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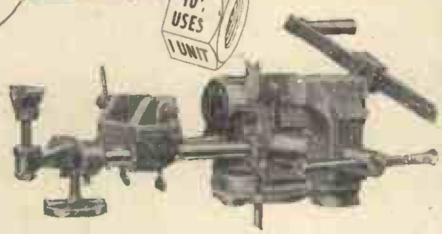

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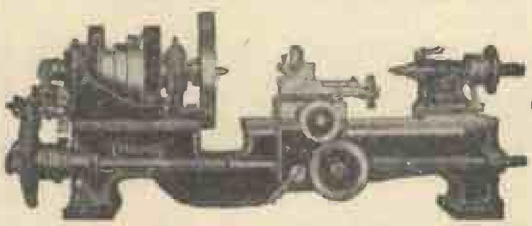

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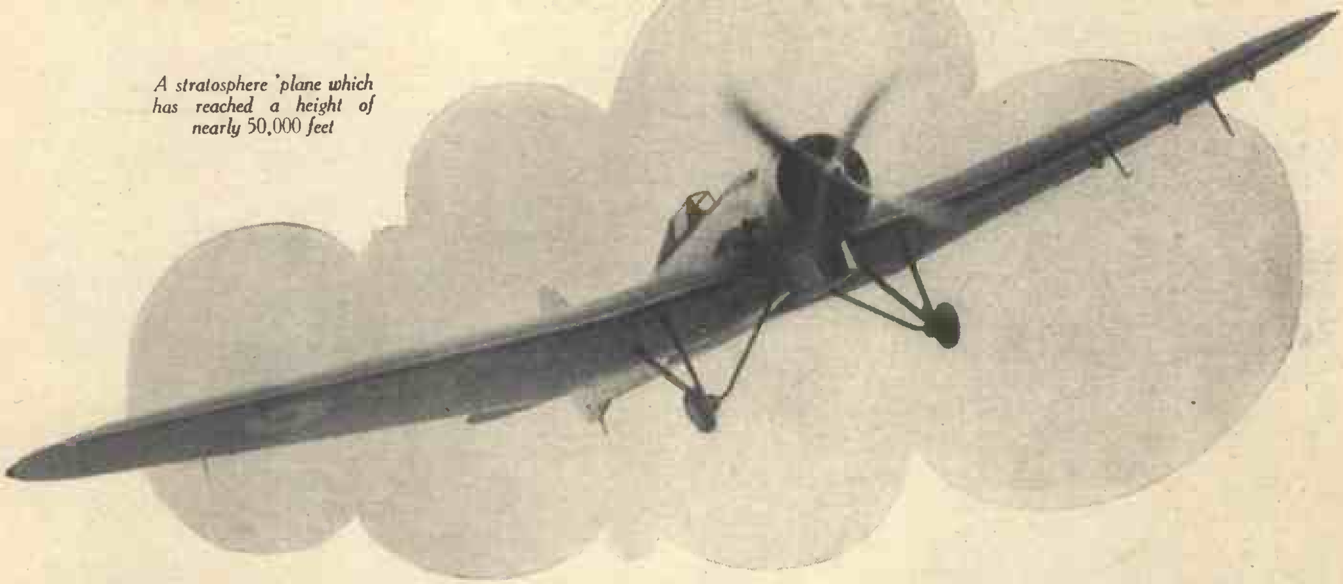
How High Can We Fly?



A stratosphere 'plane which has reached a height of nearly 50,000 feet

To the question, " What is the altitude limit of human flight? " the answer is that, in all probability, there is no such limit, for if we had available a suitably-designed aerial-rocket capable of carrying passengers, we could fly practically as high as we wished. As matters are, however, at the present day the greatest possible height to which it is possible to ascend by means of a specially-designed balloon or aeroplane is represented by the lower regions of the stratosphere.

