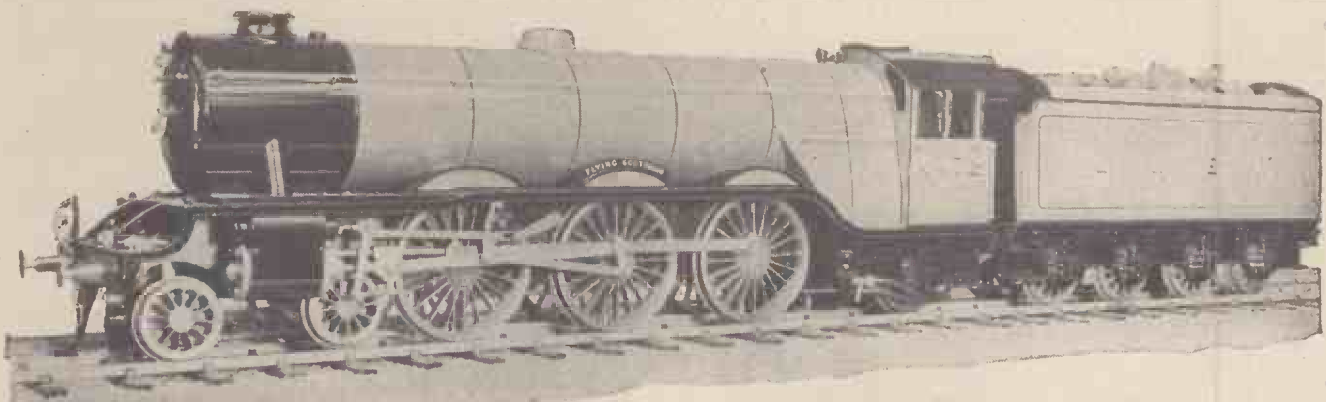
The various brands of brown transparent soap are produced by carefully drying purified soap base and then by shredding the material and by dissolving it in warm alcohol (methylated spirits will do). The spirit solution is then evaporated down, whereupon the soap is left as a brown, translucent mass.

Liquid Soaps

Liquid soaps very frequently comprise merely strong solutions of ordinary soap, suitably perfumed and dyed, and usually the lower the cost of these liquid soaps the greater the amount of water they contain. Sometimes, however, liquid soaps contain small amounts (2-4 per cent.) of sodium silicate and/or sodium metasilicate which improve their detergent properties.

Shaving soaps and creams are usually made from mixtures of fat and olive (or cocoanut) oil. The resulting soap is carefully purified and then a small quantity (about 5 per cent.) of glycerine is stirred into it.

Adding a few drops of concentrated perfume to the refined soap before pressing into moulds



This picture of the completed and painted locomotive gives a good idea of the realistic appearance of this remarkable model.

Building a $2\frac{1}{2}$ in. Gauge Model of the "Flying Scotsman"—3

Constructional Details of the Inner Boiler Barrel, Boiler Casing and Cab

THE inner boiler barrel is a piece of $2\frac{1}{2}$-in. diameter solid drawn copper tubing, and this must have the ends carefully filed square till it measures exactly 16 in. long. There are five $\frac{1}{4}$-in. water tubes, and after being bent to shape, the ends are silver-soldered into holes drilled in the underside of the boiler barrel (see Figs. 17 and 25). The centre line for the holes for the front ends of the water tubes is $1\frac{1}{4}$ in. from the front end of the boiler barrel, the centre line for the holes at the rear end being $\frac{1}{2}$ in. from that end of the boiler barrel. The centres of the holes are spaced $\frac{3}{8}$ in. apart at the rear end of the boiler, but the holes are staggered at the front end, as shown in Fig. 26, which shows all the tubes soldered in place.

Boiler Ends

The boiler end castings are turned to fit the boiler barrel and are silver soldered in place. In the front end, two holes $\frac{3}{16}$ in. and $\frac{1}{8}$ in. diameter are drilled for the steam pipe and blower respectively (see Fig. 16), and these are silver-soldered in place at the same time as the boiler end.

Before fixing the rear boiler end in place it is riveted to the back plate, which is made of $\frac{1}{16}$ in. sheet brass, and shaped as in Fig. 18. These are brazed together at the same time as the boiler end is silver soldered into the boiler. Holes are drilled through the back plate and boiler end, and tapped for the $\frac{1}{2}$ in. steam regulator, blower valve, water gauge, check valve, and pressure gauge fitting (see Fig. 18). It should be noted that the steam pipe is a piece of $\frac{3}{16}$ in. diam. copper tube, and this passes right

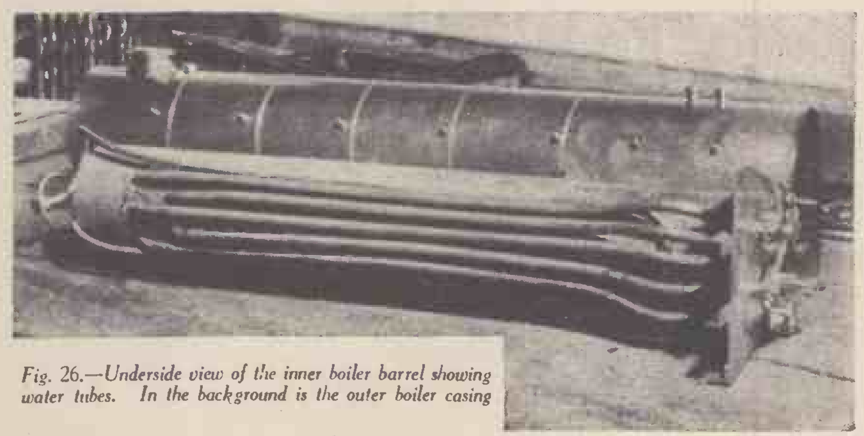


Fig. 26.—Underside view of the inner boiler barrel showing water tubes. In the background is the outer boiler casing

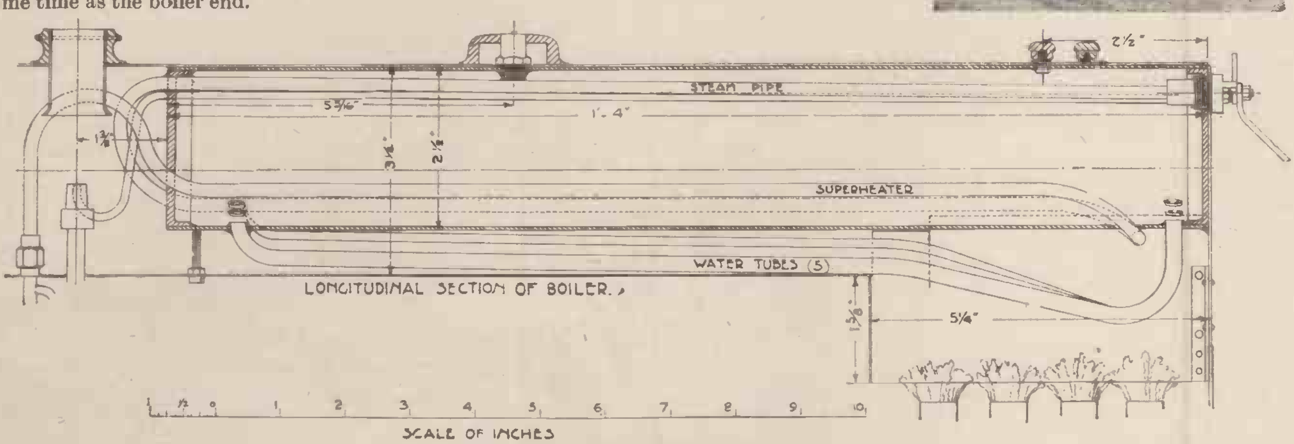


Fig. 25.—Section of inner boiler barrel and outer casing, showing water tubes, steam regulator and superheater pipe

through the boiler, and is bent back into the firebox, thus forming the superheater. Pieces of $\frac{3}{8}$ in. angle brass are riveted to the sides of the back plate for fixing to the outer casing.

The safety valve bushing is silver-soldered in the top of the boiler barrel in the position indicated in Fig. 25.

Fig. 27.—Outer boiler casing, showing chimney and smoke-box door in position

Boiler Casing

This is made from a piece of $\frac{1}{32}$ in. sheet brass measuring $19\frac{1}{4}$ in. by $10\frac{1}{2}$ in. After making saw cuts for the firebox throat-plate, the metal sheet is formed into a tube $3\frac{1}{4}$ in. diameter, lapped and riveted on the underside with $\frac{1}{16}$ in. copper rivets. The firebox sides are shaped as shown in Fig. 17, and the throat-plate is built up with $\frac{1}{32}$ in. sheet brass and fixed to the firebox sides with $\frac{1}{4}$ in. angle brass.

The smokebox front can be turned from a $3\frac{1}{4}$ in. gunmetal boiler end, with a central hole bored $2\frac{3}{8}$ in.; two small lugs are silver-soldered on to carry the hinge of the door, which is $2\frac{3}{8}$ in. diameter. This is made from a piece of $\frac{1}{16}$ in. sheet brass, domed with a hammer. The hinges are made of $\frac{3}{32}$ in. strip brass with lugs silver-soldered on, and are riveted to the door. A piece of $\frac{1}{16}$ in. German silver wire is used for the hinge pin. Fig. 27 shows the smokebox front and hinged door in position.

The chimney, which is turned from a casting, is bored $\frac{1}{8}$ in. and riveted to the boiler casing. The casing can now be set up on the chassis to the correct height, with the smokebox saddle in position (Fig. 28) and marked out for the hand-rail knobs. Holes are drilled $\frac{3}{32}$ in. for the screwed stems of the knobs, which are fitted with brass nuts on the inside of the casing.

Fig. 28.—The finished outer boiler casing in position on the chassis

German silver wire $\frac{1}{16}$ in. diameter is used for the handrail. At the same time the position of the dummy safety valves is marked out, the snifting valve, and the working safety valve, which is fitted under the dome. The safety valve is a standard $\frac{1}{2}$ in. scale fitting, and is used on this model for safety's sake, as the twin valves, in their correct position over the fire box, are too small to ensure satisfactory working.

Boiler Bandings

The boiler bandings are of $\frac{1}{4}$ in. wide thin strip brass, and are set out and fitted with $\frac{1}{16}$ in. brass bolts and nuts for clamping the ends together underneath the boiler casing. In the case of the banding interrupted by the dome, this is riveted on each side of the $\frac{1}{2}$ in. diameter hole which is drilled for the safety valve.

Fixing the Inner Boiler Barrel

The rear end of the inner barrel is held in the casing by $\frac{3}{32}$ in. screws each side on to the brass angle of the back plate. The front end of the inner boiler barrel is supported by a $\frac{1}{8}$ in. screw at a distance of $3\frac{1}{4}$ in. from the front of the outer casing. This screw is clearly shown in Fig. 25. The boiler casing is held in position on the saddle by a $\frac{1}{8}$ in. screw on each side, the firebox sides resting on the footplate, to be eventually attached by the cab.

The Cab

The spectacle plate for the cab (see Figs. 18 and 29), is cut out of $\frac{1}{32}$ in. sheet brass with $\frac{1}{16}$ in. angle brass riveted and soldered to the sides. The cab sides are also cut out of $\frac{1}{32}$ in. sheet brass, and the windows are beaded round with $\frac{3}{32}$ in. half-round brass (see Fig. 4). The cab roof is bent to shape, and on top is soldered a piece of $\frac{1}{8}$ in. flat brass, curved to suit. Standard round-head buffers are screwed into the front buffer beam, and a steel coupling hook with German silver links is fitted.

Wheel Splashers and Nameplate

The wheel splashers are castings, which are cleaned up and soldered to the footplate. The nameplate, which is soldered on, above the central splasher on each side of the engine, is cut out of $\frac{1}{32}$ in. brass, and the name can either be engraved, or painted on.

The steam pipe covers between the footplating and smokebox are made of $\frac{1}{32}$ in. sheet brass bent to shape (Fig. 15).

The axle-driven pump is fitted with a bypass, the hollow chamber for which is made out of $\frac{3}{8}$ in. square brass drilled up and tapped, and fitted with a No. 0 (male end) union cock. When this is in the horizontal position it is bypassing (Fig. 21). The vacuum pipe is made up of $\frac{1}{8}$ in. tubing, and the lamp bracket is a standard $\frac{1}{8}$ in. scale fitting.

The cylinders are lagged with thin Russian iron, held in place by $\frac{1}{16}$ in. round-headed screws.

(To be concluded)

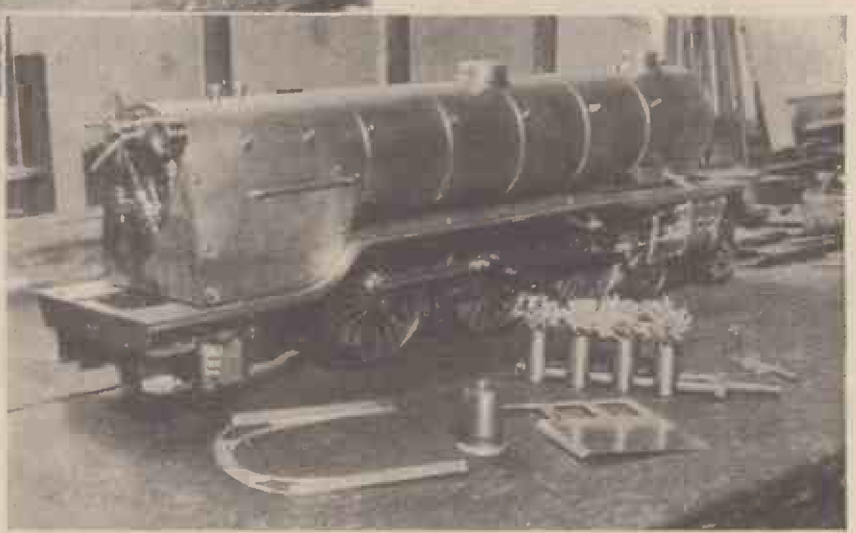
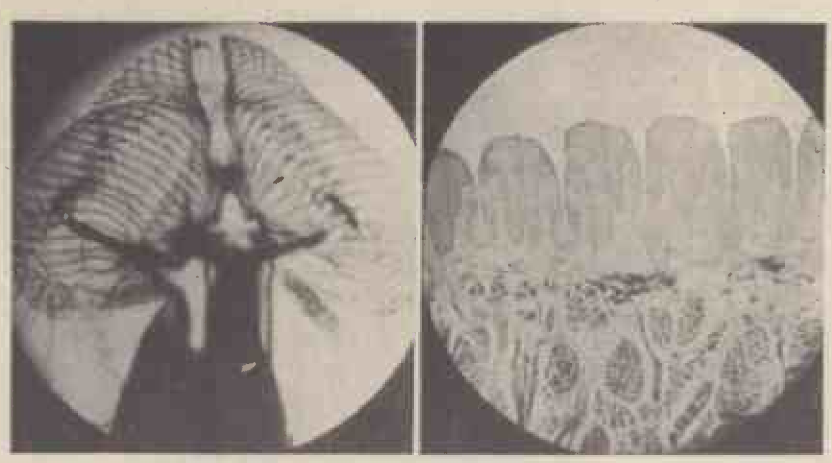


Fig. 29.—Rear view of outer boiler casing and engine chassis. In the foreground are seen the spectacle plate, cab side, and spirit burner

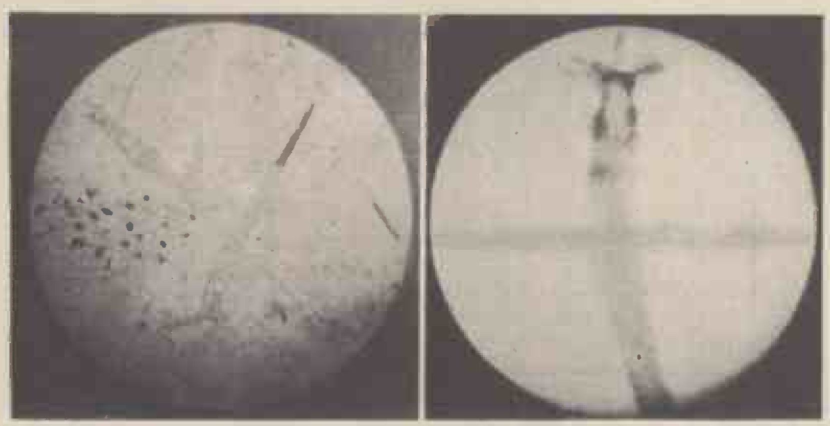
Simple Photomicrography

How to obtain Successful Results with the Simplest of Apparatus

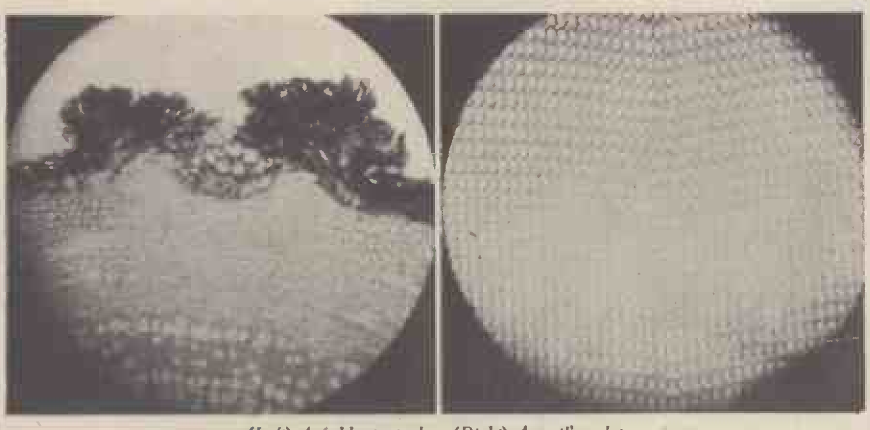
By D. Leatherdale



(*Left*) *The proboscis of a blowfly.* (*Right*) *A human tongue papillae*



(*Left*) *Stinging hairs of a nettle.* (*Right*) *Hydra fusca*



(*Left*) *A n elder tentacle.* (*Right*) *A snail's palate*

IN these days of mental stress and nights of black-out, many of us are looking around to find some way of occupying our evenings on a subject far from the topic of the war. Of course, there are numerous hobbies and pastimes to which we can turn attention for respite, both scientific and otherwise, assuming that we are not already enthusiastic followers of some particular line. However, in this short article I intend to discuss some of my experiences in the realm of photomicrography, as the results have been well worth the small amount of trouble expended upon them.

From the few failures I have had valuable lessons have been learned, as I do not consider a spoilt negative a wasted one. It is important to find out *why* a thing goes wrong before trying a second time.

The apparatus described is simple in the extreme, and, apart from the microscope itself, costs very little. It is an advantage to be already in possession of a microscope, as such an instrument is admittedly expensive, and at least an elementary knowledge of its use is essential before attempting photomicrography. When I began taking photographs through my microscope I was definitely a beginner, since I spoilt my first plate by exposing the backing instead of the emulsion, through sheer ignorance! Yet I think my second photograph was not far from excellent, purely by chance.

Arranging the Microscope

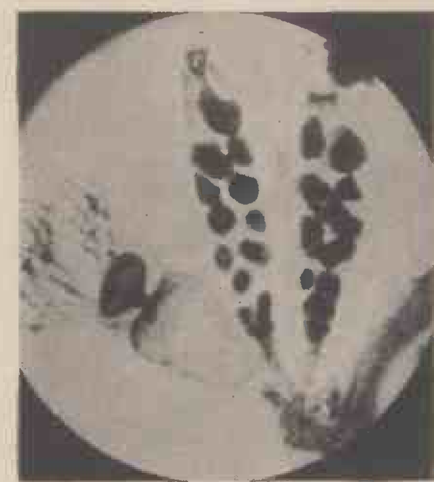
The microscope is set up vertically, with the substage condenser in position. A filter should be employed, and normally a "daylight blue" glass will suffice, but if the object to be photographed is highly stained, a filter of the opposite colour will give sharper definition. Thus a section stained red would require a green filter.

The beginner is well advised to use the lower powers of his microscope, as the exposures are easier to estimate, the focusing is simpler, and the pictures are clearer, all of which are important points to the novice. The majority of my photographs shown in the accompanying illustrations were taken using a 2/3 in. objective and a ×10 eyepiece. A 100 watts pearl lamp was used, built in a well-ventilated cocoa-tin housing, and great care must be taken to see that the mirror of the microscope centralises the light correctly, or else the pictures will be unevenly illuminated. In some microscopes annoying reflections may occur from the inside of the tube of the instrument, in which case it should be lined with velvet or matt-surfaced black paper.

Supporting the Camera

The type of camera used may depend on the work in hand, but I used a very cheap box camera. As a camera in the normal sense it functioned extremely crudely, so no harm was done when I cut the back completely off. A piece of finely ground glass 2½ in. by 3½ in. fitted into the hole at the back as a focusing screen. That was all the preparation needed to adapt it for photomicrography. I supported it on end above the microscope eyepiece by the simple expedient of putting a pile of books on either side of the microscope, and laying a couple of rulers across the top. This held the camera in position quite satisfactorily.

The choice of a plate or film is an important matter, and one that can only be decided after several trials have been made. Ilford Process Film meets all requirements, and is supplied ready cut in 2½ in. by 3½ in. pieces. It is thicker than the normal film, and is thus easier to handle. Process Plates are also obtainable, but I think film is easier to store, develop and manipulate generally. If it shows signs of bending when placed in the back of the camera it may be straightened by laying the focusing screen upon it. But the most useful point about this type of film, and plate, is that it has a very



Obelia Hydroids

slow speed (H & D 15 or 25), and the exposures are thus allowed a greater margin of error.

Making an Exposure

We are now ready to start trying some photomicrography. The room must be darkened, except for a red working lamp and the microscope illuminant, and the object displayed to its best advantage in the field of the microscope, bearing in mind the previous remarks about making use of the low powers. The condenser is racked up to give the brightest light, and if it has a diaphragm this should be closed sufficiently to gain a clearer definition of the finer details of the object. And remember to choose a suitable filter now. The camera is then placed centrally over the eyepiece, resting on the two rulers, and the shutter left open. The ground glass screen is rested on the film guides, and any minute corrections in focusing made.

The next step is to cut out all extraneous light, and this can be done by draping a blanket over the lamp-housing and around the piles of books, thus enclosing everything except the back of the camera, which projects out at the top.

The microscope lamp is now switched off. A piece of film or a plate, previously kept in a light-proof box or an adjacent cupboard, is then exchanged for the focusing screen, and the back of the camera covered with a box lid or some similar object. The exposure is made by operating the lamp switch for the required interval, as this does not jar the camera in any way. The length of exposure can be calculated from the accompanying table. The film may then be replaced in its box for later attention, or it may be developed on the spot, the latter method for preference. Keep the dishes ready on one side, as mistakes are then seen at once, and the next film saved from probable ruin. It is essential to keep notes on the photographs as you take them, embracing such data as the subject, date, objective, eyepiece, exposure, filter, opening of diaphragm, light power, etc.

That is all that has to be done except, of course, to obtain prints from the negatives, and unless you feel capable of making a good job of this part of the work, it is best to let it be done by a professional man.

Several photographs may be taken and developed in one evening, but never let yourself be hurried; take your time over each step and nothing will go wrong.

In the accompanying table it is assumed that the film is Ilford Process, or one of similar speed, and that a 100 watt lamp is used to its full advantage. The figures given are not intended to be absolute, but are the average figures of my results.