The earth's atmosphere, as most aviation amateurs are aware, reaches upwards to a height of nearly two hundred miles. Men of science nowadays divide the atmosphere into four different regions: The *Troposphere*, which is our " ordinary " atmosphere consisting of the air we breathe, with its winds, clouds, mists and water vapour. Next comes the *Tropopause*, which is a sort of buffer layer, some two miles thick, between the troposphere and the *Stratosphere*. The latter is the vast region of rarified atmosphere consisting principally of nitrogen, which extends upwards above the tropopause to a height of between fifty and sixty miles above the earth's surface. Finally, comes the *Upper Stratosphere* extending above the stratosphere proper and reaching to about two hundred miles above the surface of our globe. The upper stratosphere is believed to consist mainly of light gases such as hydrogen and helium, and its upper reaches constitute that ill-defined and still somewhat problematical boundary between the earth's gaseous envelope or atmosphere as a whole and the gasless, matterless void of outer space.

The Upper Stratosphere

No human being has ever attempted to voyage upwards into the upper stratosphere, but many have been the endeavours to sail into the stratosphere proper and to explore its many perplexing and mysterious conditions. With an ordinary aeroplane, no matter how well-powered and speedy it may be, it is, of course, impossible to get up substantially into the stratosphere, since not only is that region of the atmosphere devoid of sufficient oxygen to sustain human life, but it is, also, far too rarified to impart the necessary amount of uplift to the normally-designed aeroplane.

Indeed, an ordinary gas galloon has a far better chance of taking a man up into the mid-stratosphere than any of the usual types of lower-level aeroplanes, for, after all, a balloon filled with hydrogen gas, the lightest of all material substances, will continue to rise to an enormous height before eventually it bursts owing to the expansion of the gas within its envelope consequent upon the increasingly reduced air-pressure without.

For many years previous to the invention of the aeroplane, the exploration of high altitudes by means of the balloon had proceeded apace. Little scientific data, however, had been accumulated, first of all on account of lack of sensitive recording instruments, and secondly in view of the fact that the early high altitude observers in mid-Victorian times found it impossible to retain consciousness at altitudes much above five or six miles.

THE PROBLEMS OF ULTRA-HIGH ALTITUDE AVIATION OUTLINED

Scientists and meteorologists, therefore, evolved what is now known as the " sounding balloon," a balloon which is equipped with various types of registering instruments and which is sent up into the higher regions of the atmosphere without any human occupants whatever. When the balloon reaches a certain height, it bursts, whereupon a parachute automatically comes into play and allows the instruments to descend to the ground unharmed.

Sounding Balloons

The instrument-equipped sounding balloons were first used near Trappes, in France, in 1894, by an individual named Teisserenc de Bort. By analysing two or three hundred instrument registrations he came to the conclusion that after a certain height has been reached (a height of approximately seven miles) the temperature of the air no longer shows a steady decrease with increase of height, but that it remains practically constant at about 50 degrees Centigrade below zero. It was from these observations that Teisserenc de Bort discovered that region of the upper air which we now term the stratosphere, the region which commences some ten miles above the earth's surface at the equator and about six and a half miles above the earth at the poles.

Of very recent years, an enthusiastic group of Russian scientists have utilised the sounding balloon method of obtaining records of the earth's upper atmosphere. They have even gone so far as to cause automatic radio transmitters to be taken up in sounding balloons in an endeavour to obtain an accurate indication of the maximum altitude reached by these balloons.

Maximum Height Reached

Up to the present date, the maximum height reached by any sounding balloon is twenty-three miles, that is to say well into the stratosphere proper. Temperature records obtained with these balloons all bear out the fact that in the stratosphere the temperature is practically constant. Other records show, also, that in the stratosphere there is no moisture, very little oxygen and that the region is one of abounding ultra-violet light and cosmic rays.

Modern stratosphere exploration by means of lighter-than-air craft was established by the renowned Dr. Piccard and his companion, Dr. M. Cosyns, who, on May 27, 1931, ascended to a height of about nine and three-quarter miles. On a second voyage (August 10, 1932) Piccard reached a height of ten and a half miles,

Stevens and Anderson in their stratosphere balloon in which they reached a height of nearly 73,000 feet

whilst in the following year a Russian observer, one M. Prokofief, attained an altitude of practically twelve miles.

Air-Tight Gondola

All these ascents were made possible by means of a very light, air-tight aluminum gondola of spherical shape which was attached to the balloon, the observers taking up their own oxygen with them and bringing back with them a considerable number of scientific records.

High as these altitude records were, however, they were greatly eclipsed on November 11, 1935, when Captain Stevens and Anderson, of the United States Army Air Corps, ascended in their stratosphere balloon, *Explorer II*, to a height of no less than 72,395 feet, or nearly 14 miles above land level. This constitutes the highest altitude to which human beings have ever ascended, and although no doubt this record will in its turn be exceeded, the feat of Stevens and Anderson in ascending without mishap to that unprecedented height is one which will not lightly be forgotten.

American Balloon

Explorer II, the American stratosphere balloon, had an envelope whose area was no less than 2¾ acres, and when fully inflated at the highest point of its ascent the envelope was distended with 3,700,000 cubic feet of helium gas, which gas, at ground level, occupied a volume of 300,000 cubic feet.

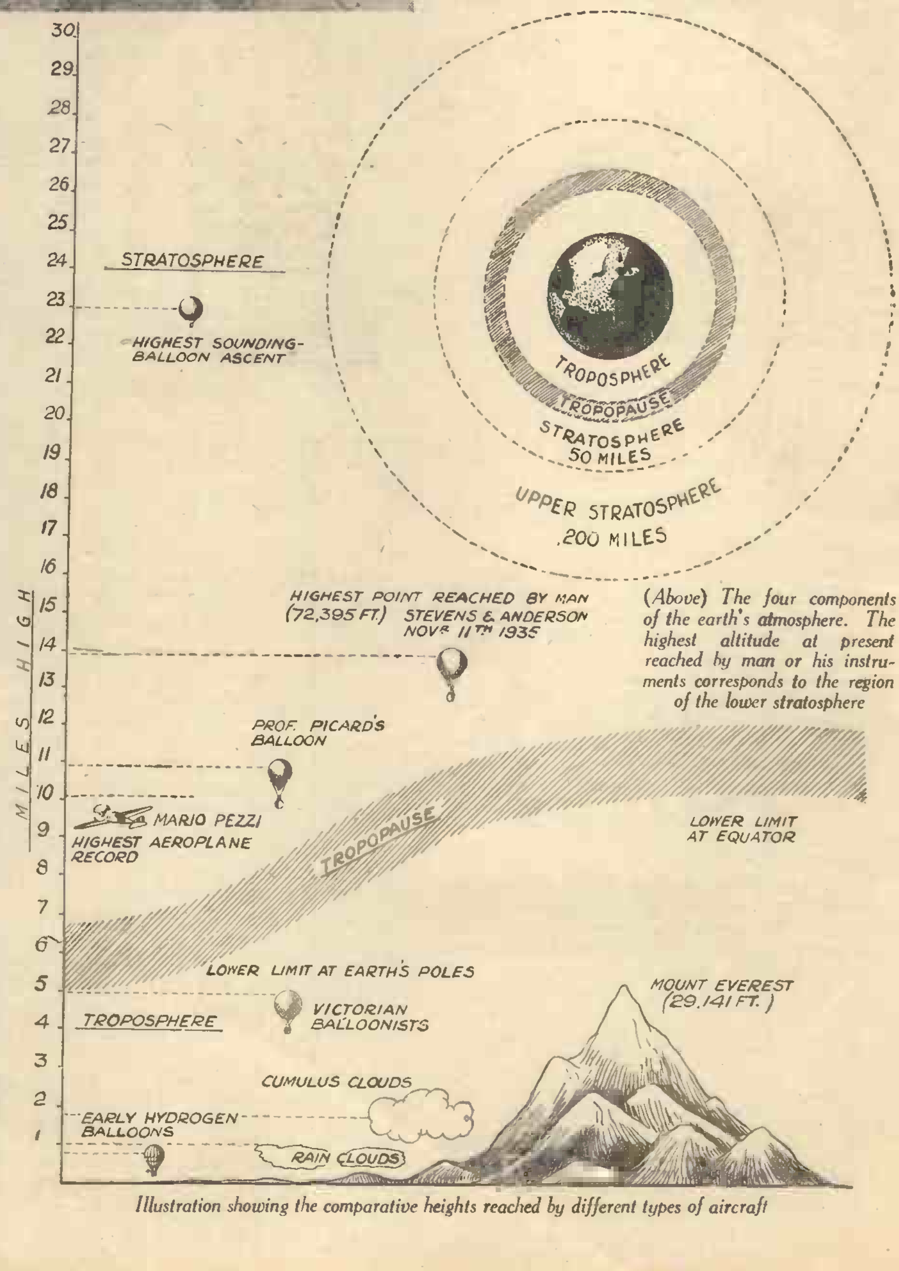
The ordinary aeroplane cannot, of course, hope to reach these colossal heights, for, in the first place, the air at those altitudes is so rarified that it is unable to impart the necessary degree of uplift and, again, because of the lack of oxygen at such extreme heights.