Type of Object	*Objective*	*Eyepiece*	*Exposure*
Botanical sections	⅔ in. ⅙ in. ⅔ in.	×10 × 6 × 6	5 secs. 5 secs. 4 secs.
Hairs, rock sections	⅔ in. ⅙ in.	×10 ×10	5 or 6 secs. 8 secs.
Histology (dark stain)	⅔ in.	×10	5 secs.
Histology (light stain)	⅔ in. ⅙ in. ⅔ in.	×10 × 6 × 6	4 secs. 5 secs. 4 secs.
Insect parts, etc.	⅔ in. ⅔ in.	×10 × 6	5 secs. 4 secs.
Diatoms, coelenterates, protozoa, etc. ..	⅔ in. ⅙ in. ⅔ in.	×10 × 6 × 6	4 or 5 secs. 5 secs. 3½ secs.
Extremely thin objects	⅔ in. ⅙ in. ⅙ in.	×10 × 6 ×10	3 secs. 2½ secs. 8 secs.

BOOKS worth READING

"Modern Ignition Simply Explained." By Harold H. U. Cross. Published by The Technical Press, Ltd. 144 pages. Price 5s. 0d. net.

THE purpose of this handbook is to describe, in simple language, the fundamental principles of the electrical ignition systems used upon motor vehicles, aircraft, motor-boats, tractors, tanks, etc., and without delving too deeply into technical details, the differences between the various systems of ignition now in use are clearly explained. The book is divided into twelve chapters, the subject matter dealt with including Ignition Systems in a Nutshell; Principles of Induction; Magnetos at a Glance; The Coil. Dynamo-Battery System; Modern Magnetos and Coil Sets; The Art of Timing, and Care and Maintenance. It is interesting to note that among the various magnetos described in the book, the old model T Ford Magneto finds a place. The book is well illustrated in half tone and line, and there is also a full index.

"Soldering, Brazing, and the Joining of Metals." By Thomas Bolas, F.C.S. Published by Percival Marshall & Co., Ltd. 84 pages. Price 1s. 6d. net.

THIS is an enlarged edition of a useful handbook which deals with all kinds of soldering; including soft soldering; electric wire and cable jointing; "wiped" joints; brazing; burning; and soldering with tinfoil. The book is well illustrated in line and half-tone.

THE STRAND MAGAZINE

WHEN M. Curie and his brother announced in 1880 that they had discovered a curious thing about crystals of quartz they did not imagine that their observation would make television possible, or protect us from icebergs and submarines.

Readers of this paper are likely to be interested in an extremely able article in the April issue of "The Strand Magazine" on "Discovery of Inaudible Sound." The amazing uses of supersonic waves are described, and it is rightly pointed out that although nobody knows yet the limits of their usefulness, they are already one of the most important safeguards to our country.

This same issue of "The Strand" also contains a particularly interesting account of the training of the Naval diver. It is obtainable through all Newsagents and Bookstalls.

POSTAL MILLIONS

THE Commercial Accounts of the Post Office for the year ended March 31st, 1939, just issued, give some interesting figures. There is a surplus of £10,254,578, a reduction of £973,302 on the surplus for the previous year. This reduction is largely accounted for by the increase in staff costs.

During the year 8,150,000,000 letters, and 184,832,000 parcels were dealt with. This is an increase of nearly 4 per cent. in the case of letters and 3 per cent. in the case of parcels.

There were 2,122,400,000 local telephone calls and 111,553,000 inland trunk calls. Out of 5,715 telephone exchanges, 2,925 are automatic. There are 49,518 call offices and 3,235,498 telephones. Wire used in connection with the postal services runs to 15,299,000 miles.

The Post Office employs a staff of 283,371 and owns 17,384 motor vehicles. Business transacted with the public reached the enormous figure of £1,062,217,000. Capital expenditure during the year amounted to £21,585,156. It was mainly for the development of the telephone system.

Chemistry for Beginners

Left.—Making boric trioxide by fusing boric (boracic) acid in a crucible
Right.—Showing the method of upwards filtration by means of a cloth tied over a funnel. By plunging the mouth of the funnel downward into the liquid, the latter will be forced through the filtering cloth into the funnel from where it can be run off into a bottle merely by sharply inverting the funnel. This is a very useful procedure to adopt in many forms of laboratory technique

No. 13.—The Chemistry of Boron. Simple and Interesting Experiments with Borax, Boric Acid and Related Compounds

STRANGELY enough, the various compounds of boron are usually left severely alone by the average experimenting amateur, who frequently labours under the missapprehension of regarding boron as a "difficult" element to experiment with. True it is that boron is not altogether easy to isolate in its pure state, yet the element is one which gives rise to numbers of most interesting compounds, the majority of which may be simply, and inexpensively, prepared.

Boron is the element of borax, that well-known sodium salt of boric (or boracic) acid, which has been known and used for at least a couple of thousand years. The ancient Arabs called borax "buraq," whilst the Romans, during their civilisation, gave it the name by which it is now known. Hence, when the chemical element contained in borax was first isolated in 1808 by J. L. Gay-Lussac, and J. Thénard, nothing was simpler than to call it "boron," the borax element.

Boric Acid

Borax and boric acid are two very closely related compounds, borax being the sodium salt of boric acid. What is usually termed "boric acid" is chemically spoken of as ortho-boric acid, and it possesses formula $B(OH)_3$. There are, however, two related boric acids, one, meta-boric acid, $BO(OH)$ (or $H_2B_2O_4$), and pyro-boric acid (sometimes called tetra-boric acid), $H_2B_4O_7$. Ordinary borax is the sodium salt of this pyro-boric acid or tetraboric acid, and is thus chemically spoken of assodium pyroborate, or sodium tetraborate. It has the chemical formula, $Na_2B_4O_7.10H_2O$.

Both boric acid and borax are well-known commodities which have an extensive usage. Boric acid is known and used for its mild antiseptic properties, whilst very large amounts of borax are employed in the production of vitreous enamels and, also, of optical glass. Borax forms an ingredient of soldering fluxes. It is also sometimes employed as a food preservative, whilst its other uses are concerned with soap manufacture, varnish production, laundry work, and in certain types of metal production.

Making meta-boric acid by heating ordinary boric acid to 100° C. on a water bath. The ordinary boric acid contained in a small beaker which is secured within a beaker of boiling water and is thus heated by the steam arising from the latter

Most of the borax of the present day comes from the vast deposits of calcium borate which are to be found in Bolivia. Boric acid, on the other hand, comes from Italy, in which country it occurs (particularly in Tuscany) in the volcanic jets of steam which are common in that region. These steam jets condense to small ponds of water which become highly charged with boric acid. Thus the water is simply drained away and evaporated to crystallising point.

It was only at the beginning of the 18th century that boric acid became known. It was then made from borax and was called in England *Sal sedativum*. Towards the end of the same century, its acidic nature became recognised and it was then termed "boracic acid." It is only within comparatively recent times, however, that "boracic acid" has been abbreviated to "boric acid." Both "boric acid" and "boracic acid" are one and the same substance, but "boric acid" is nowadays the correct, and the scientific name to use for this material.

Both boric acid (which, as we have already seen, is chemically termed "ortho-boric acid") and borax are inexpensive and plentiful materials, and, using them as a starting point, we can prepare a considerable number of different substances from them.

Meta-Boric Acid

Take boric acid (ortho-boric acid), for instance. If we heat a quantity of this material in an open basin on a water-bath it becomes converted into meta-boric acid, $H_2B_2O_4$, with loss of water. Thus :—

$$\underset{\text{ortho-boric acid}}{2H_3BO_3} = \underset{\text{meta-boric acid}}{H_2B_2O_4} + \underset{\text{water}}{2H_2O}$$

By heating meta-boric acid to a temperature of 140°C. for some time it becomes converted into pyro-boric (or tetra-boric) acid, $H_2B_4O_7$. This pyro-boric acid may, also, be obtained directly from ortho-boric acid ("ordinary" boric acid) by heating it to a temperature of 140°C.

All the three boric acids are white, crystalline solids which are only slightly soluble in water. Ordinary boric acid (ortho-boric acid), in particular, is more soluble in alcohol than it is in water. Consequently, when a spirit lamp is fed by methylated spirit containing boric acid in solution, the flame is always tinged with the very characteristic livid green hue of boron compounds.

Boron Trioxide

We now turn to a very interesting compound, to wit, Boron trioxide, B_2O_3, which is readily made by heating boric acid to redness. At this temperature, the acid fuses and gives up the elements of water :—

$$\underset{\text{ortho-boric acid}}{2B(OH)_3} = \underset{\text{boron trioxide}}{B_2O_3} + \underset{\text{water}}{3H_2O}$$

This fusion is best carried out in a procelain crucible, although, for convenience, it may be conducted in almost any vessel. The fused mass of boron trioxide congeals on cooling to a glass-like solid which very slowly absorbs moisture from the air and becomes opaque.

Boron trioxide is interesting in respect of the fact that it is capable of dissolving many metallic oxides, and becoming coloured by them. Borax itself has also this property—upon which the well-known laboratory "borax bead" tests depend. In these tests, a small amount of borax is fused on the end of a glass rod, or platinum wire, and then touched with or dipped into a quantity of the oxide or other compound whose metallic nature it is required to determine. The "bead" is again re-fused, whereupon it will acquire a colour due to the solution of the metallic oxide in the borax, this colour being characteristic of many metals. Thus, copper compounds in a borax bead will give rise to a blue coloration of the bead, iron compounds will colour the bead yellow, nickel compounds will impart to the bead a brownish hue, manganese compounds will produce an amethyst tint and so on. Full particulars of these "borax bead" tests are usually to be found in any elementary textbook of practical inorganic or analytical chemistry, such as can be referred to in any Reference Library.

Sulphur Trioxide

Using boron trioxide, we have a convenient method of preparing sulphur trioxide, which latter compound, when dissolved in water, produces sulphuric acid. To make sulphur trioxide (*not* dioxide) boron trioxide is fused with potassium sulphate. White clouds of sulphur trioxide are expelled. In order to collect these, the heating, of course, should be done in an enclosed vessel provided with an outlet tube dipping below water at its extreme end. By this means, a reasonably strong solution of sulphuric acid can be obtained.

Another very interesting compound which can be obtained from boron trioxide is boron trifluoride. It is, in fact, one of the few fluroine compounds which the ordinary amateur can prepare. To make boron trifluoride, BF_3, we mix equal quantities of powdered fluorspar and powdered boron trioxide, and heat the mixture with concentrated sulphuric acid. The ensuing reaction is a complicated one, but boron trifluoride will be evolved as a colourless, pungent gas which will give rise to dense white fumes in contact with moist air.

Boron trifluoride is truly remarkable in respect of its violent affinity for water. So great is this affinity that if a piece of paper be held in a stream of the gas, the paper will actually become charred owing to the abstraction of water from it by the gaseous boron trifluoride.

Boron trifluoride is not an inflammable gas. It is, however, very soluble in water, one volume of water dissolving nearly 1,000 volumes of the gas at 0°C. By passing boron trifluoride gas into water until the latter liquid is saturated, a syrupy fluid will be obtained. This is often called fluoboric acid although its composition is by no means certain. However, the liquid is a strongly corrosive one, and it will char paper, wood and similar materials. Hence it should be treated with due respect.

If this "fluorboric acid" is diluted to half its volume with water, it will form meta-boric acid (which will separate out in white crystals) and hydrofluorboric acid, HBF_4, which will remain in solution.

Hydrofluorboric acid will usually dissolve metallic hydroxides with the formation of borofluorides (or fluorborates). Some interesting salts may therefore be made by taking advantage of this property.

Boron Trichloride

Boron trichloride, BCl_3, is another product which can be prepared from boron trioxide. It is made by passing dry chlorine gas over a mixture of powdered boron trioxide, and charcoal, which is heated to redness in a poreclain tube. The boron trichloride should then be condensed in a vessel immersed in ice and salt or in a freezing mixture. It is a colourless, fuming liquid which boils at 18°C. and when acted upon by water, produces boric and hydrochloride acids. Boron trichloride, therefore, should always be kept in a sealed glass tube.

By mixing equal amounts of boron trichloride vapour and ammonia gas, a white crystalline compound having the formula, $2BCl_3 3NH_3$, is produced. Incidentally, boron trifluoride gas undergoes a like reaction, for when it is mixed with ammonia (in equal volumes) it gives rise to the compound, BF_3NH_3, which is also a white, crystalline material.

The well-known "Borax Bead" test, as described in the text

Boron sulphide, B_2S_3, may interest some experimenters, although it is not a pleasant substance, being lachrymatory or tear-producing in its effects. It is a yellow solid which is made by passing a stream of carbon bisulphide vapour over boron trioxide which has been mixed to a paste with soot and lubricating oil, the mixture being heated to bright redness.

This experiment must be performed with much care and preferably out of doors, since carbon bisulphide has not only an overpowering and disgusting odour, but its vapour is extremely inflammable when mixed with air. Using common-sense precautions, however, the experiment is quite safe.

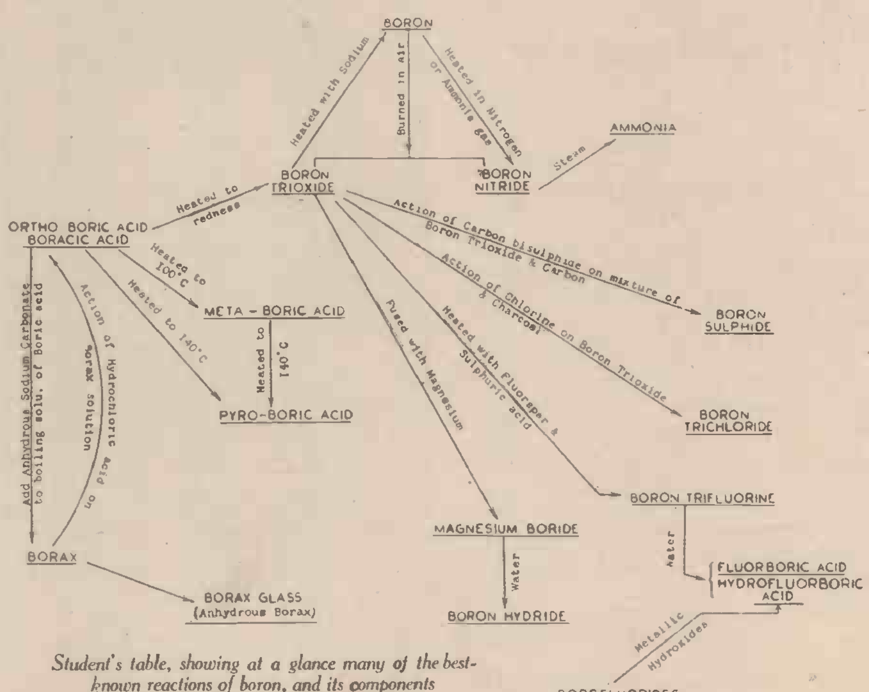
And now as regards the element boron itself. It is not very easily prepared, and, indeed, to prepare it in a state of 100 per cent. purity is an extremely difficult operation.

Preparing Boron

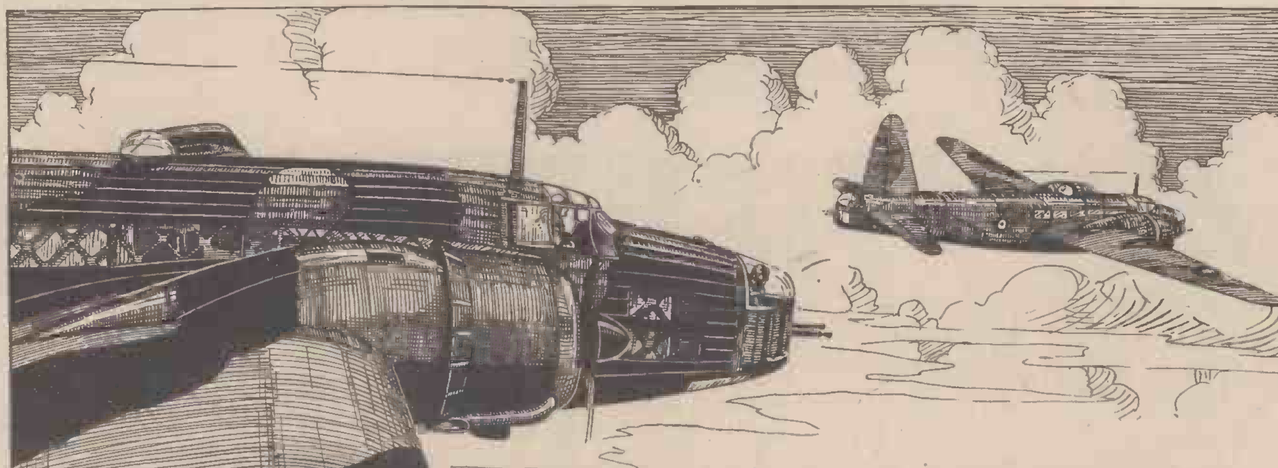
The experimenter, however, can best prepare boron by heating in a covered crucible sodium and boron trioxide. The mixture should be fused at the highest possible temperature and the greatest care must be taken to see that no water comes in contact with the crucible, otherwise the heated sodium will explode. After the mass has been fused for five or ten minutes, allow it to cool completely, and then immerse the crucible bodily in dilute hydrochloric acid. After any action has died down, the acid (with the crucible still immersed in it) should be boiled. As a result, a dark brown powder will be observed. This, which is fairly pure boron, should then be filtered off, washed and dried.

Baron, although it can exist in other forms, appears, when prepared by this method, as a greenish-brown powder which is insoluble in water or most acids. When acted upon by cold concentrated nitric acid, however, it is converted into boric acid. With concentrated sulphuric acid, too, a similar result occurs.

(*Continued on page* 335)



Student's table, showing at a glance many of the best-known reactions of boron, and its components



SCALE MODEL AIRCRAFT
No. 1

THE VICKERS - ARMSTRONGS WELLINGTON I

By J. H. Stevens, A.R.Ae.S.I.

THE Wellington I, although it has not been very long in service with the R.A.F., is already familiar to the general public because of its marked success in the Wilhelmshaven raid early in the war, which has received a great deal of publicity in the film *The Lion Has Wings.* Apart from its aerodynamic qualities the Wellington is of exceptional interest to the engineer because it represents the successful incorporation of the Vickers-Wallis geodetic construction in an aeroplane of very modern performance.

Geodetic Construction

Geodetic construction is a method of building shell structures with a latticework of pre-formed metal sections. The term "geodetic" is derived from a surveying word used in the measurement of distance on the earth's surface, and means that a geodetic line is the shortest distance between two points in a curved plane surface, lying on that surface. By making the fuselage, main planes and tail unit from curved panels consisting of intersecting diagonal members (each with a slight curvature) it is possible to divide each panel into a very large number of small areas braced by diagonals joined at their mid points. It is well known that slender struts are much stronger in tension than in compression, and it has been found that it is possible, by linking these curved diagonals in the middle, to convert the compressive force developed in one into a tension load in the other. As soon as the member in compression begins to bow minutely, the other diagonal takes the load in tension and the deformation is arrested. Each strut formed by the length of geodetic member between links is very short (about 9 in. on the average), so that the panels made by them are small, and when fabric covered they are capable of resisting air pressures of 1,000 lb./sq. ft.

Since geodetic construction forms the shell, albeit an openwork one, of a structure, and carries all the essential loads—were it not for the need of detachable panels for maintenance work and the like, it would be unnecessary to have spars and frames—it is more truly a stressed-skin than the wings of that name, which have to be given spars and ribs to help carry their loads and conserve their shape.

First Geodetic Aeroplanes

The first geodetic aeroplanes, which were flown in 1935, were the Vickers G4/31 biplane and a monoplane, the former built to an Air Ministry Specification for a general-purposes aeroplane, and the latter as a private venture to beat the specification. The biplane had a geodetic fuselage: the monoplane was entirely of the new construction and was awarded the contract. This aeroplane was named the Wellesley and was, of course, later responsible for gaining the World's Distance Record for Great Britain. The experiences gained in service with the Wellesley were incorporated in the Wellington, a twin-engined bomber to the Air Ministry Specification B9/32, and resulted in there being a considerable difference between the prototype, which appeared in 1936, and the production machines which began to reach the squadrons in 1938.

FACTS ABOUT THE VICKERS WELLINGTON I.

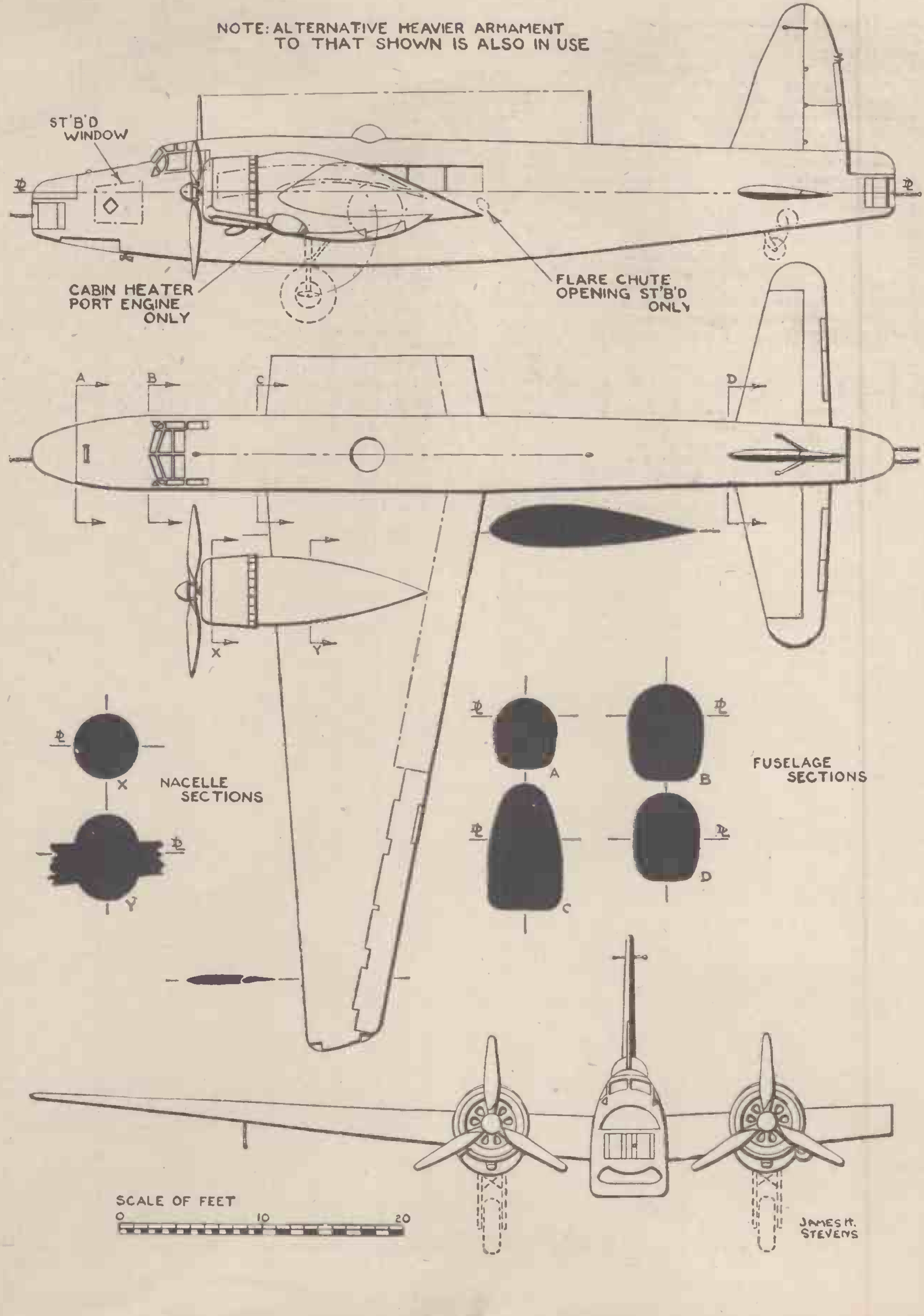
Span	*86 ft. 0 ins.*
Length (tail down) ...	*61 ft. 3 ins.*
Height (tail down) ...	*17 ft. 5 ins.*
Loaded weight (normal) ...	*24,850 lb.*
Wing loading	*29.6 lb./sq. ft.*
Power loading	*12.8 lb./h.p.*
Rated powers: 4,750 ft. ...	*815 b.h.p. per engine*
14,750 ft. ...	*750 b.h.p. per engine*
Max. power (at 15,500 ft.)	*885 b.h.p. per engine*
Max. speed, 17,000 ft. ...	*265 m.p.h.*
Normal cruising speed, 15,000 ft.	*215 m.p.h.*
Max. range, at 180 m.p.h.	*3,200 miles*
Service ceiling	*26,300 ft.*
Climb to 15,000 ft.... ...	*18 mins.*

The Wellington is a mid-wing monoplane with very high-aspect ratio tapered wings. With normal construction it is more economical to make low-aspect ratio wings, i.e. the ratio of span to chord is small, because the weight increases greatly with the span. The geodetic structure, on the other hand, does not get proportionately heavier as the span increases, in fact it is only on the high-aspect ratio wing that its qualities come into their own. The great advantage of having a large-span, narrow-chord wing is that the take-off is much better and all climbing characteristics, including the ceiling, are improved without a corresponding increase in drag.

Wings

An idea of the principle of the geodetic wing has already been given. In practice, the ideal has to be modified slightly in the interests of production and maintenance. The leading edge is metal covered and is made in detachable sections; the trailing-edge portions (over the flaps) and the ailerons are too small, together with being comparatively lightly loaded, to make them worth constructing on any but the conventional duralumin tube with fabric covering construction. The main portion of the wing has three very light tubular spars and three light transverse members which act solely as locations for the geodetic panels. The main portion of the wing is almost free from obstruction so that the

A SIDE, PLAN AND FRONT VIEW OF THE VICKERS-ARMSTRONGS WELLINGTON I.



tanks can easily be stored inside them. The engine nacelles, which incorporate the undercarriage units, gravity tanks and oil tanks, are of metal-skinned construction and they carry fittings to which the centre-section and outer main-plane panels are attached. The lattice work of the geodetic main-plane members has an unfortunate repercussion on the appearance of the finished machine from the modeller's point of view. The fabric sags slightly between the members, giving the effect of a large number of diamond-shaped depressions—when in flight the suction on the top surface transforms these depressions into slight bulges which impart a quilted effect. These surface irregularities are very slight in fact, although distinctly noticeable, and are not sufficient to affect performance by more than one or two miles an hour.

Fuselage

The fuselage is built up from large geodetic panels with only six cross frames and four slender tubular longerons for locating purposes. The frames are placed one in front of the pilot to "gather up" the ends of the geodeses at the nose, one behind the pilot to do the same for the main fuselage members, two frames for the front and rear wing spar positions and two tail-plane spar frames respectively. The covering of the fuselage is by fabric stretched over thin longitudinal slats which obviate the dimpled effect of the main planes. Round the crew's quarters the walls are packed with sound-proofing material. A distinctive feature of the Wellington is the large number of windows, which are, of course, simply made by substituting transparent panels for fabric where necessary. Interior arrangements consist of a hydraulically-operated gun turret in the nose, just aft of which the bomb-aimer's position is located, the first pilot is seated on the port side with the reserve on a movable seat on his right. Behind the pilot's come the wireless operator's and the navigator's posts with their equipment, including a hatch with a transparent dome for making astral and solar observations. This section, which is over the main plane, contains bunks and the general amenities for the crew, including an embarrassingly centrally situated and lofty necessity! Beneath the floor lie the bomb (or leaflet) compartments. The last member of the crew is seated in the rear turret—a journey of some ten or twelve yards along a narrow catwalk. It is a peaceful spot this—on manœuvres in peace-time—remote from the throb of the engines, with a magnificently detached view in all directions, including the latticed perspective of the interior and one's own wing tips and tail plane, at the same time comfortably warmed by a controllable jet of air from the exhaust heater, with only the occasional movement of the elevator spar or rudder control rods to disturb the calm.

Tail Unit

The fixed surfaces of the tail unit are made with geodetic panels like the wing, while the controls are of the conventional ribbed, fabric-covered type with mass balances and servo tabs. The tips of all surfaces (including the main planes) are formed by detachable metal-skinned panels easily replaced in the event of damage.

The engines on the Wellington I are the Bristol Pegasus XVIII nine-cylinder air-cooled radials of 885 h.p. They are fitted with two-stage superchargers which give two operating altitudes of 4,750 ft. and 14,750 ft.—this makes the machines speed much more equal at all heights. These engines are carried on curiously humped nacelles designed to improve the flow of air over the main plane, and are covered with N.A.C.A. type cowlings with cooling outlet gills. Bristol nose exhaust-collector rings, together with a shuttered crankcase cowling unique on British aeroplanes, are also fitted. De Havilland controllable-pitch airscrews are used. The Wellington has also been fitted with the 1,075 h.p. 12-cylinder vee liquid-cooled Rolls-Royce Merlin and 1,375 h.p. 14-cylinder sleeve-valve Bristol Hercules air-cooled engines, which must increase the already high performance considerably.

Superior to German Plane

The comparable German aeroplane with the Wellington is the Heinkel He 111k Mark V which, with two 1,200 h.p. liquid-cooled engines, weighs 24,900 lb., has a range of 2,170 miles and a maximum speed of 274 m.p.h. The 111k Mk. V is a more modern development of a design contemporary with that of the Wellington. The structure of the Wellington should be far less vulnerable than the Heinkel and its defensive fire power is far superior to that of the three manually-operated German machine guns.

The British dark green and brown "shadow-shading" is now familiar and needs no describing. The under surfaces of large bomber aircraft are painted dull black, as are the airscrews and engines. Red, white and blue cockades are carried on the sides of the fuselage and under the wing. The cockades on the top surface of the wing are dark red and blue only. It will be understood that to give too particular colour-scheme details in wartime would be inadvisable.

NEW INVENTIONS

Handy Handles

TO facilitate the close packing of tea cups, to limit the space required, and to reduce to a minimum the danger of breakage, are some of the aims of an inventor who has devised a new tea cup. The characteristic feature of this article is the handle, which consists of a flange projecting radially and horizontally from the rim of the cup. The upper face of the flange is slightly concave so as to provide a thumb grip. Furnished with a longitudinal oblique groove, the lower face comfortably accommodates the finger of the user.

Not only does the handle make convenient the nesting of the cups for packing and transport, but it is affirmed that the arrangement is useful during their manufacture.

Wind-driven Cycle

WIND as a driving force is not utilised as was the case in the past, although neither the windmill nor the windjammer is extinct. However, there is a possibility of wind as a dynamic force being used in connection with the bicycle. An application to the British Patent Office has been made to protect an invention which has for its object the employment of wind-power to aid the propelling of cycles. It comprises an air motor, a rotor with vanes mounted on the crank axle and rotatable within a casing supported from the frame of the cycle. There is a funnel extending forwardly and upwardly from the casing. The broad, open upper end of the funnel faces the front of the cycle. The casing has an air escape outlet and means is provided for coupling the rotor to the driving wheel.

The foot of the cyclist will now be able to collaborate with the breeze.

Back Washer

DURING ablution, there is one part of the body which it is difficult to reach. That is the region between the shoulder blades. A long-handled brush has hitherto been used to scrub this almost inaccessible spot. The implement, at least in shape, resembles the scratch-back, with which our ancestors were accustomed to relieve the irritation of the skin on their backs. In an antique dealer's shop one sometimes sees an edition de luxe of this scratch-back with an ivory hand.

There is now a back washer which has been patented in the United States. The inside of a bath has fixed to it a clamp and there is a rod pivotally movable, with a handle which operates a brush, enabling one with convenience to scrub the back.

If this back washer should not be thoroughly effectual, it would be possible for the occupant of the bath to rub his or her back against the brush, after the manner of a horse in a field in rubbing its back against the trunk of a tree to neutralise irritation.

SKYBIRD RALLY

THE fourth North of Ireland Skybird Rally will be held on Saturday, April 20th, 1940, at the Ards Airport, at 2.30 p.m. The Classes are as follows:—

1. OPEN COMPETITION, for the Marquess of Londonderry's Challenge Cup. This class is open to all members of the Skybird League Club or Associate in Great Britain and Northern Ireland.
2. Competition for the Marchioness of Londonderry's Challenge Cup for the BEST MODEL made in Northern Ireland. This class is confined to members living in Northern Ireland.
3. CLUB COMPETITION, for Mrs. C. Blakiston-Houston's Challenge Cup. This class is open to all modellers who are members of the Skybird Club.
4. UNDER 14 COMPETITION, for Lady Reid's Challenge Cup. This class is open to all Skybird Members under 14.

Here are the rules:—

Any Model of the Skybird series may be entered in all classes with the exception of models which won awards in this rally last year.

Entry forms to be completed and sent to the District Commodore: Lady Mairi Stewart, Mount Stewart, Newtownards, Co. Down, N.I., not later than April 12th, together with 1s. per model in stamps or postal orders. Models must be sent not later than April 16th.

Any number of machines may be entered in each class, but only one machine in each class can win a prize.

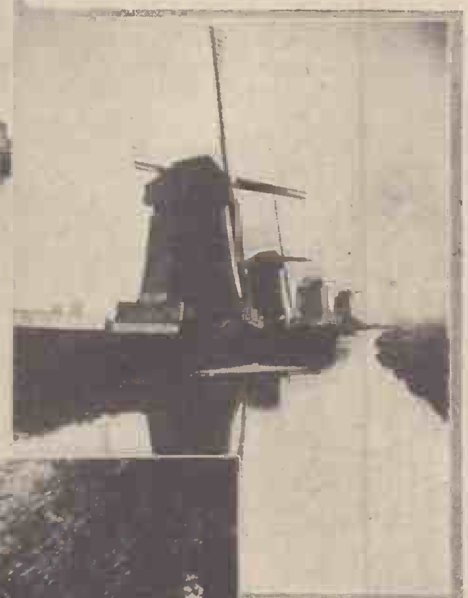
There will be a special prize for the best machine entered by a novice, i.e., one who has never entered a competition before.

Holland's Water Defences

How They Were Built

By G. LONG, F.R.G.S.

ALL the peaceful neutral nations next to Germany have found it necessary to construct defensive lines, but Holland alone boasts a Maginot Line of mud. At first sight mud and water may seem a poor defence, but a moat may be as good as a wall, and twice in her history



Farmhouse on reclaimed land near Breda

(Top centre and above) Drainage windmills near Alkmaar. (Left) A picturesque canal at the Hague

Holland has fought a great power, and won, helped by mud, so that she still holds her independence, and rules the third greatest colonial empire in the world as well. Nearly half of Holland is far below sea level, so trench digging is out of the question, and when such defences are constructed, they must be built up with mounds of earth carted to the spot in lorries.

The Dutch main water-line runs from Muiden on the Zuider Zee past the Lower Rhine to the River Waal, a distance—allowing for bends—of perhaps 80 miles. There is a further water-line to the south of this to fill up the gap between the Waal and the Belgian frontier. There is also another water-line between the main defences and Germany. This is called the Grebbe Line, which runs from the Zuider Zee, near Amersfoot Junction, to the Lower Rhine at Wageningen, a distance in a straight line of about twenty miles, but double this by numerous windings.

Enough to Stop Tanks

It is proposed to flood these water-lines to a depth of about twenty-eight inches. It has been suggested that this may be enough to stop tanks and mechanical transport, but would prove no obstacle to cavalry. It should be remembered, however, that when the water has stood on the land for some time, the heavy clay beneath becomes soggy beyond belief, and may even bog horses. Further, these polders—as the low-lying meadows are styled—are anything from 12 to 18 ft. below the level of the sea, and of the canals which intersect the country in all directions. It follows, therefore, that the Dutch could easily let in enough water to drown the invaders while they were floundering in the swamp. It is certain, however, that they will use as little water as possible, because every gallon which flows on the polders will remain there *until it is pumped out again*, and extensive flooding would mean huge damage and enormous expense to rectify afterwards.

The unique nature of the soil in Holland is well illustrated by the famous case of the "floating farm." During drainage works in 1848, near the village of Aalsmeer, some acres of meadow were separated from firm ground by the cutting of a canal and were driven by a violent wind to the other side of an inland lake. The farmer appealed to the authorities for help, as his fields were now on the wrong side of a large pond, and were detached from the rest of his farm. Incredible as it may seem, these fugitive fields were towed back and pinned down by piles and poles so that they remained in their original position. We have shown, then, that the soggy soil and flooded belts of the Dutch water-line should offer serious resistance to an invader. We must next describe how these remarkable defences were constructed.

A Strange Paradox

Here we come to a strange paradox. The water-line was *not* made to let the water in; it was constructed to keep the water out. The Dutch water defences were built for a fight *against the water*, and it was a battle with many defeats.

In 1277 thirty-three villages were overwhelmed and 20,000 acres of land were inundated. In 1421 thirty-five villages and 25,000 acres were overwhelmed, but the greatest disaster of all began on All Saints Day, 1170, when two great rivers overflowed, and in the course of 200 years the floods continually extended until a million acres had been submerged and the Zuider Zee was formed. To-day this is being drained, and in a few years hence fertile fields will take the place of this vast shallow sea. It is interesting to remark that land reclamation was not possible until the engineer had provided mechanical means for pumping out the water. Tradition avers that the first hydraulic windmill was set up near Alkmaar early in the fifteenth century, and 100 years later reclamation —or impolderisation—had become general. The neighbourhood of Alkmaar even to-day is celebrated for its huge number of drainage windmills. I have counted 17 close together on the road between Alkmaar and Hoorn.

In 1643 an engineer named Leeghwater proposed draining 17,000 acres of the Haarlemmer Meer by means of 160 windmills. Long before the work could be performed, the Meer had increased to more than 45,000 acres and was growing month by month and threatening to overwhelm the countryside.

Steam Power

The tremendous task of draining this inland sea was successfully performed about a century ago, but by means of steam power. Eight hundred million tons of water had to be pumped out merely to empty the lake, with at least another 100 million tons from infiltration and rainfall, and all below the lowest point of outlet.

A canal was dug encircling the lake and the excavated soil was used to build a stout bank of earth on the inner side. The canal was 40 miles in length and as wide as the Thames at Hampton Court. The area of enclosed water was 70 square miles. English engineers constructed three engines each capable of pumping a million tons of water in 25 hours. In four years this vast lake had been pumped dry, and two years later it was producing splendid crops. The total cost of the work was about £800,000, but 41,675 acres of splendid land were recovered and were sold at an average cost of £24 16s. 8d. per acre, i.e. more than a million pounds. The cost included building 130 miles of roads and 70 bridges. The land is largely used to-day for flower cultivation.

Even more remarkable was the reclamation of the Y polders near Amsterdam. To accomplish this, the North Sea Canal was constructed, which not only served to drain the polders, but formed a direct route for big ships from the North Sea to Amsterdam. The canal is 15 miles long, 110 yards wide, and 30 ft. deep. The work was carried through by English contractors —Messrs. Lee & Sons, of Westminster—in 11 years, at a cost of two million pounds. With the lesser drainage canals, there are 40 miles of banks in the whole system. Twelve thousand four hundred and fifty acres of land were reclaimed, and form the richest fruit and flower gardens in all Holland. I have seen splendid crops of strawberries and vivid beds of tulips flourishing where once deep waters flowed. The *average* selling price of this land was £80 per acre, but some of it sold as high as £340 per acre.

Picturesque Windmills

These polders require draining all the year round, because all surplus rainfall *has to be pumped out.*

There are hundreds of picturesque windmills, some of them still at work, but since the great electrification scheme for Western Holland a couple of decades ago, most of the drainage is done by electricity. The electric plant lacks the picturesque effect of the windmills, with their neat thatched towers and wide, sweeping sails, but it is immeasurably more efficient.

Windmill pumps can only work *when there is a wind*, but the electric plant works only when it is required, and then stops. Switches are controlled by floats, and when the water-level is correct the current is switched off.

We have fully described the water defences against rivers and inland lakes, but there are others against the sea itself. Along the broken coasts of Groningen and Friesland, and on the fringes of Zeeland, there is a system of impolderisation from the sea.

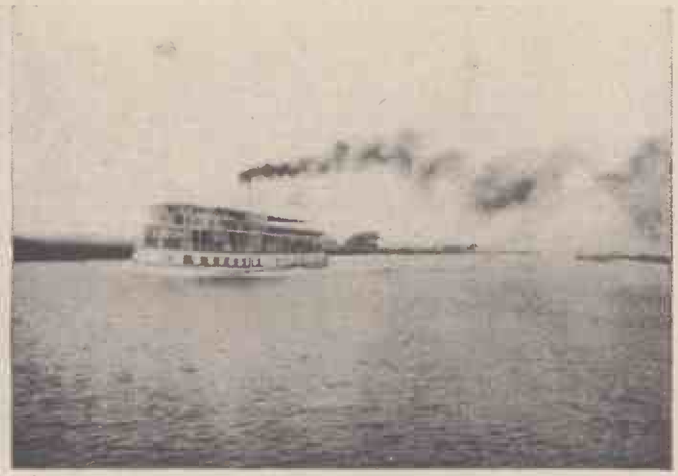
The shallow sea area to be drained is encircled by dykes, the water is pumped out, and soon contented kine are grazing where once the ocean rolled. Some of the sea dykes are enormous, faced with granite, and held together by osier branches woven throughout the mass. The biggest dyke is at Helder—5 miles long—and there are many more. Seen from the polders, they resemble huge railway embankments striding through the fields.

A Dyke Threatened

When a dyke is threatened by a storm it is protected by osier branches placed upon its face, and its height is raised by planks filled in with clay. Flood-time is by law a state of emergency, and the engineers have autocratic powers to commandeer anything necessary, whether men or materials, to prevent the water breaking through. Even houses have been demolished to supply stop-gap materials, but the old story of the heroic tiny child who saved his country by stopping a leak with his chubby hand is not believed in Holland. All the Dutchmen to whom I recounted it roared with laughter.

There is one weak point in Holland's water-line and that is the road system. Roads and railways are always constructed on the *top* of the dykes, and if they are not destroyed when flooding takes place, they will provide an easy path through the inundation. No doubt the canny Dutch engineers are well aware of this, and I do not envy the Hun invader who tries to get through this way.

Reclaimed polders near Haarlem drainage windmills



North Sea Canal which drains the famous Y polders

PREVENTING GLASS FROM SPLINTERING

THERE seems to be a widespread belief that strips of brown paper gummed to windows in criss-cross patterns will prevent, or minimise, the shattering of the glass by bomb explosions.

The research laboratory of the "Triplex" Safety Glass Co., Ltd., has carried out a number of experiments to ascertain the shatter point of different types of glass now frequently seen in use as intended to prevent splintering, and the following results may be of general interest.

Ten types of glass were tested. The method of test was to take a number of samples of each type 12 in. square and to drop on each one a steel ball weighing ½lb. from a minimum height, increasing the height by stages until the sample broke into two or more large fragments. Mere cracking was not recorded as a break. The shatter point given below is the average taken of the various samples.

Where strips of reinforcing materials are referred to they were 1 in. wide and 3 in. apart arranged in diamond pattern. In all cases the ball was allowed to fall on the sample on the side remote from the reinforcing material.

Ordinary 24 ounce sheet and ¼ in. plate-glass broke at 1ft. 9 in. and 1 ft. 10 in. respectively, while the same types of glass reinforced with paper strips 1 in. wide and arranged in diamond fashion broke at 1 ft. 11 in. and 2 ft. 1 in.

Sheet glass reinforced with Cellophane type material either covering the whole window or in strips and sheet glass reinforced with adhesive tape both broke at 6 ft.; plate glass reinforced with Cellophane type material broke at 8 ft. 6 in., and plate reinforced with adhesive tape at 9 ft 6 in.; sheet laminated safety glass broke at 18 ft. and Georgian cast wired glass at 22 ft.

"PRACTICAL MECHANICS" WIRELESS SUPPLEMENT

A "Spare-Parts" A.C. Three Valve Receiver

As the Name Implies, this Mains Receiver is Built from a Varied Assortment of Old Parts

THIS month we give details of a three-valve A.C. mains receiver which has recently been constructed from a varied assortment of old parts, some of which were over five years old.

Despite the very rapid advances that have been made in radio design since the majority of the components and the circuit design were current practice, excellent results have been obtained.

Circuit Considerations

The circuit is given in Fig. 1, which shows that a screen-grid H.F. stage is used in conjunction with a leaky grid detector, and a pentode output valve. Power supply is derived from an H.T. 8 Westinghouse metal rectifier.

A single tuned circuit precedes the screen-grid valve, the volume control not only increasing the resistance in the cathode circuit when volume is required to be reduced, but also reducing the resistance shunted across the aerial tuning coil, thus by-passing the aerial input voltages. This method of both cutting down the aerial input, and at the same time reducing the gain of the valve, gives a continuously variable control which is very effective in practice.

Choke capacity coupling is used between the H.F. and the leaky-grid detector stages, a tuned-grid coil being used. This arrangement gives a good compromise between selectivity, sensitivity and quality.

It will be noted that a 500-ohm resistance is inserted in the reaction circuit, which otherwise is quite normal. This is to stop parasitic oscillation caused by the detector valve going into oscillation at a frequency determined by the combined constants of the reaction circuit, and that portion of the grid circuit between grid and earth, and shown up by the set going into oscillation, especially on long waves, with the usual slight "plop," but without giving the usual heterodyne whistle on the received signal, and before the full reaction amplification has been reached.

From the point of view of progressive and efficient reaction, we have found the following combination of values to give the best results :—

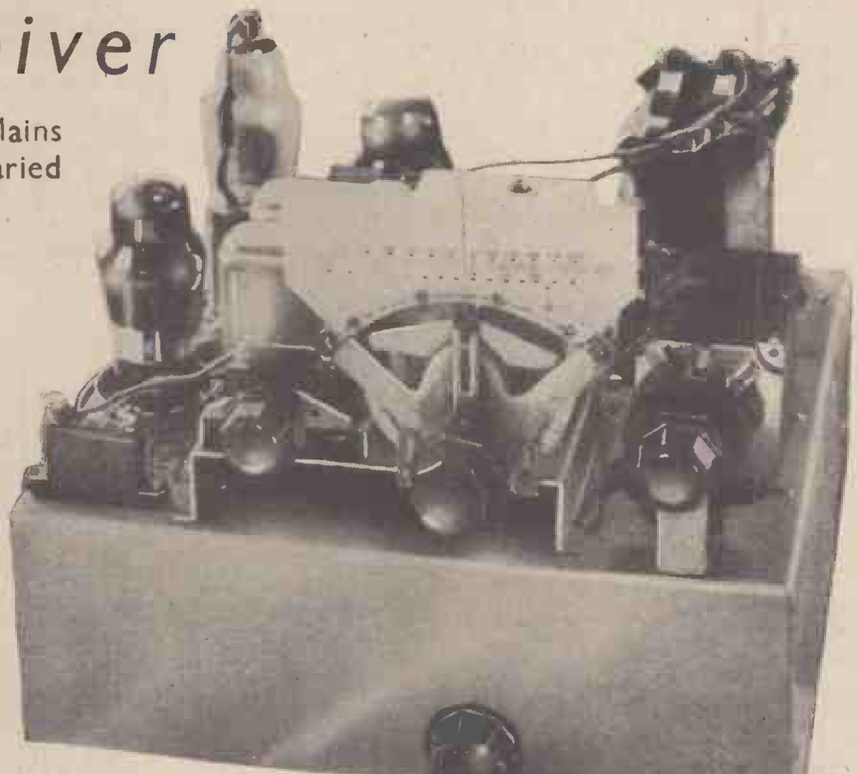
Detector anode by-pass, 0.0002 mfd.; Reaction condenser, 0.0003 mfd.; Stopping resistance, 500 ohms; Detector grid condenser 0.0001 mfd.; Detector grid leak, 0.25 megohm.