The height record for an aeroplane is approximately ten miles, a record which was achieved by the Italian airman Mario Pezzi in October, 1938. This height, of course, was rendered possible by the employment of an engine super-charger and also oxygen apparatus for the pilot, for at that height neither man nor engine could breathe without artificial aid.

Air Supply

The problem of the air supply of an engine at great heights has brought back once again into the realm of aviation the suggestion of the steam engine as a power unit for high-flying 'planes. Despite the greater weight of a steam power unit compared with that of an internal-combustion engine of approximately equal horse-power, it is a simpler problem to supply oxygen or air to a steam boiler at great heights than it is to a petrol engine. Hence, when the nowadays projected "strato-planes" come into practical being, it is quite possible that the engines of some of them may be steam-driven instead of petrol-propelled.

The firms of Farman in France and Junkers in Germany have, even at the present juncture, constructed experimental aircraft for lower-stratosphere flight. In both instances sealed cabins have been provided in the 'planes for the pilot and his observer, whilst in the case of the Farman 'plane an engine of some 400 h.p. was used, the carburetter taking air normally up to about 13,000 feet. Above this level and up



(Above) The four components of the earth's atmosphere. The highest altitude at present reached by man or his instruments corresponds to the region of the lower stratosphere

Illustration showing the comparative heights reached by different types of aircraft to 25,000 feet a compresser was brought into action to feed air to the cylinders, a second compresser functioning similarly between 25,000 and 60,000 feet, whilst a third compresser was arranged to operate at altitudes above 60,000 feet.

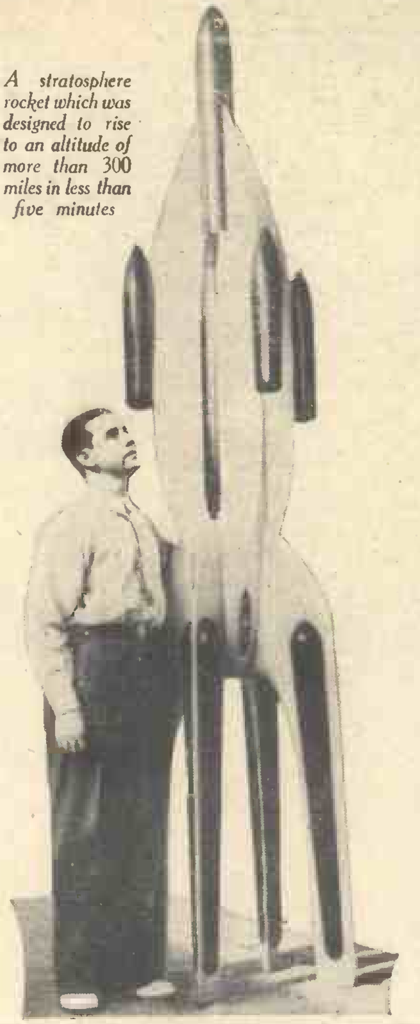
The design of the German Junkers machine ran on similar lines, and by either of these planes it was intended that a minimum height of some 12 miles would readily be attained and maintained.

Variable Pitch Propellers

Such machines were designed with variable-pitch propellers, the "cut" of the propeller being made more acute as the machine ascended to stratosphere levels. Telescopic wings were also designed in order to give the machines huge wing-spreads at high altitudes, these ultra-large wings being necessary in order to enable the machine to ride on the intensely rarified air at heights of ten miles or more above sea level.

Unfortunately for scientific research, war preparations in several countries prevented the making of sustained trials with specially-designed machines of this type. Hence it would appear that all ultra-high flying and stratosphere research must necessarily be postponed until times of peace again return.

Although no ordinarily-designed plane can hope to attain the height of a stratosphere balloon, it may, in the future, be possible to design mechanically-propelled aircraft which will travel at enormous speeds at heights well above the present-day limit for aeroplanes. After all, stratosphere or lower-stratosphere travel, quite apart from its enormous scientific interest, would, if made practicable, possess much commercial value. Owing to the rarity of the air at stratosphere levels, friction thereat is greatly diminished. Consequently a plane can be propelled at a far greater speed for the same effort than it can be at ordinary air levels.



A stratosphere rocket which was designed to rise to an altitude of more than 300 miles in less than five minutes

No Danger of Ice

At the lower stratosphere levels, despite the great cold prevailing, there will be no danger of ice forming on the 'plane, since the air in those regions is perfectly dry. At these levels, also, the air is still and windless, although, towards the upper limits of the stratosphere it is now considered that violent storms rage and circulate. The lower stratosphere is, of course, perfectly cloudless and the sun is visible uninterruptedly from its rise to its setting. Many of the brighter stars are visible in the day-time, also. Hence, a commercial service of stratoplanes operating, say, between England and Australia or betwixt Europe and America would experience no navigation difficulties, for the only "blind flying" which such pilots would be required to undertake being that involved in flying upwards or downwards through dense cloud-belts when ascending into or descending from the lower stratosphere.

The Upper Stratosphere

The upper stratosphere, that entirely unattained region of the earth's atmosphere existing at a height of from approximately fifty to two hundred miles above sea level, will, perhaps, never be conquered by methods of flight as we know them at present. No ordinary hydrogen or helium balloon has ever reached the upper stratosphere, so far as we are aware, and it is, of course, impossible for any present-day powered flying craft to attain that enormous height.

It would seem, therefore, that if man is ever to lift himself up to the level of the upper stratosphere he must await either the coming of the rocket projectile or else the ultra-light plane which, propelled by the as yet undiscovered atomic power, will be capable of journeying upwards to the extreme boundary of the earth's atmosphere and of cruising thereat by means of energy supplies which are, at present, not merely unknown, but also wholly undreamed of

An Engineering Miracle

Producing Power from "Thin Air"

FOR startling effects of legerdemain, engineers of Ford Motor Company and General Electric Company feel that they have pretty well surpassed the magician who produces a whole live rabbit from the apparently vacant atmosphere somewhere to the right of and above his right ear. Instead of a mere rabbit these engineers have produced some 2,500 to 3,000 extra horsepower before the very eyes of all present, and to make the analogy complete they have produced these horses from what may well be called "thin air."