We cannot guarantee that these values are the best for every coil, but they will certainly suit the majority. Coupling between the detector and output stages is by means of a parallel-fed transformer, the transformer ratio being 4 : 1.

It will be noted that the screen of the output valve has been decoupled. This is not always necessary, but the valve we used had a fairly high magnification and was getting beyond its best. Decoupling of the screen was necessary to stop L.F. oscillation.

LIST OF COMPONENTS

- 1 screen-grid H.F. valve. Marconi VMS4B.
- 1 triode detector valve. Marconi MH4.
- 1 pentode output valve. Marconi MPT 4.
- 1 H.T. 8 Westinghouse Metal Rectifier.
- 1 mains transformer to suit H.T. 8 rectifier, with 4-volt 4-amp. L.T. winding.
- 1 two-gang 0.0005 mfd. tuning condenser.
- 1 aerial tuning coil. Colvern G.10.
- 1 tuned grid coil with reaction. Colvern G.3.
- 3 valve holders.
- 1 4 : 1 L.F. transformer. R.I. Parafeed.
- 1 10,000 ohm volume control.
- 1 25,000 ohm resistance.
- 1 20,000 ohm resistance.
- 1 250 ohm resistance.
- 1 500 ohm resistance.
- 1 0.25 megohm resistance.
- 1 10,000 ohm resistance.
- 1 50,000 ohm resistance.
- 1 5,000 ohm resistance.
- 1 300 ohm resistance.
- 2 8 mfd. electrolytic condensers (or 8 + 8 block).
- 2 4 mfd. 200 volt working paper condensers.
- 2 0.0001 mfd. condensers.
- 2 0.0002 mfd. condensers.
- 1 0.0005 mfd. condenser.
- 3 0.1 mfd. condensers.
- 1 1 mfd. condenser.
- 1 50 mfd. electrolytic condenser.
- 1 0.01 mfd. condenser.
- 2 H.F. chokes.
- 2 on-off switches, if not included in coil unit.
- 1 0.0003 mfd. reaction condenser.
- 1 L.F. choke capable of carrying 50 mA.



A three-quarter front view of the receiver

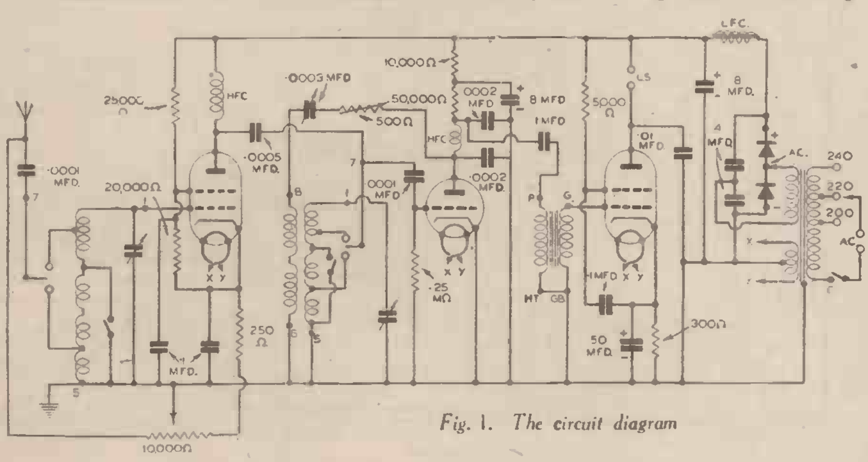


Fig. 1. The circuit diagram

Alternative Components

The only alternatives that are likely to cause any bother in constructing a receiver to this design are coils and valves.

We have dealt with the coils above. As regards valves, any high impedance triode will do for the detector, but it may be necessary to alter the value of the 50,000 ohm load resistance shown in our diagram. With the pentode output valve, different makes require different values of bias resistance, and screen decoupling may not be necessary. The only really serious difficulty lies with the H.F. valve.

Some readers may not have a spare variable-mu valve, in which case volume control may take place in the L.F. stage or simply as an aerial shunt across the coil. In either case, the cathode resistance of the H.F. valve must be joined direct to earth. Note too that different types of H.F. valve may necessitate alterations to the values of the two resistances forming the screen-grid potentiometer. These details may be obtained from your valve catalogues, but the values we have chosen are about right for most valves.

A different type of power supply may of course be used, provided that it delivers sufficient voltage at the current of 50 mA A valve rectifier will be found quite suitable.

Construction

Either baseboard or chassis construction may be used. The former is cheaper and easier, but the latter makes a more workman-like job and certainly helps to avoid instability. If a wooden baseboard is used, it is essential to cover it with metal foil.

Whichever method you use, mount the components first, and then do the wiring—the whole job can easily be done in three hours. We used a metal chassis which we had by us and the layout is shown in Fig. 2. The layout and proportions shown allow for plenty of room for components and quite widely differing sizes and plenty of spacing between them. If the H.F. and detector valves are not metalised, it is advisable to put a valve screen round both or to erect a metal screen between them.

Provided the H.F. chokes are mounted in the positions shown, it does not matter whether they are of the screened variety or not.

Wiring is very simple, and easily checked when completed, but be sure to check it before you insert the valves and switch on. If you are at all doubtful, insert a 60mA fuse in the H.T. positive supply lead.

Results to be Expected

Results will naturally depend on the efficiency of the valves and coils. Provided these are not much below normal, it will be possible to get quite good quality from the local stations and also to receive a good many of the continental stations free of interference. Should selectivity prove to be insufficient when receiving a foreign programme or a very powerful local station, reduce the volume control and bring up the reaction nearly to the point of oscillation. The selectivity will then be at maximum, but quality will suffer somewhat.

The 0.01 mfd. condenser between the pentode output valve anode, and earth provides fixed tone control, but may be altered to a variable tone control in the normal way, viz., by the inclusion of a variable 20,000 ohm resistance between the condenser and earth.

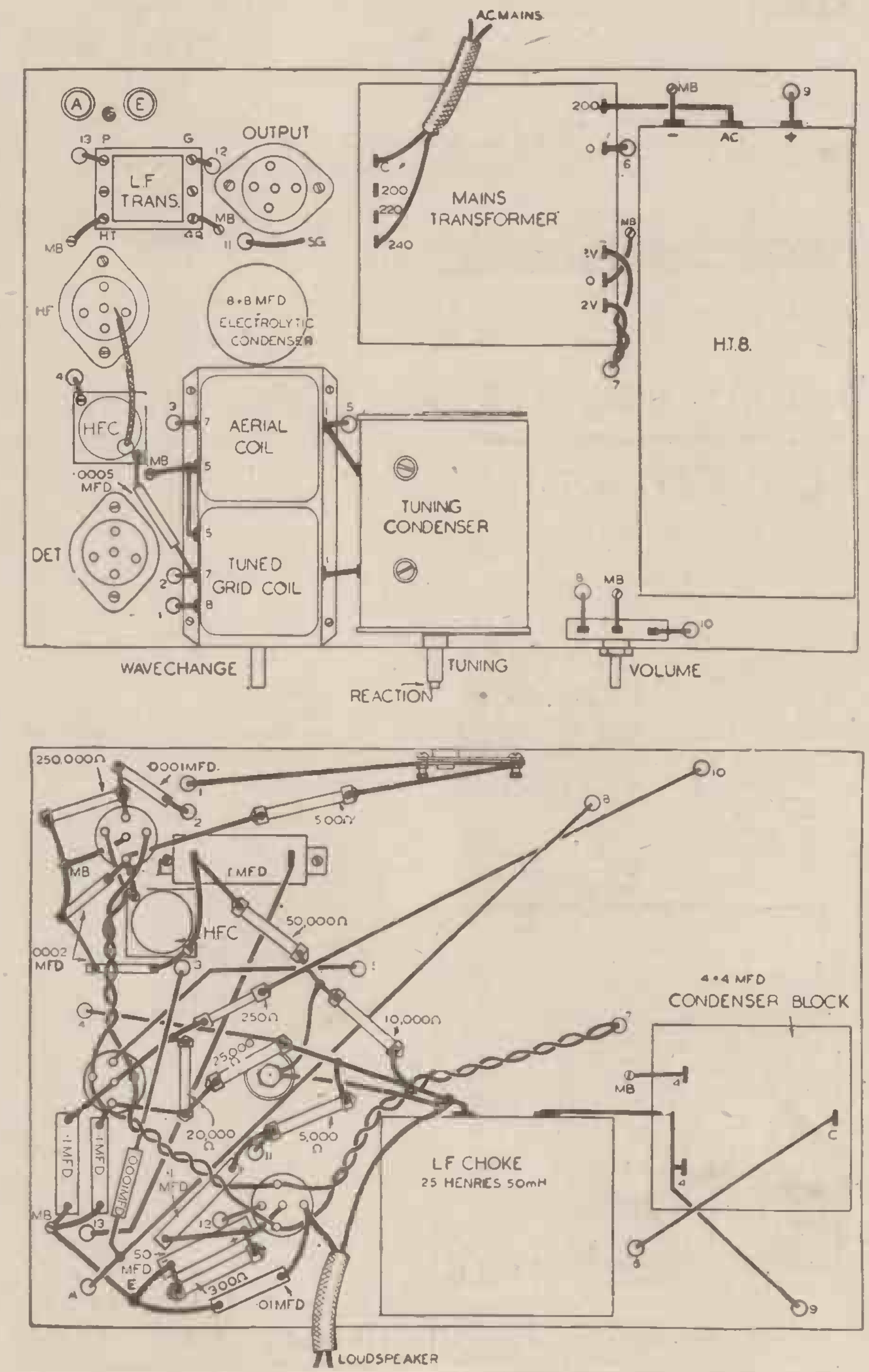
H.T. supply is obtained from an H.T. 8 Westinghouse metal rectifier, and is smoothed by an L.F. choke and a 8 mfd. condenser.

The total current taken by the three valves will be approximately 50 mA, and the unsmoothed output of the rectifier about 300 volts, which is not sufficient to allow of the use of a mains energised loud speaker. For those who have mains energised speakers with field resistance of 2,500 ohms, and would like to use them, we would point out that the voltage drop in the field will be about 125 volts, so that, allowing for a smoothed output of 250 volts, the rectifier must deliver 375 volts, unsmoothed, at 50 mA. In this case, it will be advisable to use the H.T. 9 rectifier.

Components

The complete list of components is given on the previous page We have given the makes we have used ourselves, but good results will be obtained from alternatives provided they are of reliable make. If alternatives are used for the coils and transformer, for example, the connections will be numbered or lettered differently, and we call your attention to an article which appeared in the June 18th, 1938 issue of our companion journal *Practical and Amateur Wireless,* where details of the connections to a good many of the earlier types of coils which are likely to be used in a receiver of this type, are given.

Plan and Underneath Wiring Diagram of the "Spare-Parts" Three-Valver



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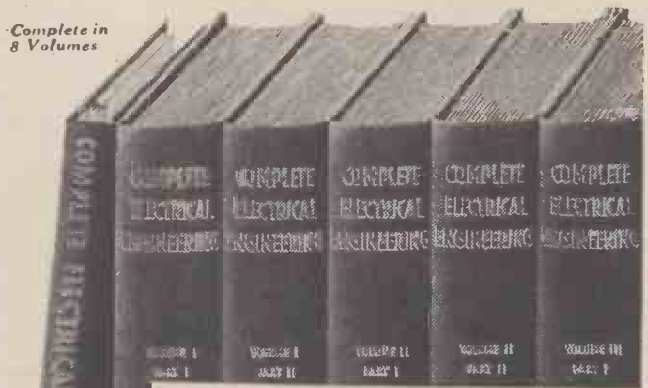

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Our Busy Inventors

By "Dynamo"

Geography Without Tears

A PATENT has been granted in the United States for a microscopic revolving map. This consists of a tiny globe and includes a magnifying glass and means for illumination. One wonders whether the invention is intended for practical purposes—being reduced in size in order to save space—or has been designed merely as a toy. In the latter case, the budding juvenile might thereby be taught geography without tears.

Incidentally, this miniature sphere will afford the philosopher an opportunity of moralising upon the comparative insignificance of our terrestrial orb viewed from the point of view of the planet Jupiter.

"Dummy" Addicts

AUTHORITIES on the management of infancy, including that adept in the art of training other people's children—the mature maiden aunt—condemn the artificial teat known as a "dummy" or "soother." For one reason, the suction involved may materially increase the sale of dill water. Now, the opium eater is more difficult to cure than what I will term the "dummy" addict. But the latter has formed a habit which cannot be broken without a cascade of tears.

Sometimes the child improvises a "dummy" in the shape of its own finger. With the object of preventing such a habit, a patent in America has been granted for an infant's hand guard. This anti-finger sucking device is a stiff shield which loosely encloses the hand of a child and is secured to the youngster's wrist. In order to combine amusement with protection against a bad practice, there is a rattle affixed to the guard.

Indoors Clothes Line

ALFRESCO drying of clothes is subject to that fickle jade, the weather. As a consequence, especially during the winter, there is visible in the kitchen a wooden horse—no relation to its Trojan namesake—caparisoned with damp underwear.

The industrious housewife will be intrigued by a newly devised clothes line for indoors drying. To fit this up, all that is necessary is to attach a small suction cup to one wall, draw a line off a spool, and fix two other cups to any convenient wall. An adjustable feature permits the line to be stretched across any room, at any height, at any angle, and to any length not exceeding 25 feet. It should be added that the suction cups do not damage the walls. This obliging contrivance will enable the fair to festoon their kitchen with laundered lingerie. It will also be very accommodating in the matter of airing garments.

A Good Point

PENCIL sharpening by hand is an art. Like other arts, it is dependent very largely upon natural aptitude. And, of course, in spite of the adage "A bad workman quarrels with his tools," a keen knife is an important factor in producing an effective, tapering point. For many years mechanical sharpeners have come to the rescue of the man or woman whose hand has no cunning as regards the pointing of pencils. In the case of a cheap sharpener, it is a matter of luck whether one secures a good and durable blade. I myself possess a twopenny sharpener which for more than twelve months has done me yeoman service.

One of the latest things in pencil sharpeners is a self-starting electric grinder. Inserting a blunt pencil through the opening at the top sets a small motor going. When the lead has been ground to a fine point, the current shuts off automatically. I have no information as to the exact cost of this sharpener, but I learn that it is inexpensive.

Stainless Table Linen

THE fastidious mistress of the house aspires to keep her table linen immaculate. She will, therefore, be interested in a new table-cloth which is stated to be stainless. It resembles linen, and its stainproof character is said to be attained by coating it with a transparent synthetic substance. For this table-cover it is claimed that it is unaffected by food stains, and impervious even to ink, which can be wiped away with a damp rag.

At this juncture I am moved to recall a story told of Lord Tennyson, the poet. It is related that the laureate, waiting for a friend in the drawing-room of the latter, beguiled the time by composing verses.

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."

While committing his effusion to paper, he turned the ink over on to the cream carpet. He at once summoned the maid who, with alacrity, poured a jug of milk over the sable stain, and in collaboration with the poet, who went down on his knees, managed to obliterate the gigantic blot.

I learn from an expert on washing that milk will sometimes efface ink stains, but it depends on the nature of the ink. Some writing fluids, unfortunately, adhere to a fabric with annoying obstinacy.

Harness for Beds

THE great frost in the early part of the present year compelled the shivering public to adopt any means which would induce warmth. In view of the shortage of fuel, some frigid folks were forced to take refuge in bed. This method is effective, but the bedclothes at times have a vicious habit of becoming displaced, leaving the recumbent one exposed to the sharp tooth of Jack Frost. To obviate this disadvantage there has recently been invented and patented in America harness for bedclothes. The device consists of an adjustable belt designed to encircle the bedclothes and has a number of straps to secure the clothes to the mattress.

The custodian of the nursery will be aware of the fact that restless young children are especially liable to disarrange their bedclothes. This bed harness will be particularly useful in keeping the infant warm at night.

Tinned Sunshine

OWING to a film founded on "Gulliver's Travels," the subject of at least a portion of that caustic satire has been in the limelight. The man in the street, as a rule, is familiar with only the first part of the book; which records a visit to Lilliput—the land of the little people. But Lemuel Gulliver repaired to other remarkable countries. Among them was a flying island known as Laputa. There he met with a professor who bottled sunshine—if I remember rightly—extracted from cucumbers. One would expect something cooler than the rays of the sun to emanate from a vegetable which proverbially does not suffer from a temperature.

Dean Swift, in this invention of his imagination, was in some degree prophetic. Tinned sunshine appears to be an actual achievement. I am informed that sunshine absorbed by luminescent powder and "canned" by being frozen in liquid air, has been transported by aeroplane 1,000 miles and then released. The "canning" occurred in the sunny state of Florida and it was set free in New York. It commenced with the exposure of a glass tube containing the luminescent powder to sunshine for several hours. Then the tube was placed in a vacuum flask of liquid air.

If this "canned" sunshine can be produced at a reasonable cost, it will afford a solution of the problem as to how coal is to be replaced when that fuel is exhausted. During the great frost preserved sunshine would have been a godsend.

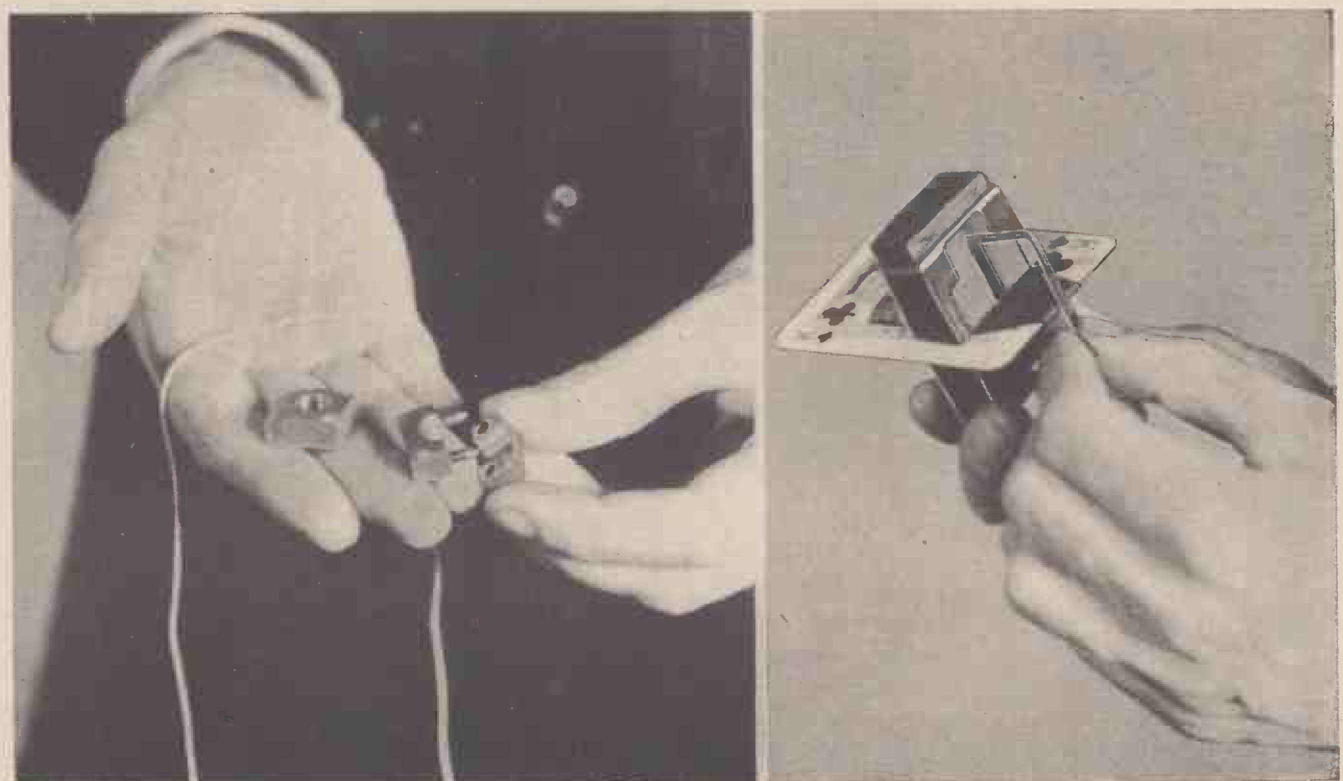
After all, in coal there is stored the sunshine of prehistoric ages. In fact, I understand that many years ago a coal merchant in this country sold his best quality coal under the registered name of "Bottled Sunshine."

To Guard the Make-up

IN those secret cubicles in which the heads, faces and hands of ladies are artfully beautified, I understand that, when the hair is being washed, the face, in order to keep the make-up inviolate, is enveloped with towels. To prevent soapy water and lather from entering the eyes and to shield artificial eyebrows and eyelashes, a face protector is the subject of an accepted application for a patent made to the British Patent Office. This face mask includes a pouch of waterproof material enclosing an absorbent pad exposed through a single opening in one side of the pouch. The opening is large enough to extend over both eyes of the wearer. The ends of the pouch are attached to opposite ends of a one-piece elastic head band of such a length that the pad will be pressed against the eyes of the wearer, when the band is placed around the back of her head.

A Slight Light

TO answer the purpose of the fairy light which affords a limited amount of light in nurseries and bedrooms, there has been constructed a novel table lamp. It has a translucent base which glows softly when the light is switched off. The base contains a quarter-watt neon tube which is just sufficient to eliminate groping in the dark. Such a mild kind of illumination is peculiarly fitted for the black-out, and would exempt one from the warning of the A.R.P. warden



Figs. 1 and 7.—(Left) A neatly made fake nut, dividing across the centre, enables the conjurer to remove the nut from a string held by spectators. A duplicate unprepared nut is exchanged for it and given for inspection. (Right) Cutting a matchbox in two with a card. The metal attachment makes it possible to open and close the box although the card passes through it

MINIATURE MAGIC

Effective Tricks that can be Performed with Articles carried in the Pockets

YOU take a box of matches and, with a playing card or visiting card, proceed to saw through the box. When the box is apparently cut in two with the card projecting on all sides, you open and close the drawer of the box exactly as if there was no card in the way.

Fig. 1 shows the secret of this ingenious trick. The matchbox is prepared by

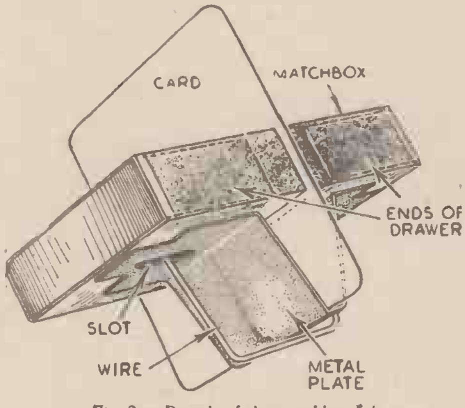


Fig. 2.—Details of the matchbox fake

cutting it through the centre. The drawer is discarded and two small blocks of wood are prepared by having the heads and stalks of a few matches glued to one side. A piece of metal is now cut and bent to the shape shown in Fig. 2, and slots are cut as

By Norman Hunter
(The Well-known Conjurer of "Maskelyne's Mysteries")

Further Articles on the Secrets of Conjuring will appear Regularly and Exclusively in this Journal

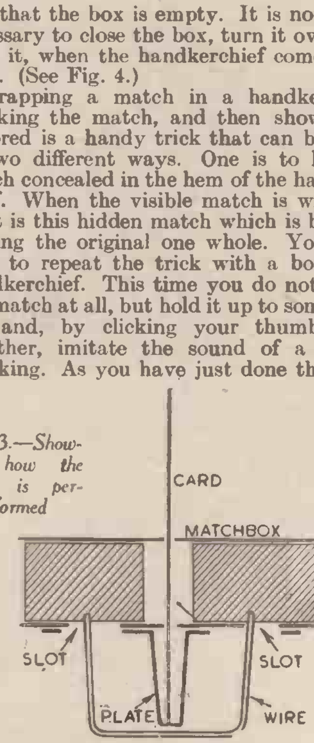
marked. This is glued to the underside of the cut matchbox, and a stout wire operates through these slots, the ends being fixed to the small blocks of wood so that the drawer can be apparently pushed in and out. Fig. 3 shows the exact working of the trick. When the card is removed, the fake matchbox is secretly changed for an ordinary one, which can then be left about for inspection.

A Matchbox Trick

Another neat matchbox trick consists of changing the entire contents of a box of matches into a silk handkerchief or other article. For this purpose a row of matches is glued on to the bottom of the drawer, on the outside. The handkerchief is tucked into the drawer, which is then put into the case. If the drawer is opened upside down, the false row of matches gives it the appearance of being full. If one loose match is included, this may be struck to light a cigarette, and so give weight to the suggestion that the box is empty. It is now only necessary to close the box, turn it over and open it, when the handkerchief comes into view. (See Fig. 4.)

Wrapping a match in a handkerchief, breaking the match, and then showing it restored is a handy trick that can be done in two different ways. One is to have a match concealed in the hem of the handkerchief. When the visible match is wrapped up it is this hidden match which is broken, leaving the original one whole. You then offer to repeat the trick with a borrowed handkerchief. This time you do not break the match at all, but hold it up to someone's ear and, by clicking your thumb nails together, imitate the sound of a match breaking. As you have just done the trick

Fig. 3.—Showing how the trick is performed



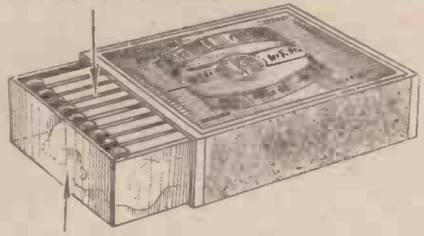


Fig. 4.—By closing the box and turning it over, the handkerchief comes into view

and quite obviously broken a match, the breaking will be accepted as genuine. All you then have to do is to shake out the whole match and return the borrowed handkerchief.

Mysterious Card

Fig. 5 shows a card that turns to a box of matches. The card is hinged with a strip of paper or linen tape to fold on to the top of the box and a label, steamed from another matchbox, is pasted on the half of the back of the card not attached to the box. Show the card by holding it with the hidden box in the palm of your hand, your fingers gripping the card at the edges, and holding it facing squarely to the audience. Pass the other hand downwards in front of the card and, in doing so, fold the card down on to the box. The box may, of course, be filled with matches, and some of them can be struck to prove the box genuine.

From matches to cigarettes is a short step. The cigarette shown in Fig. 6, when dropped into the little metal tube also

Fig. 6.—Vanishing a cigarette. The cigarette is a metal tube which fits tightly into the case and can only be removed with the key

shown, changes instantly to a single match. Moreover, the case can be thoroughly examined before and after the change.

In this instance the cigarette is a fake, being actually a tiny metal tube. The gold tip is a slight extra thickness of brass which makes a very tight fit in the case. The match is inside the hollow cigarette and a tiny portion of tobacco can be stuck to the closed end of the fake to help the illusion. The cigarette may be taken from a case in the ordinary way, placed into the tube, closed end first, and the cap put on. When the cap is removed, only the match can be extracted, as the hollow cigarette is closely wedged in the tube and its presence cannot be detected. To remove the cigarette after the performance, the key shown in the illustration is employed. The straight end of this is threaded to screw into a hole in the closed end of the fake cigarette. When this has been done the fake can be removed from the tube by pulling the key.

Cigarette and Handkerchief

Pushing a lighted cigarette through a borrowed handkerchief without causing any damage is a trick that will always cause excitement. The necessary apparatus consists of a metal false thumb tip painted flesh colour. Wearing this on your right thumb, where it is invisible as long as the hand is kept moving, the borrowed handkerchief is taken and spread over the closed left fist. The right thumb now pokes down the centre of the handkerchief, and in doing so leaves the thumb tip hidden in the handkerchief. The cigarette, which by now should have been smoked down to a fairly short length, is placed deliberately, burning end down, into the handkerchief. Of course,

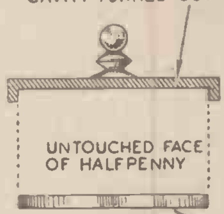
Fig. 5.—A card which can be converted into a box of matches

it goes into the metal thumb tip, where it is firmly crushed out. The thumb, under pretence of pushing the cigarette well down, withdraws the false thumb tip. The handkerchief is then shaken out, the cigarette has vanished, and the mouchoir is returned undamaged to its owner.

Fig. 7 exposes the secret of a clever little trick in which an examined brass nut is threaded on a piece of string, the ends of which are held by spectators. Covering the nut with a handkerchief, the performer removes it without breaking the string and at once hands the nut for further examination.

As will be seen, there are two nuts, both outwardly alike. One of them is cleverly prepared by being cut in two and jointed with a pair of minute spring plug points which fit into holes in the opposite half of the nut. The joint is so accurately made that it cannot be distinguished when the halves of the nut are pressed together. In performing the trick the plain nut is given for inspection with the string. The nut is

Fig. 9.—A brass cap hollowed out to fit tightly over the halfpenny



then changed in the hand for the fake nut, and the latter is threaded on the string. This nut can, of course, be removed by simply pulling it apart, after which the pieces are concealed in the folds of the handkerchief and the plain nut again given for inspection.

Coloured Discs

A somewhat similar trick, but with a totally different secret, consists in removing one of three coloured paper discs from a string without damaging discs or string. To do this you have duplicates of the three coloured paper discs handy, and as soon as the colour is announced you palm the corresponding duplicate, tear the correctly coloured disc off the string under cover of a handkerchief, and hand out the duplicate, concealing the pieces as before.

Vanishing a halfpenny by covering it with a metal cap and a brass ring is an old trick which, for the sake of completeness, is explained in Fig. 8. The ring is covered with white paper and the trick is worked on a sheet of similar paper. The metal cap is placed on the ring, and both are lifted and put over the halfpenny. The cap alone is lifted and the halfpenny seems to have vanished, because it is hidden by the paper with which the ring is covered.

Improved Version

This trick is so well known as to be hardly worth doing, but there is an improved version which will catch the knowing ones. In this the brass cap, as shown in Fig. 9, is hollowed out just sufficiently to fit tightly over a halfpenny. One side of the halfpenny and the edge are turned down to present a plain, smooth, bright surface. The trick is worked on a sheet of white paper with an unprepared ring, exactly as if it were the old version. When cap and ring are put over the halfpenny, the cap is pressed down and the halfpenny literally becomes part of it. The cap is then lifted, showing that the coin has gone. Someone who knows the old method either picks up the ring or asks to see it, suspecting the

Fig. 8.—Vanishing a halfpenny by covering it with a brass ring

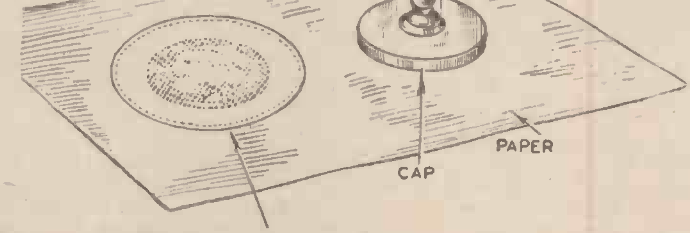


Fig. 10.—A disappearing cup. The cup has a lining with a sharp hook on it which is engaged in the sleeve and secretly withdrawn

presence of the paper masking. You then calmly pick up the ring and show that it is unprepared. The faked halfpenny is removed from the brass cap by unscrewing the knob and pressing it out with a pin.

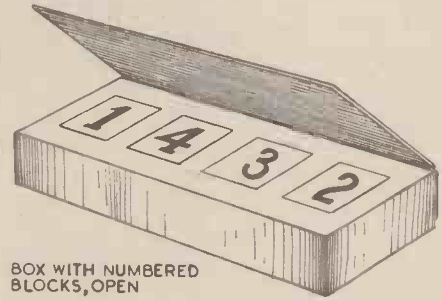
Another neat coin trick consists of putting a penny on the table with three small cardboard pill-box lids. A member of the audience is asked to put the penny under any of the three lids while the performer's back is turned, yet he is instantly able to indicate the correct cap. The secret is that the penny has a short length of human hair firmly stuck to its edge so that it projects about half an inch. This fine hair is quite invisible to anyone who is not actually looking for it, but the performer can find it quite easily, as it sticks out from under the cap which covers the coin.

Pile of Pennies

Turning a pile of pennies into a small die under cover of a metal cap is accomplished by means of a specially prepared pile of pennies. All except the top coin of the pile have the centres drilled out, leaving a rim of about an eighth of an inch all round. The pile of rims, with a whole coin on top, is fastened together with a rivet through the edges. The pile can thus be manipulated and squared up just like a pile of genuine loose coins. The little die is concealed inside the hollow stack. The metal cap is fitted over the coins, and when it is lifted the sides are pinched, thus lifting the stack of coins as well. While the attention of the spectators is directed to the die thus revealed, the hollow pile of coins is allowed to drop out of the cover into the hand, and the cover can be tossed for examination while the hollow pile is secretly disposed of in a convenient pocket.

Fig. 10 shows a very useful little piece of pocket-size conjuring apparatus. With it any small article or articles can be vanished with the greatest of ease while remaining instantly get-at-able when wanted for re-production.

The apparatus consists of a little metal cup with straight sides and no lid. It is provided with a loose metal lining reaching half way up the cup. The lining has a wire hook soldered to the side which reaches just above the outer cup. The existence of this inner lining is not known to the audience. Lining and inside of the cup are painted dead black.



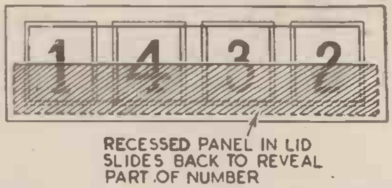


Fig. 11.—Details of the numbered cubes

Using the Apparatus

To use the apparatus, the article to be vanished is placed in the cup, going, of course, into the lining. Holding the cup in the right hand, the performer turns and reaches with his left hand for a handkerchief with which to cover the cup. Under the screening provided by this movement he presses the top edge of the cup against his left sleeve and makes a downward stroking movement with it. This causes the sharp hook on the container to catch in the sleeve and the lining is withdrawn, leaving the cup empty. The lining remains quite securely attached to his sleeve, ready to be secretly taken off and disposed of as may be required. The cup is particularly valuable for causing the disappearance of a number of small articles, such as a bunch of matches or two or three rings.

A miniature bottle that will not lie down for anybody but the performer is made to do its stuff by having the bottom weighted with a dome-shaped piece of lead. This causes the bottle to swing to an upright position whenever it is laid down. The performer has concealed in his hand a short piece of metal rod which he introduces into the neck of the bottle when he picks it up. This rod acts as a counter to the weighted bottom, and the bottle may then be laid on its side.

Divining the order of four numbered or coloured cubes placed in a row in a box, with the lid of the box closed, is another effective pocket trick. The secret in this case is a sliding panel in the lid as shown in Fig. 11. Holding the box to his forehead and pretending to read the order of the blocks by magnetic waves, the conjurer slides back the panel with his thumb and notes the order as the box passes his eyes. The panel is fitted with a spring which causes it to close again when released.

In another trick with a somewhat similar kind of effect, a member of the audience is given two short pencils, one red and one blue. He is asked to wrap either one in a piece of paper and enclose it in a matchbox, hiding the other pencil. The performer, who has been out of the room during this part of the work, returns, holds the box to his forehead and announces correctly the colour of the pencil in the box.

One of the pencils is unprepared. The other has the centre section of the lead removed and a drop of mercury inserted. There is no apparent difference in the pencils—apart, of course, from their colour—and nobody who does not know the secret could tell which was inside the box. The performer, however, shakes the box gently to and fro endwise. The tiny drop of mercury striking against the ends of the lead in the pencil is just sufficient to be felt with the fingers holding the box, and so the conjurer knows which pencil is inside. If no movement is felt he knows that the unprepared pencil is there.

BOOKS RECEIVED

"The British Journal Photographic Almanac, 1940." 452 pages, with 32 illustrations in gravure. Henry Greenwood and Co., Ltd. Price 2s. 6d. net.

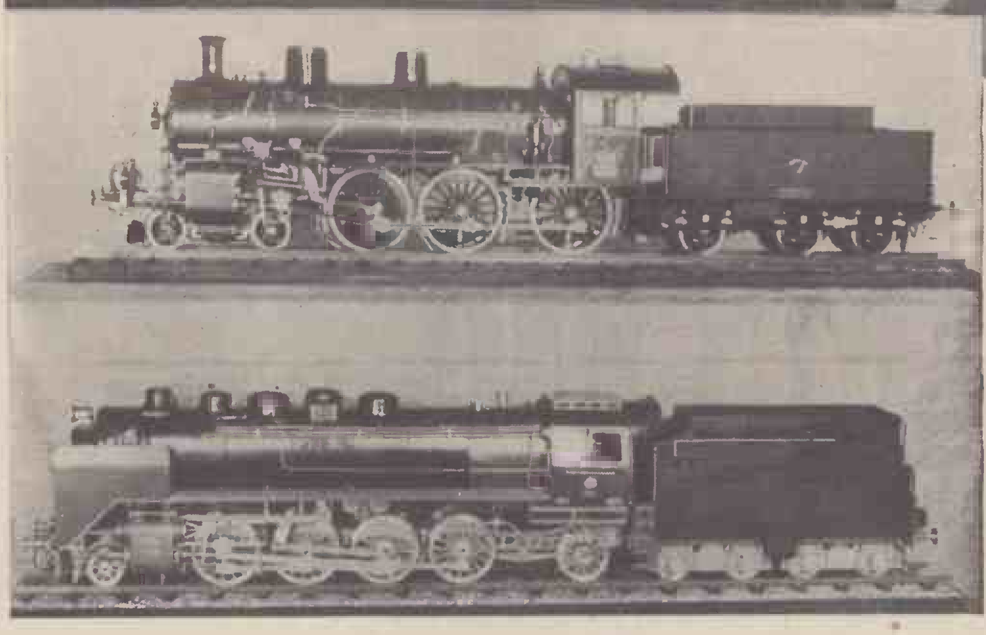
THE "B.J. Almanac" is one of the standard reference works for both the professional and the serious amateur photographer, and this year's edition is every bit as good as its predecessors in spite of the difficulties under which all publishers are working as a result of the war. In the course of his leading article in the present edition, the editor, Arthur J. Dalladay, A.Inst.P., reviews the position of the photographer in the light of present conditions, and gives his readers much valuable advice. He points out that for the photographer the war has brought many problems, many surprises and many changes, some of which may be none the less important for that they are gradual and unnoticed. There will be material changes, he adds, changes of thought, habit of mind and changes in our form of life which may even revolutionise whole industries.

Among the editorial contents of this issue the articles on the photography of wild flowers, pictorial landscape photography and retouching will probably have the greatest appeal for the amateur, while the professional is catered for in the exhaustive discussions on reversal processing, Metol Hydroquinone developers, and the Bromoil process. The miscellaneous information section contains a great deal of valuable information for those engaged in all branches of the industry, and then of course, there is the photogravure section, containing exquisite reproductions of some of the finest photographs produced during the year. These alone are worth the money.

"Scale Model Aircraft That Fly." By H. J. Towner and Howard Boys. Published by the Harborough Publishing Co., Ltd. 104 pages. Price 3s. net.

DURING recent years, coincident with the rapid development of the aeroplane, there has arisen a growing interest in the building of model aircraft, particularly scale models of particular prototypes. This book has been written more especially for those enthusiasts who spend their spare time in building scale model aircraft that fly. The authors have special knowledge of the subject, and the instructions given in the book are in simple language, while the numerous photographic illustrations and line drawings greatly assist the reader. The various chapters deal with such subjects as Aerodynamics, Distribution of Weight, Gearboxes, Directional Control, Wing Fixing, Landing Gears, Rubber Motors, Design of Airscrews, General Design, Fuselages, Wings, Finishing, and Notes on Flying. At the end of the book are included five sheets of working drawings for scale models of well-known British aircraft.

"MOTILUS" PEEPS INTO THE



Top left.—A $\frac{1}{8}$-in. to the foot scale model of the Nile steamer, "Gedid."

Top right.—A fine model yacht.

The two locomotives are high-class Swiss built models described in the article

Models from Cigarette Tins

IN one of the accompanying illustrations is seen the work of an amateur model maker, who has not only spent many happy hours making railway stock, but has at least one beautiful old-time ship to his credit. He is Mr. T. A. Spence of Potters Bar, and the Tank Engine and Wagon illustrated were both built from cigarette tins. They are "OO" gauge. The bodywork of the engine was constructed exclusively from these cigarette tins, cut up, with the exception of the boiler mountings and buffers. He even used the hinges of the tin to form the rails round the top of the tender. The tin itself, says Mr. Spence, is of light gauge and ideal for soldering, and in building the model I used ordinary scissors to cut out the various parts, files, pliers, electric soldering iron, and, of course, suitable metal drills. It may interest readers to know that Mr. Spence did not have the use of a vice, which obviously would have been a big help. In building the buffer bars and footplates, double thickness tin was used to give extra strength, and in lapping over the edges, these were started off with a broad pair of pliers and then hammered over. The coupling hooks were also made of double thickness tin, tinned, hammered and sweated together. The raised smokebox was formed by adding two thicknesses of tin to the boiler casing, and to get the curve of the boiler barrel, Mr. Spence tied the tin round a brush handle and then soldered the seams of the boiler together.

The painting was done in flat oil paint, the maker lettering and numbering the model himself, which is taken from an 0-4-4 suburban tank loco operating on the L.M.S. railway.

The wagon, says Mr. Spence, is a pretty straightforward job. The only point worth mentioning is that the body is attached to the chassis by the bars or beadings running down the ends of the vehicle. And who said model making was an expensive hobby !

"OO" Gauge Bridges

Owners of "OO" gauge twin trains seem to get an enormous amount of extra fun out of this miniature railway by running on high and low levels, and recently you will remember a notice that Messrs. Bassett-Lowke, Ltd., brought out a series of gradients of simple design and construction, which were illustrated on these pages. Since then several owners have designed and built quite elaborate high level roads, and a London customer's effort in this direction is here illustrated. It will be seen from the photograph that the selection comprises a straight viaduct with double bridge over road, skew bridge and lattice girder bridges, and also two curved viaducts, and another type of lattice bridge. The models are all made of hard wood with imitation stone piers and capping, and the rest filled in with scale model brick work. I was very taken with these attractive designs, which would meet the standard dimensions of many twin train owners' outfits.

Model Loco. Sets

The cry to-day is "Models for the black-out," and in view of the added interest in model work, two splendid engineering sets have been placed on the market recently. The first is a set of finished parts for building a gauge "O" steam locomotive, viz., an L.M.S. 2-6-0 Mogul. So popular has this become that a fully illustrated sixpenny booklet has been issued on how to make the model, containing even a set of the tools needed to construct it, and already I have seen people who have built up these sets of

MODEL WORLD

parts—people who have never built a model locomotive before. One young enthusiast in Manchester claims to have made the set up in thirty-five hours, which is only five hours longer than what is looked upon as a record.

The other set is for more advanced model engineers, and is now running in these pages —in other words the magnificent 2½-inch gauge ½-inch scale L.N.E.R. *Flying Scotsman*. For making this model, small engineering tools are required, and, if the turning

Far from hindering our favourite hobby, MOTILUS has been pleasantly surprised to see how the black-out has become a blessing in disguise to many enthusiasts

work is to be done, a small lathe also, but the result is a model worthy of exhibition in any model exhibition in the country. A special list of the parts necessary, with drawing details is available, so if you are interested in either of these model sets, write to the Editor.

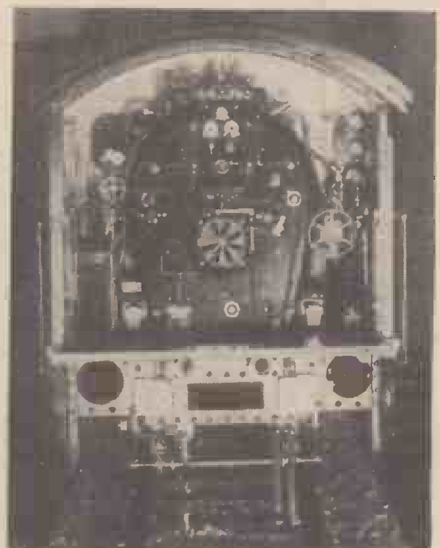
A Trim Model Yacht

The time for model yachting is not very far off now, so here is a picture of a model made last year by Mr. J. K. Robinson, of Dunton, Bassett, near Rugby. It has a 4-ft. long hull, hollow, and built from a solid block of African whitewood, and has balson fabric sails. The beam is 10½ in. and the depth 4¼ in., with an 8-in. deep keel, 10 pounds in weight. The mast is 5 ft. in height. The yacht has a polished deck with planks marked in, and is dark brown in colour, with deck of natural wood colour. The sails and fittings have been made detachable, and the little cabin has a hinged roof. The owner has unfortunately had few opportunities to sail it, and it seems a pity that it should lie idle. In the little village where he lives there is small scope for disposal, so if any reader is interested perhaps he would write to the editor, marking it "Motilus Feature," for the owner would be willing to accept any reasonable offer. I have seen the model out on one occasion, and it gave quite a brilliant performance.

High Class Model Locos.

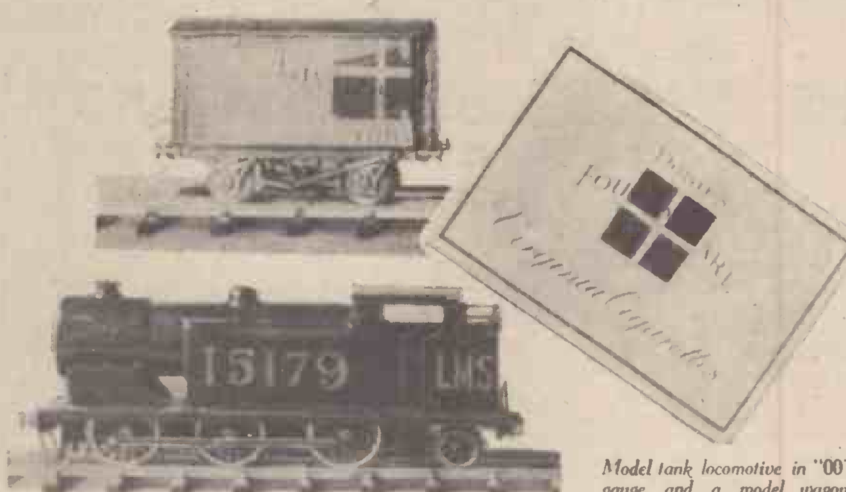
I have recently had photographs sent me from Mr. Hugo Hurlimann, of Switzerland, of some fine examples of Swiss modelling. The top illustration is the work of one of the members of the Zurich club, Mr. Robert Hager, and represents no less than nineteen year's work. It is an exact scale model of a 4-6-0 Swiss Express Federal Railway steam locomotive, and is complete in every minute detail. The scale is 1:15, the gauge about 3¾ in., and it is steam driven and coal fired, being built to operate on compressed air. The illustration of the cab of this locomotive gives us some idea of the tremendous patience and skill behind the building of this *pièce de résistance*. The second locomotive, the work of Mr. Fr. Neuenschwander, of Burgdorf (of the Bern Model Railway Club), represents a 2-8-2 Bulgarian Express locomotive, and this is also a beautiful piece of work. Displayed at the Swiss National Exhibition last year (the model was built at the Swiss Locomotive Works at Winterthur), this locomotive became nicknamed the "Tobacco" Locomotive. It was built by the Swiss in exchange for Bulgarian tobacco! The scale of the model is 1/20th, the gauge about 2·13/16 in., and it is steam driven.

Recently turning through some of my photographs, which are many and varied, I came across the rather striking picture shown on the previous page. It is a model of



The cab of the 4-6-0 model Swiss Express Federal Railway steam locomotive.

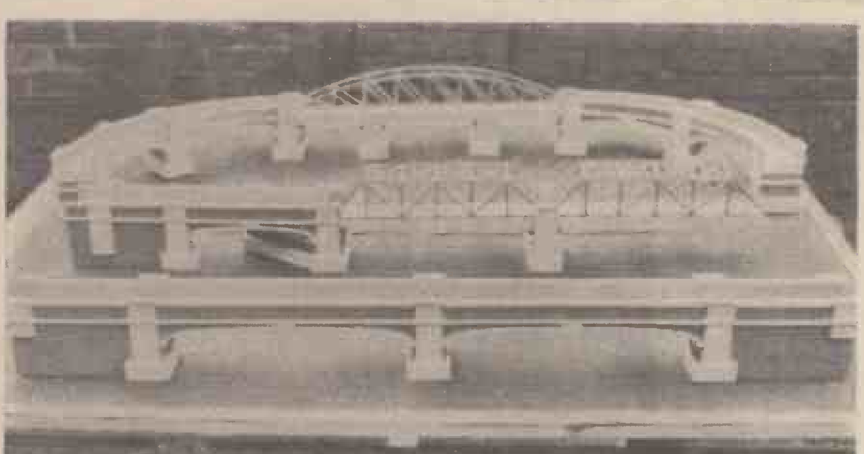
the Nile steamer *Gedid* in the service of the Sudan Government. Originally *Gedid II*, it has dropped the numeral since the first *Gedid* was scrapped. The model has exquisite detail, and is finished correct to the minutest feature. It is rather interesting to be able to see the shallow hull, and the large amount of deck work, much of it sheltered. The scale of the model is ⅛ in. to 1 ft., and the length approximately 15 in. It is now in the possession of a wealthy



Model tank locomotive in "00" gauge, and a model wagon, made from cigarette tins

Parisian, who makes a hobby of collecting models of ships in which he is interested. He is attracted by ships of all ages and types, and must have in his possession one of the most comprehensive collections in the world.

Side by side with providing fighting material for our land, sea and air forces we must place the drive for export trade to enable us to amass foreign credits for buying food and other necessities from abroad. The model-making and toy industry is alive to this, and is receiving special encouragement from Government departments. One of the most important details in this economy drive is the preparation of samples to suit the overseas market, and at a well-known works at Northampton, expert sample makers are busy making up samples of locomotives, cinemas, steam engines and other goods for export trade, which will afterwards go into production in large quantities for the overseas market.



Some fine models of viaducts and bridges.

Making An A.R.P. Pump

Construction Details of a Small Force Pump Utilising a Garden Syringe for the Pump Barrel and Plunger

THE simple force pump shown in the accompanying illustrations is intended for use in pumping out water from flooded air-raid shelters, and for assisting in extinguishing small incendiary bombs. It would also prove useful in pumping water out of a butt, for garden purposes. The chief materials required are an ordinary garden syringe, two tap washers (with brass stems), two $\frac{3}{8}$ in. brass angle fittings, and four brass discs $\frac{3}{32}$ in. thick.

The inlet and outlet valve chambers are made in a complete unit, which can be screwed on to the end of the pump barrel, as shown in Fig. 1, the top end of the inlet chamber being soldered into a hole bored out in the threaded rose end.

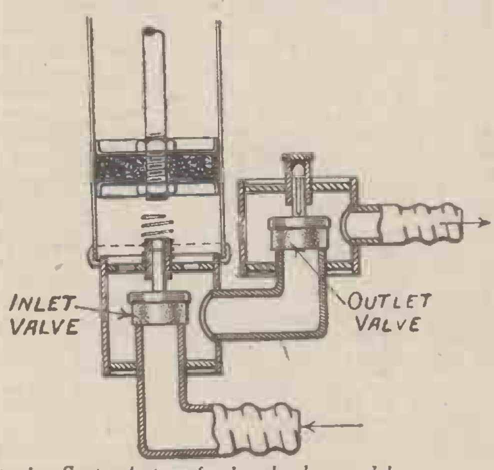


Fig. 1.—Sectional view of valve chambers, and lower end of pump barrel, showing the valves in position

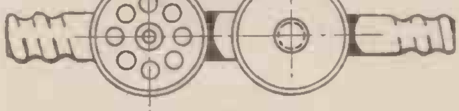


Fig. 2.—Plan of valve chambers with pump barrel removed

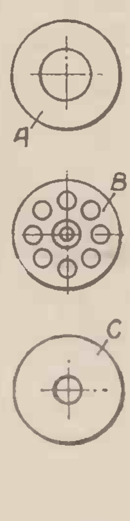


Fig. 3.—The top and bottom valve chamber discs

Valve Chambers

No sizes are given, as they depend on the diameter of the pump barrel.

The valve chambers consist of pieces of brass tubing, of a length to allow plenty of space for the movement of the valves. The tubing for the inlet chamber must be slightly smaller, externally, than the inside diameter of the pump barrel, so that it will not foul the pump barrel when screwed in place.

In the side of the valve chamber a hole is drilled to take the end of the outlet angle fitting. The outlet valve chamber also has a hole drilled in the side to take the outlet nozzle, which can be of slightly smaller diameter than the inlet fitting.

The four brass discs should be a press fit in the ends of the valve chambers. Two of the discs are bored centrally, as at A, to take the ends of the angle fittings; the disc B, which forms the top of the inlet chamber, has a number of inlet holes drilled, as shown, and a central hole in which is soldered a short length of brass tubing, which forms a guide for the stem of the inlet valve. The disc C has a central hole in which is soldered the guide tube for the outlet valve.

Soldered Joints

When soldering these discs in place, it is important that sufficient clearance is left between the bottom ends of the short guide tubes, and the tops of the valves, to allow the valves to lift a distance of $\frac{1}{8}$ in. Reference to Fig. 1 will make this point clear. It is also important to note that the valves must be placed in position before the discs at the end of the valve chambers are soldered in place. The top end of the outlet valve guide is closed by a brass disc, soldered on, but the top end of the inlet valve guide can be left open, as shown. Around this guide tube a stout helical spring should be pressed, of sufficient length to act as a cushion to take the downward thrust of the plunger, and to prevent the plunger from burring over the end of the valve guide. A plan of the completed valve chambers is given in Fig. 2, the inlet nozzle being shown in the opposite direction to that of the outlet nozzle. This nozzle can, of course, be arranged in any direction to suit requirements.

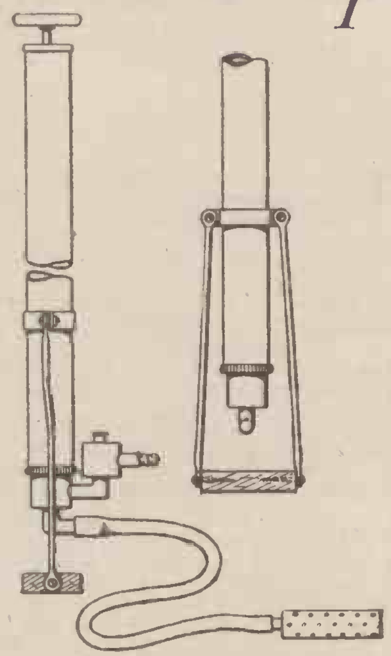


Fig. 4.—The completed pump and strainer, and a detail of the foot stirrup

Stirrup Irons

In Fig. 4, which shows the completed pump, a simple form of stirrup is depicted, consisting of two iron rods, screwed at the lower ends to a piece of hardwood, wide enough to take an ordinary shoe, the upper ends being bolted to a metal clamping band. Soft iron rod, $\frac{1}{4}$ in. diameter, can be used for the stirrup irons, which should be about 12 in. long. The ends of the rods can be made red hot in the fire, and flattened on an anvil (an old domestic iron fixed between blocks of wood will answer the purpose). After rounding the ends with a file, the holes can be drilled for the bolts and screws.

A strainer, to prevent small stones, etc., from entering the valve chambers, can be made with a piece of perforated zinc, rolled to form a cylinder, discs of the same metal being soldered into the ends. A hose-pipe connecting piece can be soldered into one end of the strainer.

MASTERS OF MECHANICS

No. 55.—HENRY MAUDSLAY

A Glimpse at the life of the "Father of the Modern Lathe"

THE story of Henry Maudslay and his many-sided creative activities begins with the life of his father, old William Maudslay, a native of Bolton, Lancashire, and a working joiner by trade. Old " Bill " Maudslay made a name for himself in and around Bolton as a reliable builder of the wooden frames for the early cotton machinery, but, somehow or other, like many another super-efficient workman, he found things becoming too ' hot ' for him in his native town. Thus it was that he threw up his occupation in Bolton and forthwith enlisted in the Royal Artillery, in which famed regiment he saw active service in the West Indies He was severely wounded, and was subsequently sent home to Woolwich, the headquarters of his regiment, where he was shortly afterwards discharged from the army.

Being a skilled workman, William Maudslay applied for and obtained a position in the Woolwich Arsenal, and it was during his employment at this famous munition-making centre that his son, Henry, was born on the 22nd of August, 1771, in a house which stood but a stone's throw away from the Arsenal gates.

A "Powder Monkey"

The boy Henry seems to have been given a rough time of it during his earliest years. He had little or no education, and when he was barely twelve years of age he was made to enter into the Arsenal's service as a " powder monkey " — a wretched and unhealthy occupation which was usually assigned to young boys, and which consisted in the hand-filling of cartridges with gunpowder.

Young Henry Maudslay found himself condemned to this irksome occupation for a couple of years or more. Then, by a lucky chance, he graduated to a lowly position in the Arsenal carpenters' shop in which his father worked. The work here was better than the monotonous and unhealthy drudgery which was the lot of the average " powder monkey." Yet, for all his increase in status, young Maudslay did not by any means excel himself in the woodworking trade of his father. Rather, he found his main interest in the surreptitious visits which he frequently paid to the blacksmiths' shops in the Arsenal, and in the making of many little articles of metalwork which the friendly smiths allowed him to create at their forges.

It was not more than a year or so after his promotion to the carpenters' shop at the Arsenal that young Maudslay, at his earnest requests, was removed to work as a " lad " in the Arsenal smithies. Here, he plunged into his fresh occupation with gusto and delight. Within a few months, although as yet merely a raw youth, he became an expert smith, displaying his skill more particularly in the forging of light ironwork.

Trivet-Forging

Forging trivets was Maudslay's favourite, albeit sparetime, occupation at this period; a " trivet " being, of course, a light and ornamental piece of ironwork which, resting on the bars of a kitchen fireplace, afforded a convenient stand for a heated kettle or for a plateful of freshly-made toast.

Maudslay's trivet-forging had to be carried out in an unofficial manner, and between his many other arduous duties, but the lad at this period of his life seems to have been blessed with an understanding overseer who recognised his inborn mechanical abilities and who, during hours of duty, was accustomed to signal his approach to the Arsenal forging shops by the loud and, indeed, the almost semi-explosive blowing of his nose, this being a tacitly assumed notification for all unauthorised jobs to be hurriedly put away in the shops during the presence of this official !

Maudslay's original screw-cutting lathe

Maudslay got on well under the kind superintendence of his overseer. Indeed, the reputation for excellence of workmanship which he made for himself in the Arsenal metal-working shops leaked even beyond the guarded gates of that official establishment. Joseph Bramah, the inventor of the hydraulic press, of a patent mechanical lock and of many other devices, heard of Maudslay's mechanical abilities, and Bramah, being in difficulties concerning the commercial making of his newly-devised locks, agreed to a suggestion which was made to him that he should have an interview with young Maudslay in order to ascertain whether the latter would be a suitable worker to have in his factory.

Meeting with Bramah

Thus it was that Maudslay was sent for, and ushered into the presence of the great Bramah who was many years his senior. Indeed, Maudslay at this time was only eighteen years of age. Nevertheless, his mechanical knowledge, and the suggestions which he made to Bramah concerning the latter's lock-making difficulties, so impressed the older inventor with a sense of his abilities that Maudslay found himself almost implored to take up a job in the Bramah workshops for the express purpose of carrying out the making of the new Bramah locks.

Bramah's career has already been made the subject of an article of this series (*Masters of Mechanics*, No. 53). In all probability, the fact that young Henry Maudslay agreed to give up his career at the Woolwich Arsenal, and to take up work under Bramah resulted in at least a proportion of the fame which Bramah gathered to himself. There is no doubting the fact that, although Joseph Bramah actually invented his mechanical locks, much of the credit for making them must go to Henry Maudslay. For Maudslay, once installed in the Bramah workshops, devised special tools and machinery for the production of the locks, which tools enabled the locks to be turned out in large quantities, and by mechanical methods which Bramah himself had, at first, hardly conceived to be possible.

Futhermore, Maudslay's assistance to Bramah became of vital import in the invention by Maudslay of the self-tightening collar of the Bramah hydraulic press. This collar comprised a simple and effective means whereby the piston or ram of the hydraulic press was effectively sealed, thereby preventing water from escaping past it. Bramah himself had wrestled with his fundamental difficulty of "sealing" his piston for a very long time, and, at periods, he was in despair of ever finding a satisfactory solution to the problem, for without an efficient seal to the hydraulic ram or piston, the device, although perfect in theory, would have been useless in practice.

The difficulty, however, was solved by Henry Maudslay, who had at that time become the manager of Bramah's works. Yet, despite this enormous aid which Maudslay had thus been to him, Bramah would never agree to pay the former a wage of more than thirty shillings per week. This pittance Maudslay put up with for as long as he could, but increasing family responsibilities eventually compelled him to severe his connection with the Bramah concern and to strike out an independent existence.

First Start in Independent Business

In this latter critical phase of his career, Maudslay had, at first, only the assistance of his wife—at one time Bramah's pretty housemaid—and a single workman. He made his first start in independent business in 1797 in a small alley off Oxford Street, London. His first customer was an artist who commissioned him to make a large ornamental ironwork easel. This commission, satisfactorily executed, brought others in its train. Gradually, Maudslay's iron-working business grew. Old customers of Bramah began to bring him their business and, after a few years, "methodical Maudslay," as he was sometimes facetiously yet truthfully dubbed, became known for his excellence of mechanical workmanship throughout the length and breadth of London.

It was in his early diminutive workshop, off Oxford Street, London, that Maudslay created the invention with which his name will ever be associated in the record of engineering history. This invention was that of the Slide Rest of the lathe. Based on this invention, the mechanical and power-driven lathe has developed through the last century until it has become in modern days a device which can be put to almost any complicated precision engineering work, short of hammering and riveting.

The Slide Rest

The lathe is an old invention which finds its earliest origin, perhaps, in the potter's wheel. In operating a pre-Maudslay lathe, the woodworker or mechanic applied and guided his cutting tool to the work in hand by means of his own muscular strength. The work was revolved on the lathe, and the operator, pressing and guiding the cutting tool against the revolving piece of wood or metal, was enabled to reduce it in size, and shape, more or less according to his pre-conceived intentions.

At the best, however, the above method of producing a lathe-turned article was a very haphazard one. Scarcely two such articles could be turned out alike even by the most expert and experienced lathe operator, whilst for the quick production of a number of identical lathe-worked articles, the method was hopelessly inadequate.

Fundamentally, all the Maudslay "slide-rest" consisted of was, as its name implies, merely a metal rest for the cutting tool, by means of which the latter could be slid along the lathe in a direction exactly parallel to the axis of the work in the lathe. The slide rest held the cutting tool firmly and securely, and, by means of it, the tool was able to be applied to the work in the lathe at any required angle, and with constant pressure. Thus it was that, for the first time in history, two articles could be turned on the lathe to identical dimensions and shapes. Precision engineering, and what is nowadays known as "repetition work" became not only possible, but practicable.

Strange as it may seem, Maudslay's invention and utilisation of his "slide rest" brought quite a good deal of ridicule upon his methods. The "rest" was for a long time dubbed "Maudslay's go-cart," and, thus characterised, it came in for a good deal of derision in the mechanical circles of the Metropolis at the beginning of the nineteenth century. But Maudslay was a determined man. He realised the firmness of the grounds upon which he had based his invention. By means of the slide rest, the heaviest and the most delicate turning work could be accomplished with equal satisfaction.

Machine Tools

And so it was that, in the end, Maudslay lathes and his slide rests conquered or, rather, subdued all opposition by reason of their appeal to commonsense. Maudslay began to turn out his lathes in large numbers, and, since, in the course of time, various modifications were made to them, as, for example, screw-cutting machines, planing machines and the like, the demand for power-driven lathes incorporating the "slide rest" principle grew continuously.

Having no more to battle with poverty, Henry Maudslay now found it possible to turn his attention to other fields of creative mechanical and engineering work. Removing his business from the confined premises in the environs of Oxford Street, London, to a more commodious building near Cavendish Square, Maudslay settled down to the interesting career of an inventor and constructor of intricate machinery for manufacturing purposes.

His first client in this direction was the famous Frenchman, Marc Isambard Brunel, who had then devised a new type of ship's "block," and who approached Maudslay in the matter of manufacturing it in large amounts. A ship's "block," it may be explained, was an article which was employed in the raising and lowering of the sails of sea-going vessels, and, as such, it was a highly important device. Brunel's block had many decisive advantages over these of the older type. It was difficult, however, to manufacture. And, indeed, therein lay Brunel's main problem which he brought to Henry Maudslay to solve.

The problem involved the designing—or, perhaps, to be more accurate, the actual invention—by Maudslay of a new system of machinery for the purpose of turning out these blocks in large numbers. From what we can ascertain, however, Maudslay appears to have attacked the whole problem with relish—and, incidentally, with complete success, for, within a year or two, he was turning out for Marc Isambard Brunel an annual quota of some 160,000 ship's blocks which were reckoned to be worth approximately £541,000.

Works at Lambeth

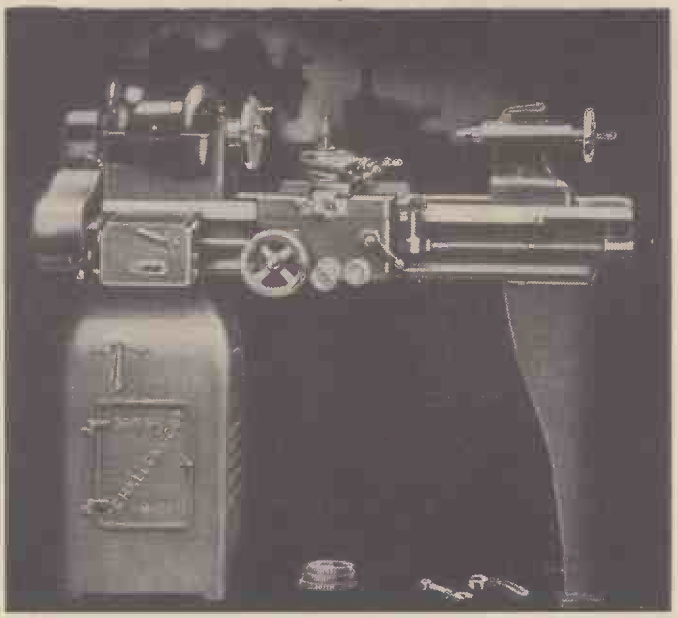
Before Maudslay left his premises in Margaret Street, Cavendish Square, London, for much more extensive works in Lambeth, on the south side of the Thames, he invented and patented a new type of steam engine which he termed his "pyramidal" engine in consequence of its pyramid-like frame. This was the first precursor of what is now called the "direct-acting" engine, the piston movement being conveyed by lateral connecting rods to the crank-shaft. Maudslay's "pyramidal engine," on account of its simplicity and the ease of accessibility of its component parts, constituted a design upon which many future engines were based.

Maudslay, too, at this period, built several steamboat engines of simplicity and robustness, one of which was fitted into the *Regent*, a steamboat which plied on the Thames for many years between London and Margate.

Screw-cutting machines, a machine for automatically drilling boiler plates, a mechanical saw, stationary steam engines of various types, coin-minting machinery, boring and mortising machines constituted only some of the many articles which Henry Maudslay turned out from his now extensive Lambeth works. Every machine of Maudslay's was characterised by excellence of design, construction and performance. Indeed, it used to be said that just as a trained artist could point to a picture and confidently remark : "This is a Turner," or "That is by Constable," so, in like manner, it was possible for a well-informed engineer to lay his hand on a piece of machinery, or on an engine, and to state categorically : "This is a Maudslay."

Famous Apprentices

"I cannot afford to turn out second-rate work," Henry Maudslay was often wont to exclaim. In the minutest details of his creations, Maudslay—"methodical Maudslay"—was characteristically thorough and painstaking. Through his workshops proceeded many an industrious young apprentice who, having imbibed the spirit and the mechanical wisdom of the Master, went out into the greater World to make a career and to meet Fame for himself. Two such apprentices were Joseph Whitworth and Joseph Clement. Another was James Nasmyth, the inventor of the steam hammer, and of other mechanical and power devices.



A fine example of a modern back-geared screw-cutting lathe, made by B. Elliott and Co., Ltd.

Of the personality of Maudslay, there is little to say. Honest, persevering, painstaking and industrious, entirely without "side," unspoiled by the fame which came to him, simple in nature, and ever available to his workmen and to outsiders, Henry Maudslay led, so far as the world at large was concerned, a particularly uneventful life.

Standing a good six feet two inches high, Maudslay, with his full, round face, and his typical good humour, characterised the very essence of straightforwardness and industry.

This pioneer died at Woolwich on 14th February, 1831, and he was buried in the parish churchyard there, where, over his grave, a cast-iron monument, made to his own design, was subsequently erected.

A Fuel-Injector Pump

A Description of a Recently Patented Appliance for Use with Internal-Combustion Engines

THIS appliance resembles the ordinary sparking plug as used for motor-car engines, except that the diameter of its body is larger. The size is controlled by the cylinder capacity of the engine to which it is fitted, and is roughly about twice the size of the ordinary plug.

As in the case of the sparking plug, all the components are housed in a casing, the lower end of which is threaded, and screws into the cylinder head in precisely the same manner as the sparking plug, and is just as easily removed.

Component Parts

All parts can be removed from the casing in the space of half a minute or less.

The main moving parts of the appliance are as follow :—

The valve needle and column (1) around which the various parts are assembled. The valve needle is loaded by means of a spiral compression spring (4) which is supported upon a collar provided somewhat lower than the centre of its length. By reducing the diameter of the needle column, a fuel space (3a) is formed between it and the plunger of the pump (2) within which it is contained. The needle rests upon a countersunk seating in the bottom end of pump plunger which forms a nozzle for spraying the fuel into the cylinder.

In the fuel pump plunger (2) a seating is formed for the valve needle.

The pump barrel (5) houses the fuel pump plunger in its lower portion, while its upper portion contains a fuel regulator sleeve (3) provided with a collar or flange which supports a compression spring (8) (surrounding it) for its actuation.

This spring is compressed by a cap (11) which fits over it and which is threaded internally to screw over a spigot formed on the pump barrel above the flange for the pump regulator collar (7).

The stroke of the fuel pump (2) is controlled or regulated by a collar (7) which fits over the outer casing, and over the flange on the pump barrel. Flange diameter is the same as that of outer casing.

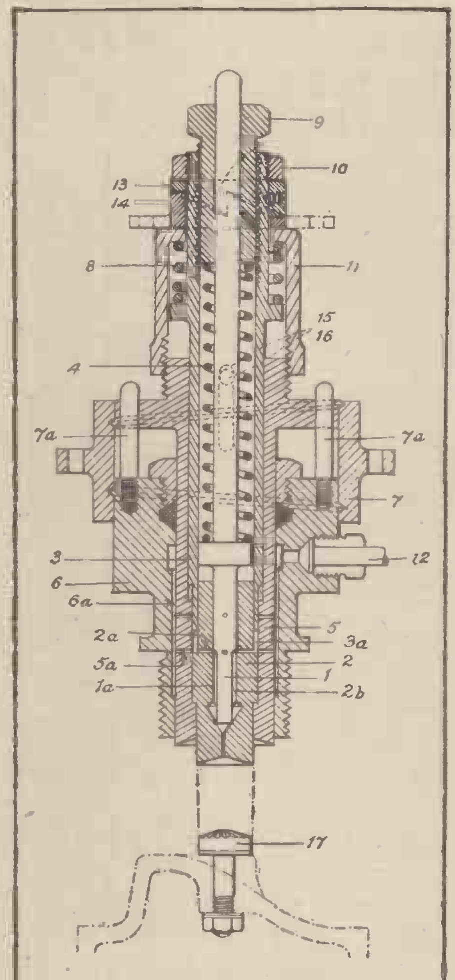
The pump is actuated by a specially designed cam or stud (17) inserted in the piston casting of the engine with which it engages for a predetermined period of the stroke.

Fuel Regulator

The fuel regulator (3) consists of a sleeve turned to fit into the upper end of the pump barrel, and is provided with a flange and compression spring (8). Its lower extremity extends into the pump barrel for a short distance beyond the collar on the valve-needle column. Its upper end is threaded internally to take the adjuster nut (9) for the needle compression spring (4), and externally to take a fuel-control-gear lock nut (10).

Pump Barrel and Plunger

The pump barrel is bored to take the pump plunger and fuel regulator sleeve, and is turned externally to fit inside the outer casing. The bore consists of three parts : The lowermost is smaller and takes the bottom end of the pump plunger while the set-off between the sizes forms a terminal stop to the plunger traverse. The set-off between the centre and top portions forms a terminal stop for the travel of the fuel regulator sleeve.



Sectional view of the fuel injector pump, showing the working parts

The outer surface is turned cylindrical throughout its length with a broad flange turned on near its upper end screwed right handed with a coarse thread which engages in a collar (7) correspondingly threaded, the rotation of which controls the stroke of the pump. Above the flange the diameter of the body is greater than the diameter of the body below it, to allow of it being threaded to take the cap for adjusting the fuel regulator spring (8). This cap is bored through at its upper end to allow of the passage of the fuel regulator sleeve. Around the sleeve its internal dimensions are generous enough to allow of the seating of the spring.

Fuel Space

The outer casing (6) is bored through, and the bore is enlarged in the central portion to form a fuel space (6a) between the pump barrel and the casing, the lower end of which forms a gas-tight joint with the pump barrel.

The upper end of the casing bore terminates in a gland around the pump barrel which seals the fuel reservoir. Externally, the casing is flanged to seat on a gasket on the cylinder head, and it is threaded below this flange to screw into the cylinder, while the diameter above the flange is reduced to save weight, and add to the appearance of the appliance.

Above this the diameter is increased and flat parellel faces are provided, for the use of a spanner, while on one side, between them, a hole communicating with the fuel reservoir is provided for the insertion of the fuel supply pipe (12).

Pump Adjustment

Above the flats, the same diameter of the casing continues to permit of a coarse left-handed thread which engages a similar thread in the lower portion of the collar (7) for controlling the stroke of the pump.

As before stated, the upper end of this casing terminates in a gland. Equally spaced around the gland nut are four studs or pins (7a) which are screwed into its top face, and extend through holes in the broad flange on the pump barrel, thus preventing it turning with the collar.

As the collar is provided with a right-hand female thread upon its upper internal face, and a left-hand thread upon its lower internal face, any rotary movements imparted to it will result in an axial movement of the pump barrel, which will thus rise or fall according to the direction of rotation. A quarter turn of the collar in either direction will raise or lower the pump barrel the required distance.

The adjustment of the fuel regulator is secured in a somewhat similar manner, save that in this case the top of the regulator spring cap (11) forms a seat for two washers (13 and 14), the opposing faces of which are each provided with four ratchet teeth of exactly similar form and, as the upper portion of the cap is secured to the sleeve by a grub screw, while the lower one is free to rotate, any movement of the loose washer will increase or diminish the distance between the faces, thus lifting or lowering the sleeve. Rotation of the sleeve is prevented by a grub screw (16) in the bore of the pump barrel engaging in a longitudinal slot (15) cut in the sleeve.

Attachment for remote control of the fuel pump, and the fuel regulator is provided by drilled lugs attached to the revolving part of each gear. Fuel is supplied to the pump chamber through small holes (5a) drilled radially in the pump barrel at a point coinciding roughly with the flange at the lower extremity of the casing.

Method of Operation

The only contact between the moving parts of the engine and the injector pump is by means of the stud or cam (17), attached to the piston.

At the moment that the cam engages with the injector end of the pump plunger, fuel commences to be injected through the jet into the cylinder, and this injection continues until the piston is at the top of its stroke. The upward motion of the engine piston after contact with the pump plunger forces the latter upwards, and thereby compresses the fuel in the pump chamber (3a), and causes it to pass into the injection chamber (2b) through the radial holes (2a) in the pump plunger.

As the pressure on the fuel increases, the injector needle valve overcomes the spring load and, lifting off its seat, allows a charge of fuel to pass through the injector nozzle.

On the down stroke of the engine piston, the pump plunger travels its full distance under the load exerted by its spring, and the fuel space (3a) in the pump chamber is filled with a fresh charge which is sucked from the annular fuel space around the pump barrel (6a) through the radial holes (5a) which connect them.

Fuel is fed to the apparatus by gravity, and there are, in consequence, no pipes under pressure.

The apparatus is capable of the following adjustments which can be made easily from the exterior, and do not involve its removal or that of any of its parts :—

1. Length of stroke of pump plunger (Zero to pre-determined limit).
2. Quantity of the fuel charge (limit as above).
3. Spring pressures.

A choked jet may be cleared by removing the fuel regulator sleeve and contents.

Removal is effected by simply unscrewing fuel regulator spring adjuster cap (11), and removing grub screw (16) in pump barrel.

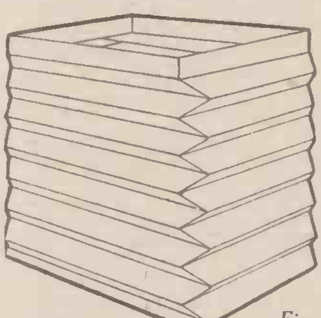
Failing a remedy by these means, the two remote controls must be removed, the fuel supply pipe disconnected, after which the appliance can be unscrewed from the cylinder, and cleaned and replaced.

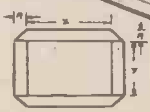
How to Make Bellows

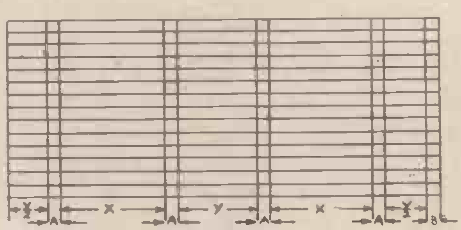
Methods of Making Bellows of Varying Shapes and Sizes

BELLOWS can be made from paper, stiff cloth, leather or imitation leather. Leather is undoubtedly to be preferred where cost is not a consideration. However, stiff cloth or even good quality paper can give good service.

It is possible to make bellows of practically any shape, square, oblong or any straight sided figure provided it has an equal number of sides. Thus nearly round bellows could be made by increasing the number of sides as far as practicable. Straight-sided bellows (where the peaks of the folds on all the sides are in a straight line, whether the bellows are square or tapered), can be made from a single sheet of paper. Where a curve is wanted, or a change of taper required, more than one piece of material must be used, usually four, but this varies. The length of the flat sheet from which the bellows are to be made requires to be two and a half times the length of the extended bellows. They can be extended further, but the folds may be displaced, and will fail to collapse later.







Figs. 1 and 2. Square bellows and details of the preliminary layout of the sheet

Square Bellows

Fig. 1 illustrates a square bellows, having internal dimensions of X by Y, and the preliminary layout of the sheet is shown in Fig. 2. The spaces "A" are equal to the width of the lines crossing them, which are equal to the depth of one fold. The fold-depth can really be anything, but the graph, Fig. 3, can be used for finding a convenient figure. The space "B" at the end of the sheet is a flap for securing to the other edge to form the first tubular construction of the bellows, and can be any convenient size according to the material used, and is usually between ¼ in. and ½ in. in width. These marking lines should be made lightly to avoid scoring where it will not be required. Having laid out the whole sheet, score in the diagonal lines and certain of the straight lines with a blunt edged tool, as shown in Fig. 4, the scored lines being shown heavily. Then turn the sheet over and score the remaining lines, which are only straight ones and although that side is not marked, the positions where the scores have to be made can be seen by the score marks already made on the other side. The second series of score marks are indicated in Fig. 4, by the faint lines. The side of the sheet shown in Fig. 4, is the inside of the bellows, and this should be remembered when making-up. The securing flap "B" must also be scored to follow on, so that its "vees" fit the "vees" at the other edge. The flap can now be pasted up and the edges brought together, the sheet forming a tube, no effort being made at this stage to form the folds.

Manipulating the Folds

When the paste has set, stand the bellows on one end and with the fingers manipulate the folds into position. Press the first scored lines inwards and at the same time, flatten the diagonal scores at each end. Then do the next lower pair, on the adjacent sides, and so on down the tube. When the last folds have been done, place a piece of wood on the top and press downwards or leave for an hour or two under a heavy weight. The end folds of the bellows instead of being creased diagonally can be folded up square as shown at the top of Fig. 1, this allowing the bellows to fit either over or inside a framework.

Tapered bellows require a layout made on the same principles, but each side must be marked out individually from a line drawn down the centre of each side. The construction is shown in Fig. 5 and the completed bellows in Fig. 6. It should be noted that the strips "A" which form the corners of the bellows are parallel and all the diagonal creases are of the same angle, i.e. 45 degrees.

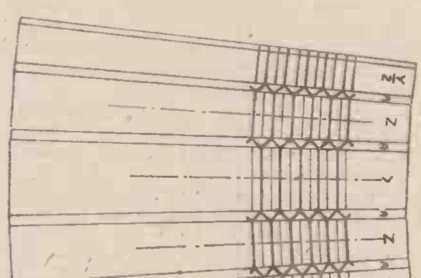
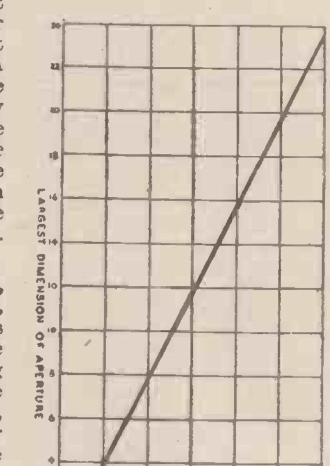
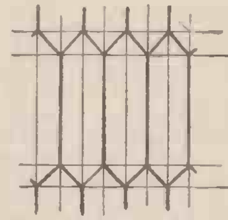
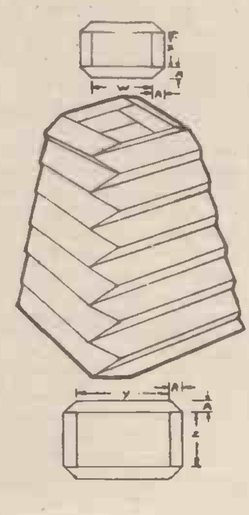


Fig. 5.—(Above) The layout for tapered bellows







Figs. 3, 4 and 6.—(Left). The fold graph. (Above) Method of marking out. (Right) Completion of tapered bellows

Facts About Metals

(*Continued from page 226 of February issue*)

Cooper's Mirror Metal.—An untarnishable metal for mirrors. Takes a very high polish. Composition: platinum, 9.49%; copper, 57.85%; zinc, 3.51%; tin, 27.49%; arsenic, 1.66%.

Cooper's Pen Metal.—A Cooper-silver-platinum alloy said to be suitable for pen-nib tipping. Composition: copper, 13; platinum, 50; silver, 36 parts.

Copper.—Metallic element. Chemical symbol, Cu (from the Latin *cuprum*, a contraction of *Cyprium aes*, "Cyprian brass," the metal having been found in the island of Cyprus by the Romans). At. No. 29; At. Wt. 63.5; M.P. 1,082°C.; B.P. 2,310°C.; Sp. Grav. 8.914; Sp. Ht. .0933; Coef. Exp. .00001678; Therm. Cond. (Silver—100) 73.6; Elec. Cond. (Silver—100) 93.

Chief ores: Copper pyrites, $CuFeS_2$; Ruby ore, Cu_2O; Malachite, $CuCO_3.Cu(OH)_2$. Also occurs in metallic state.

Copper is one of the oldest known of metals, its use dating from prehistoric times. In alchemical terms, the metal was symbolised by the planet Venus.

Copper is a lustrous red-brown metal. It is extremely tough and can be hammered out into a thin leaf. It is very ductile, also. When heated to near its melting point, the metal becomes so brittle that it can be powdered. Molten copper is dark sea-green in colour. The vapour of boiling copper is also green. Copper is fairly resistant to atmospheric corrosion and oxidation. Owing to the fact that, next to silver, it is the most electrically conductive of all metals, it is used enormously in the world's electrical industries. Copper for electrical purposes must be almost perfectly pure, since small traces of impurities seriously interfere with its conductivity. As a casting metal, as an ingredient of brass and many other non-ferrous alloys, copper is much used. Molten copper expands on solidifying.

Next to iron, copper is, perhaps, the most generally useful of all metals.

Copper Amalgam.—Many types of copper amalgam have been used from time to time. One containing 3 parts copper to 7 parts mercury is plastic, but hardens within a day or two. It has the property of softening and acquiring the consistency of clay by kneading and pounding. Other copper amalgams have been used for filling teeth, sealing vacuum tubes, bottles, etc.

Copper amalgam readily crystallizes. It can be rolled and hammered.

Copper-chromium Alloys. — These have chromium contents ranging from .5% to 1%. They are sometimes used for the manufacture of welding electrodes on account of their hardness and good electrical conductivity. They sometimes contain traces of other metals, such as silver, beryllium zirconium, cadmium, and zinc, and are marketed under various trade names.

Copper Steel.—A variety of steel introduced in 1899 by A. L. Colby. Copper steels contain, on an average, about 1% of copper. They are fairly hard and have a better mechanical strength than ordinary mild steel. Moreover, they are more resistant to certain types of chemicals. Copper steel is having an increasing use in this country for the manufacture of such articles as steel sheets, smoke-boxes, and ashpan plates of locomotives. Steel railway sleepers have also been made of copper steel, both in America and in Germany.

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

Coslettized Iron.—Iron which has been treated by a rust-proofing process originally devised by Thomas Watts Coslett, an English chemist, in 1907, but later developed and commercialized in America. The process consists in immersing the cleaned iron article in a bath containing a dilute solution of iron phosphate in dilute phosphoric acid, the bath being heated to near its boiling point. In this way, an extremely thin coating of grey iron phosphate is formed on the surface of the iron article. This coating is very hard and tenacious, and it very satisfactorily protects the underlying metal from the ravages of rust and corrosion. The process is one which at the present day is much used in the bicycle and allied trades.

The surface of a sheet of copper as it appears under a powerful microscope. Note the large crystals of metal

D

Delta Metal.—A very similar alloy to Muntz's metal. It is, in reality, a variety of brass which has a high tensile strength. It can be forged and rolled and it is much used for ship's propellers. It is resistant to corrosion.

Typical composition: copper, 55%; zinc, 43.5%; iron, 1%; lead, .4%; phosphorus, .1%.

Introduced in 1883 by Mr. Alexander Dick, who named it with the Greek letter "D" (Delta), to associate it with his own surname.

Dental Amalgams.—Dental amalgams and alloys vary enormously in composition and many of them are more or less secret in nature.

Amalgams of tin, mercury, and cadmium have long been used in dentistry. These amalgams become plastic on kneading, and set again without contraction. A copper amalgam is sometimes used in dentistry.

An amalgam of silver, tin, gold, and mercury is at times used as a metallic "filling" for teeth. Other dental amalgams contain platinum and other rare metals combined with mercury.

Dilver.—A nickel-iron alloy containing between 42% and 50% of nickel. Has an expansion coefficient similar to that of glass and is used for the "seal wires" of electric lamps, radio valves, etc., since it provides a perfectly gas-tight joint with the glass. Replaces metallic platinum, which was formerly used for this purpose. Is often used in the copper-coated condition, which provides a still stronger union between glass and metal.

Duralumin.—One of the most important of the light aluminium alloys. It possesses the remarkable property of slowly increasing in tensile strength in the course of four or five days from 18 to 26 tons per sq. in. after it has been heated for half an hour to 500°C. and then quenched in water.

The average composition of duralumin is: aluminium, 95%; copper, 4%; magnesium, .5%; manganese, .5%.

The alloy, on account of its strength, is much used for aircraft work.

(From the French *dur*, hard.)

Duriron.—A type of silicon steel containing from 14% to 14.5% of silicon and from .2% to .6% of carbon, together with very small amounts of phosphorus and manganese. Its tensile strength is only three-quarters that of cast iron, but it has a very high resistance to acids, for which reason it is employed for making into acid containers and similar articles.

Dwi-manganese.—This is the name given by the chemist, Mendeléeff, for the metal, Rhenium, the discovery of which he predicted.

"Dwi" is a Sanskrit numeral, meaning "the *second* after," and, in this connection, it refers to the position of Rhenium in Mendeléeff's Periodic Table of Elements.

Dysprosium.—Metallic element. Chemical symbol, Dy; At. No. 66; At. Wt. 162.5.

A rare metal discovered in 1886 by Lecoq de Boisbaudran in certain rare earth minerals, and by him given the name "dysprosium," from the Greek word *dysprositos*, "difficult of access," in allusion to the difficulty of extracting the metal and its compounds in the pure state. The metal has a light greyish colour, but it is, of course, a mere chemical rarity.

E

Electric Amalgam.—Name given to a class of amalgams which are employed in frictional electric machines for assisting the conduction of the generated charges. There are several different varieties of electric amalgam, although they are usually tin or zinc amalgams.

See **Singer's Amalgam, Kienmayer's Amalgam, Böttger's Amalgam.**

Electrolytic Copper.—This is copper of the highest commercial purity which has been refined by a process of electrolysis. It contains about 99.86% of copper. It is essential to employ copper of this purity for most electrical purposes, for the presence of any impurities often considerably reduces the electrical conductivity of the metal.

Electron Alloys.—Name given to a group of very light alloys of which the chief constituent is magnesium. Used for aircraft construction, etc. A typical electron alloy has the composition : magnesium, 95%; copper, 4.5%; zinc, .5%.

Emerald Brass.—A hard brass alloy of a rich golden colour. Gives a good colour when lacquered and is much used for ornamental purposes. Composition : copper, 50%; zinc, 49%; aluminium, .5 to 1%.

Erbium.—Metallic element. Chemical symbol, Er; At. No. 68; At. Wt. 167.7.

A rare metal, the oxide of which is found in traces in the mineral Gadolinite, found at Ytterby, in Sweden and from the latter half of which name the metal's title was derived. Originally discovered (in the form of its oxide, "erbia") by Mosander about 1840. Although much work has been done on the subject in America, it is doubtful whether perfectly pure erbium has ever yet been obtained.

Erythronium.—This was the name given in 1801 by Del Rio to the metallic element contained in a lead ore which he had obtained from Mexico. The name was derived from the Greek *erythros*, red, on account of the red salts which were obtained from this ore. Subsequently "erythronium" was re-named "vanadium."

See **Vanadium.**

Europium.—Metallic element. Chemical symbol, Eu; At. No. 63; At. Wt. 152. Discovered in 1901 by E. Demarcay and given its name in allusion to the continent of Europe.

Despite the fact that it is said to occur to the extent of .02% in some varieties of monazite sand, europium is one of the rarest of rare metals, and it has only been prepared in minute quantities.

Although a very rare metal on earth, europium has been discovered by spectroscopic methods in the sun and in some of the brighter stars.

Eutectic Alloy.—Name given to the alloy which has the lowest melting point of a series of alloys having the same components. During the solidification of a mixed metal from its molten condition, the eutectic alloy will remain liquid the longest. The term "eutectic alloy" is frequently contracted to "eutectic."

(From the Greek : *eu*, easily; *teko*, I melt.)

Everest Metal.—A bearing or white-metal alloy of the anti-friction class. Composition : antimony, 14-16%; tin, 5-7%; copper, .8-1.2%; nickel, .7-1.5%; arsenic, .3-.8%; cadmium, .7-1.5%; remainder, lead. Also known as "Thermit" metal.

Extra-terrestrial Metals.—Metals which have been derived from sources beyond the earth in the form of meteorites. Gold, iron, nickel, cobalt, tungsten, and other metals are frequently contained in meteorites and are, therefore, "extra-terrestrial" metals.

F

Fenton's Metal.—A white bearing or anti-friction metal, employed specially for axle-boxes of locomotives and wagons. Composition : zinc, 80%; tin, 14.5%; copper, 5.5%.

Ferro-chromium.—Name given to iron-chromium alloys containing more than 60% of metallic chromium and less than 2% of carbon. It is a hard crystalline material, much used in the manufacture of the various chrome steels.

Ferro-molybdenum.—An alloy of iron and molybdenum of varying proportions made by fusing molybdenite (molybdenum sulphide ore) with scrap iron, lime, and coke in an electric furnace. It is a grey, metallic-looking mass and is much used in the production of molybdenum steels.

Ferrous Alloying Elements.—These are the various elements which are employed for alloying with steel in the preparation of the now very numerous "alloy steels" or "special steels." They are :

Nickel	Cobalt	Copper
Manganese	Chromium	Titanium
Vanadium	Tungsten	Aluminium
Silicon	Molybdenum	Uranium
Zirconium	Beryllium	

File Alloys.—Many copper-tin alloys are employed for the manufacture of files, such files (to distinguish them from steel files) being designated "composition files." A typical file alloy has the composition : copper, 64.4%; tin, 18%; zinc, 10%; lead, 7.6%.

Fontainemoreau's Bronze.—Name given to a number of now old-fashioned alloys containing zinc, copper, cast iron, and lead. These so-called bronzes were cast in iron moulds and were used for statuette work, etc. They are practically obsolete.

Fusible Alloys.—Name given to a large group of alloys containing lead, tin, bismuth, antimony, and sometimes other metals. Such alloys melt at an unusually low temperature, some of them melting when immersed in warm water. They are based on the property of certain metals to melt at a lower temperature when alloyed with other metals than they do in the unalloyed state.

Fusible alloys are difficult to obtain in the perfectly homogeneous condition, since, when melted, the heavier components of the alloy tend to sink down to the bottom of the mass of metal. The addition of mercury to any fusible alloy lowers its melting point still further, and may result in the alloy attaining a permanently pasty condition.

In this Dictionary, the fusible metals are entered under their individual names, as, for example, *Wood's Metal.*

G

Gallium.—Metallic element. Chemical symbol, Ga; At. No. 31; At. Wt. 70; M.P. 30°C.; Sp. Grav., 5.9. Occurs in minute quantities in a number of zinc ores, an ore containing as little as .002% of gallium being considered to be rich in the metal.

Gallium was discovered in 1875 by Lecoq de Boisbaudran, a French chemist, who derived its title from *Gallia*, the Latin name for France.

Gallium is related to aluminium in properties. It is a silvery-grey metal having a greenish-blue reflection. Its extremely low melting point (30°C.) constitutes its main characteristic, and molten gallium remains liquid at temperatures considerably below that of its melting point unless touched with a piece of solid gallium, when it instantly congeals. In consequence of its low melting point, attempts have been made to substitute metallic gallium for mercury in high-temperature thermometers. Such endeavours, however, have not been successful, for, unlike mercury, molten gallium "wets" glass and clings to it like water, thereby preventing a definite temperature reading from being obtained. Gallium, therefore, still remains a mere chemical curiosity, although, doubtless, it possesses latent and yet undiscovered uses.

Galvanised Iron.—Iron which has been covered with a protective layer of zinc to prevent it from rusting. In the galvanising process, the sheet iron is cleaned with acid or by means of a fine sand-blast, and afterwards dipped in molten zinc. In another process, the zinc coating is deposited electrolytically.

In the presence of water a galvanic action is set up between the zinc and the underlying iron, whereby the zinc very slowly dissolves, and no rusting of the iron occurs so long as any of the surface zinc remains. The term "galvanised" is, of course, derived from Luigi Galvani, the electrician, of Bologna (1737-1798).

See **Sacrificial Metal.**

Genelite.—A "synthetic" bearing metal material consisting of graphite impregnated with metal. Developed in America by the General Electric Company. It has a low tensile strength (3½ tons per sq. in.), but the material is very porous and will absorb about 3% of its weight of oil, which is gradually exuded when the bearing is in use, thus maintaining the latter in a satisfactorily lubricated condition.

Germanium.—Metallic element. Chemical symbol, Ge; At. No. 32; At. Wt. 72; M.P. 958°C.; Sp. Grav. 5.47.

Discovered in 1885 by C. Winkler, in argyrodite, a silver ore, which he found to contain about 7% of a new element, subsequently termed by him "Germanium," from *Germania*, the Latin name for his country.

Germanium is a metal which is related to tin on the one hand and to silicon on the other. It is greyish-white, lustrous, and brittle, and, in ordinary air, is untarnished.

Gold.—Metallic element. Chemical symbol, Au (from the Latin, *aurum*). At. No. 79; At. Wt. 197; M.P. 1,062°C.; B.P. 2,530°C.; Sp. Grav. 19.5; Sp. Ht. .030; Coef. Exp. .0000147; Therm. Cond (Silver—100) 53.2; Elec. Cond. at 0°C. (Mercury—1) 44.

Gold is one of the prehistoric metals, having been known from the earliest times. The alchemists called it *sol* (the sun) and represented it by the circle, the symbol of perfection, for, to them, gold was the most perfect of all metals. Gold is usually found in the metallic state. It is widely distributed in Nature. Sea-water contains 3½ grains of gold per ton, and granite, on the average, contains .37 parts of gold per million. Gold is a yellow metal, being the most malleable and ductile of all metals. Gold sheets as thin as .000004 in. have been made. In such thin sheets, gold transmits green light, and the vapour of boiling gold is also green.

Gold is not acted upon by air or oxygen, or by most chemical reagents. Hence it forms one of a group of *Noble* metals which remain unattacked by most influences. Hot selenic acid is the only single acid which will dissolve gold. The metal is, of course, dissolved by *aqua regia*, a mixture of strong nitric and hydrochloric acids.

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.

Making Bromine

WHAT is the laboratory method for the preparation of bromine?—G. S. (Bow, E.3).

IF you have the necessary apparatus, you will not find it a difficult matter to prepare a quantity of bromine.

All you require is a glass retort, a tripod on which to rest it, and a retort stand, together with a bunsen burner or a spirit-lamp. The materials required are potassium bromide, manganese dioxide and concentrated sulphuric acid.

Powder up the potassium bromide crystals and intimately mix them with one-fifth of their weight of manganese dioxide. Place this mixture into the retort and just cover the mixture with concentrated sulphuric acid.

The glass receiver must be kept cool by being immersed in water (or, preferably, in ice water). When the material in the retort is very gently heated, bromine will be liberated and will distil over as a heavy, red, pungent-smelling vapour which will condense to a heavy, red liquid in the receiver.

The liquid bromine is very volatile and it readily attacks corks and other materials. It should be kept in a glass-stoppered bottle, the stopper of which is very lightly smeared over with vaseline.

The materials and apparatus for the above preparation are best procured from Messrs. F. E. Becker & Co., Hatton Wall, E.C.1. You might, also, be able to procure the necessary chemicals from any branch of Boots the Chemists, and we would suggest that you obtained ½ lb. potassium bromide, ¼ lb. manganese dioxide and 1 lb. concentrated sulphuric acid.

Stamping Glass

IS there any chemical I can use for stamping glass which will prove absolutely indelible. If so would an ordinary rubber stamp be effective?—W. B. (Glos.).

APART from the well-known process of sandblasting, which you cannot possibly apply yourself, there is only one method of making an indelible mark upon glass without actually scratching it, and that is by the use of hydrofluoric acid.

By the employment of this material, two processes are open for your use :—

(*a*) Make up a paste of hydrofluoric acid with powdered fluorspar and apply this to the glass, either by stamping it on, or, better still, by means of a stencil.

Alternatively, you can cover the glass with a thin coat of wax or varnish and scratch in the varnish the required letters. The above paste is then smeared over the scratched varnish, left for a few minutes and finally washed off, the varnish then being removed, when the writing will be found etched in the glass.

Hydrofluoric acid, obtainable from all wholesale chemical houses, is a highly corrosive liquid which has to be kept in hard rubber bottles. In place of this acid, you might prefer the following method :—

(*b*) Use for the etching paste a mixture of powdered fluorspar and concentrated sulphuric acid, the paste being warmed somewhat. This, applied in the above manner, will do the same work, but it is considerably slower in action. In this case, however, it will be impossible to stamp the paste on to the glass by means of a rubber stamp, since the sulphuric acid present in the paste would quickly destroy the rubber.

Concentrated Heat

IS it possible to concentrate the heat from a radiant heat bulb or other electrical apparatus by means of a lens in the same manner as the sun's rays can be concentrated? Also, if radiant heat bulbs were made on a larger scale, would the rays emitted have a longer range?—D. H. (Westcliff-on-Sea).

TO a certain extent, the heat content of any luminous rays may be concentrated by means of an ordinary lens, as witness, for instance, the well-known "burning glass" by means of which paper may be set on fire with the sun's rays.

Glass, however, is not perfectly transparent to heat rays. Hence, if one desires to transmit and concentrate heat rays by means of a lens system, it becomes necessary to use a lens made of transparent rocksalt, which lenses, although they are commercially available in small sizes, are very expensive and not very durable.

Polished metal surfaces have the property of reflecting heat. It is for this reason that the heat of a radiator element is usually concentrated into a roughly parallel beam by means of a specially curved reflector of polished metal placed behind the radiator element.

If the radiator element were increased in size, the amount of heat radiated would necessarily be increased, and would, therefore, be felt at a greater distance. The size of the radiating element, however, would not, in ordinary circumstances, influence the type of heat-ray radiated; it would merely modify the intensity of the ray, a larger radiant giving the ray more energy and thereby enabling it to travel to a greater distance.

Jointless Flooring Composition

I AM experimenting with a jointless flooring composition, mainly for bathroom floors, and have been advised to use sawdust, wood flour, magnesite, asbestorine and a solution of magnesium chloride. Will you kindly inform me as to the right quantities to use of each substance and in what order to mix?

What is Asbestorine and is it the same as Asbestine?—K. S. (South Africa).

"ASBESTORINE" and "Asbestine" are trade names, but, unfortunately, we have not been able to trace the makers of these products. You may take it, however, that they are identical, and that they consist of some type of natural asbestos flour, such as may be obtained from Messrs. Thomas Hill-Jones, Bow, London, E.3.

The jointless flooring composition you name is quite good, and, within reasonable limits, you may proportion the various ingredients just as you require them. If necessary, you can omit the asbestorine (or asbestine) and substitute for it fine sand (passing 1/16th mesh sieve).

A suggested formula using the ingredients which you name is the following :—

Magnesite (Magnesium carb.)	100 parts
Sawdust	35 ,,
Wood Flour	40 ,,
Asbestine (or fine sand)	50-70 ,,

The above to be mixed intimately together and then worked up like mortar with a fairly strong solution of magnesium chloride.

The above composition will take about three days to dry out properly and, on setting, it will expand very slightly.

In making up the composition, a reasonable mixture of finer and coarser particles should be aimed at, the finer particles of the ingredients, or "aggregate," imparting a smooth surface to the composition, and the coarser particles giving strength to the mixture.

Chemicals for Respirators

WHAT chemical is suitable for use in a respirator as a protection against sulphur dioxide? Is there any choice of chemicals for this purpose?—E. C. (Essex).

A MIXTURE of equal parts of soda lime and activated granular charcoal will form the best filtering medium for the removal of sulphur dioxide. These materials are cheap and can be obtained from any firm of wholesale chemical suppliers, as, for instance, Messrs. May & Baker, Ltd., Dagenham, or Messrs. Harrington Brothers, Ltd., Oliver's Yard, City Road, Finsbury, London, N.

Lead peroxide and, also, sodium peroxide are, in addition, two materials which powerfully absorb sulphur dioxide. In most instances, however, these cannot be used for respirator work, since they become hot in consequence of their chemical action on the gas.

Vitamins in Foodstuffs

CAN you tell me how to test for vitamins in food and how to find in what quantities they are present? Is it possible to obtain a chart showing the calorific value of various foodstuffs?—A. L. (S.W.17).

THERE is absolutely no simple chemical test for the presence of the various vitamins in foodstuffs. The few tests which are available are extremely complicated and lengthy ones, and, moreover, they do not usually allow the actual amounts of the vitamins to be estimated, since vitamins exist in such small quantities in foodstuffs.

If, however, you will write to the British Drughouses, Ltd., Graham Street, City Road, N.1., or to Messrs. Boots Pure Drug Co., Ltd., Nottingham, either of these firms will probably let you have copies of any special literature which they may issue on the subject of vitamin tests.

It is obviously impossible for us to supply you with a chart giving the calorific value of foods. If, however, you will consult almost any textbook of food chemistry in your local library, you will be able to obtain abundant information on this subject.

Most textbooks on Foods are expensive, but if you care to do so, you will be able to obtain a good selection from Messrs. W. & G. Foyle, Ltd., Charing Cross Road, W.C.2.

Trouble with Vacuum Cleaner Motor

I HAVE a "Viking Junior" vacuum cleaner motor which is supposed to run on D.C. or A.C., 25 to 60 cycles. When connected to the standard A.C. supply the motor sparks at the commutator with a ring of bright sparks right round from brush to brush. After about 10 seconds the motor starts to slow down and in a further 10 seconds the armature has almost stopped and the whole motor is very hot.—W. T. C. (Lancs.).

ELIMINATING such troubles as arise from defects in design, the principal causes of sparking such as described are: (1) Faults in the armature winding; (2) Wrongly connected field coils; (3) Bad condition of commutator; (4) Unsuitable grade of brushes. Of these the only way to ascertain (1) definitely is by the method of "drop-testing," (explained in Avery's "Dynamo Design & Construction"). If the fields are interconnected correctly (2) one pole will be north and the other south. If both are of similar polarity the sparking will be incurable, and the machine develop a very weak torque. No. 3 may arise from copper particles embedded in the mica insulation between commutator bars, or solder at the back of the segments where the armature junctions are made. The best remedy is to undercut the mica to a depth of 1/32 in. where the brush track comes. This is always desirable in very high-speed machines, such as electric drills and vacuum cleaners. The condition of the brush faces (4) should also be examined. If the commutator has been polished with emery this nearly always leaves grains embedded in the copper, which rapidly wear down the brushes and copper bars, leading to imperfect contact between the two. A very hard grade of brush is preferable for these machines, such as the Morgan Crucible Co.'s "Link C/4". Apart from the possibility of the above troubles existing there is always a considerable tendency towards sparking in such motors when running on A.C. unless they have a large number of commutator bars, and there is generally a critical speed where the trouble is more pronounced.

What is Light?

IS light an electro-magnetic radiation? If so, is it possible to collect and amplify after the manner of a radio-frequency amplifier?

Is it possible to measure the frequency of light (say sunlight)?

If it were possible to amplify light in the above manner what sort of reproducer would be necessary?—R. J. L. (Lisbellaw, N.I.).

LIGHT is an electro-magnetic radiation, according to most theories, a sort of vibratory impulse which is transmitted through the medium of space. Unlike the wireless radiation of longer wavelength, it is not possible to amplify light by any direct electrical means, although it is very possible that at some future time, this feat may be accomplished satisfactorily.

To amplify light in the manner which you infer would necessitate the invention of some means of transforming the short wavelengths of light into the long wavelengths of ordinary electrical (wireless) radiation. Such "converted light" energy would be amplified by means of a type of radio-frequency amplifier and then reconverted back into light.

The problem is a huge one, and, very likely, it will not be solved in our time.

There are several methods of ascertaining the wavelength and frequency of light, all of which are rather complicated and difficult to explain briefly. Here, however, is one such method:—

When a beam of sunlight is made to fall upon a "diffraction grating," which is a smooth reflecting surface having ruled upon it many thousands of fine lines, the light beam is "diffracted" or spread out. The diffracted light rays may be brought to a focus by a lens, and by measuring the angle of their diffraction in a special instrument designed for this purpose, we can calculate the wavelength of the light in accordance with the following mathematical equation

$$\lambda = \delta \sin \theta$$

where

λ = wave length of light.

δ = average distance between the scratches or ruling of the diffraction grating.

$\sin \theta$ = sine of the angle of light diffraction.

From the wavelength of the light, its frequency (i.e. number of vibrations per second) is calculated by means of another formula.

As you will now realise, the whole subject is a highly technical and mathematical one, and for further elucidations of it we must refer you to any advanced textbook of physics or optics.

Testing Linseed Oil

FROM time to time I do a fair amount of indoor and outdoor painting about my home. I use various grades of paints, but some of these do not dry properly, in fact remain more or less permanently sticky. I have come to the conclusion that this is due to the quality of linseed oil used in their manufacture. I would be glad if you could tell me of a simple test for the purity of linseed oil, so that I could decide beforehand of its suitability or otherwise for paint work. —W. K. (Warrington).

MANY cheap paints are adulterated with "white spirit," a petroleum product, which, of course, does not harden like linseed oil or turpentine, and hence results in the paint remaining permanently sticky. Unfortunately, however, there is no simple test for its presence in already made-up paint.

A good test, however, for the purity of raw linseed oil is to rub a small film of it on to a sheet of glass. On holding this to the nose, there should be no odour of paraffin oil; also, the film of oil should harden within a few days.

If you have been making up your own paint with linseed oil, it is quite possible that the failure of your paint to dry out properly is due to your not having incorporated any or sufficient "drier" with the paint. A "drier," as, no doubt, you will be well aware, is a chemical substance which, when added in small quantity to the paint, accelerates the rate of the paint's final hardening after being brushed on to the required surface. Driers may be obtained from any paint stores. A good drier is cobalt linoleate, which may also be obtained from Messrs. A. Boake, Roberts & Co., Ltd., London, E.15, price about 1s. 6d. a pound.

Cleaning a Cash Register

I HAVE recently acquired a national cash register. This is an oxydised model heavily embossed with pattern. Will you please tell me the best way to clean it?

Is it possible for me to get a booklet showing how to clean and repair the register?—E. T. (Long Eaton).

THE best way for you to go about the job of cleaning the exterior of your cash register is to procure 1 lb. of sodium metasilicate from either Messrs. Harrington Brothers, Ltd., 4, Oliver's Yard, 53a, City Road, London, E.C.1 or Alcock (Peroxide) Ltd., Luton, Beds. (price about 8d. lb.), and to make up a fairly strong solution of this substance in warm water.

Using a stiff brush, rub the above solution thoroughly into the surface crevices of your cash register, taking care, of course, that it does not penetrate to the interior of the machine. This solution (which is not caustic) will loosen all the caked dirt on the metal surfaces, so that it can be rinsed away readily with fresh water.

Use plenty of rinsing mops, and then carefully wipe the surface of the machine dry.

For subsequent polishing, you would be advised to use precipitated chalk made into a paste with benzene. This is applied to the metal surfaces, allowed to dry on, and then vigorously rubbed away with a fairly stiff brush.

Do not use an acid, alkali or sandpaper for the cleaning of your cash register, for such materials will not do the job properly, and moreover, they will cause trouble if they get into the interior of the machine.

For an instruction and other booklets dealing with the maintenance of your cash register you should apply to The National Cash Register Company, Ltd., 206-216, Marylebone Road, London, N.W.1.

SIMPLE EPISCOPES

(*Continued from page* 295)

Improved Model

A more ambitious episcope is shown in fig. 5. In this case the picture is inserted at the bottom, and held by a swivelling platform operated by a handle. The springs hold the picture against a glass plate. Four 100-watt bulbs are used, and ventilation is necessary. Rows of holes provide this, and a tin baffle inside prevents light leakage. The mirror at the top enables the lantern to be used in *front* of the screen, since it reverses the print a second time. Fig. 6 shows the mirror holder, a, and its supports are shaped from strip metal as at b. The supports for the lantern are 3/8 in. (inside size) gas pipe, bent to shape in a pipe bender at the local gas works. They are bolted on, and holes are drilled to take the ends of the operating lever, which are bent as in c, fig. 6.

Finally, it is important that the bulbs are placed so that no light enters the lens directly. The picture is projected by reflected light only. This incidentally enables coloured pictures to be used. The only unsuitable pictures are those with a high glaze, or those which are too indistinct to stand enlargement.

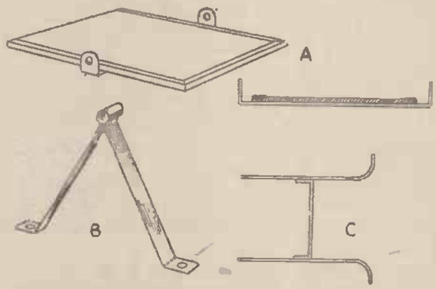


Fig. 6. Mirror and supports for an improved episcope

CHEMISTRY FOR BEGINNERS

(*Continued from page* 308)

Boron burns in air when very strongly heated, but, unlike most elements, it combines with some of the nitrogen, as well as with the oxygen of the air. Hence, the product of the combustion of boron in air is a mixture of boron trioxide, B_2O_3, and boron *nitride*, BN.

When boron powder is fused with caustic soda or potash, or with potassium (or sodium) sulphate, nitrate or carbonate, it forms the borate of the metal.

In most of its properties, boron (despite the fact that it is non-metallic in nature) shows itself to be closely allied to aluminium. It is, therefore, included in the aluminium family of elements.

Boron nitride, which we have just mentioned, is peculiar in that when heated in a current of steam, it evolves ammonia, forming boron trioxide. Thus :—

$$\underset{\text{boron nitride}}{2BN} + \underset{\text{water}}{3H_2O} = \underset{\text{ammonia}}{2NH_3} + \underset{\text{boron trixoide}}{B_2O_3}$$

The nitride itself is a white powder, which is insoluble in water. It is best obtained in the pure state by heating boron in ammonia gas.

At the temperature of the electric arc, boron combines with carbon and silicon, forming, respectively, carbon boride, CB_6, and silicon boride, SiB_3 (and, also, SiB_6). These at present little known compounds are awaiting future development and exploitation, for they are, like our nowadays well-known carborundun (or carbon silicide), exceedingly hard materials which resist attack by most chemicals and which, in some ways, resemble diamonds. We shall, no doubt, hear more industrially concerning these materials in the time to come.

Boron Hydride

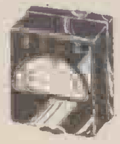
Finally, on our list of interesting boron compounds we must refer to boron hydride, BH_3, or "boronetted hydrogen," as we might well term it. Boron hydride is a gas which is difficult to obtain in a pure state, but, mixed with considerable amounts of hydrogen, it may be generated by acting with dilute hydrochloric acid upon magnesium boride, which substance may be obtained (more or less impure) by fusing magnesium powder and boron trioxide powder at a high temperature in a covered crucible.

This boron hydride gas, even although, when prepared as above, it will be largely diluted with hydrogen, should not be inhaled in any quantity, for it has an unpleasant smell, and is apt to give rise to a feeling of sickness. When ignited, it burns with a green flame, and when passed through a heated glass tube, it deposits boron within the tube as a brown powder.

By heating metallic calcium with boron trioxide in a covered crucible calcium boride (more or less impure) is obtained. This is in some ways analagous to the familiar calcium carbide, for just as calcium carbide generates acetylene gas when acted upon by water, calcium boride will produce boron hydride gas when brought into contact with the same liquid.

Incidentally, the boron hydride produced in the above-mentioned experiments consists, in reality, of a mixture of at least four different hydrides of boron. They have all similar chemical properties, however, and their precise differentiation interests only the specialist in boron chemistry.

ELECTRADIX



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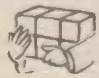

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Advertiser	Page No.	Information Required

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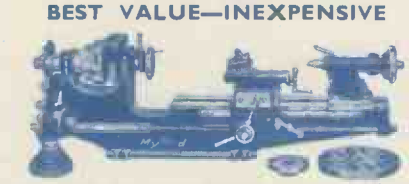

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PRACTICAL MECHANICS, APRIL, 1940.

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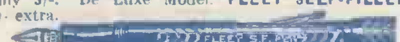

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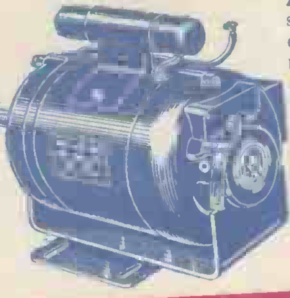

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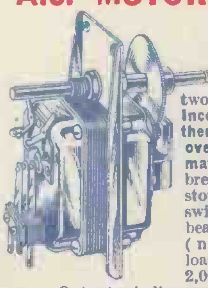

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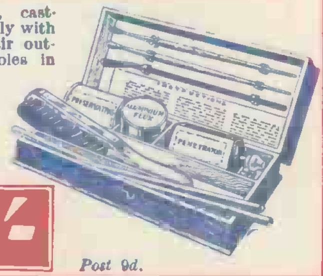

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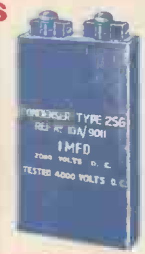

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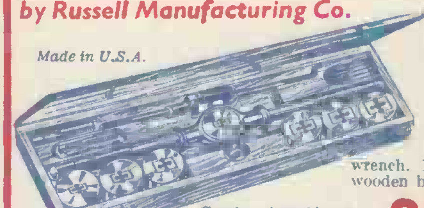
Made in U.S.A.



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