Trick of the Trade

Unlike the prestidigitators of old, the engineers are glad to explain the clever trick of their trade which dispels the mystery. It is the substitution of "thin air," or more properly, hydrogen, for air as a cooling medium for the armatures of the new 110,000 kilowatt turbo-generator at the Ford Rouge Plant Powerhouse, Dearborn, Mich. Weighing only 1/14 as much as air, hydrogen offers far less resistance to the turning of the giant armature, effecting a gain of 2½ per cent. in power output at the 80,000 kilowatt normal "cruising speed" of the generator. That amounts to an output gain of from 2,500 to 3,000 horse power per hour without any increase of input energy. Although the magician's rabbit may not legitimately be a creation of "something from nothing," this feat of the engineering profession certainly is.

The armature of the generator is enclosed in a sealed casing mounted on the armature shaft through oil-sealed bearings. This casing, or jacket, is provided with controlled valves at top and bottom. The first step in filling the jacket with hydrogen is taken by opening both valves and pumping carbon-dioxide gas, which is heavier than air, through the bottom valve until all the air has been displaced. Both valves are then closed and the jacket is ready for charging with hydrogen.

Inlet and Outlet Valves

Hydrogen being lighter than air, the selection of inlet and outlet valves for the charging is reversed. The top valve is opened and hydrogen is pumped in, carbon dioxide being allowed to escape through the bottom valve until the concentration of hydrogen in the jacket reaches 97 per cent. Both valves are then closed. Stability of the hydrogen content of the jacket is ensured by automatic gas analysing devices which flash warning lights and audible signals in the event the concentration of hydrogen falls below 90 per cent.

New Generator

The generator to which this interesting principle has been applied is the third 110,000 kilowatt unit to be placed on the line of the world's largest industrial powerhouse at the Ford Rouge plant. Official starting of the new generator was accomplished recently when William Clay Ford, grandson of Henry Ford, turned a Mercury 8 steering wheel to open the starting valve. Companion unit to its two predecessors, installed in 1931 and 1936 respectively, the new generator embodies engineering improvements which markedly increase its efficiency over the other units. With the new unit in service the capacity of the power house has been raised to 462,000 horse-power.

Hydrogen Cooling

Efficiency of the generator has been increased by hydrogen cooling along principles almost identical with those underlying the increase of automobile efficiency through streamline styling. In other words, both are problems in which the resistance of a moving body to the medium through which it passes must be reduced. In the case of the automobile the solution has come through careful wind-tunnel tests to determine changes of external design which will allow it to move through the air with a minimum of wind resistance. A similar procedure could not be followed in the case of the generator, but an identical result was obtained by the substitution of the much thinner medium through which the armatures must move.

THE MONTH IN THE WORLD OF—

SCIENCE AND INVENTION

Television in War'Planes

A NEW YORK newspaper states that Italy has now fitted a squadron of war 'planes with television sets. Previous difficulties due to the weight of the television installation and necessity for very strong light have now been overcome.

They state that the installation has been reduced to "flying" weight and that the television set will now work in ordinary daylight.

The first experiments carried out were limited to the transmission of cloud formation pictures to a ground station, but it is now claimed that it is possible to recognise the make of a car travelling along the road from an aeroplane flying at a height of 6,000 ft. It is possible to attain a television range of 100 miles. Experiments in this field of television have been in progress in other countries for some time.

England's Oldest Watch

DURING the recent alterations to the Cloister Garth of Canterbury Cathedral, a Saxon 10th century pocket sundial of jewelled gold and silver was discovered. It is considered to be the oldest watch in the English-speaking world. The workmanship is excellent and it consists of a silver tablet with a cap and chain of gold.

The gnomen, which consists of a gold pin, is surmounted by a delicately chased animal head with jewelled eyes. The head has a ball in its mouth which when not in use rests in a pocket at the lower end of the tablet. Abbreviated names of the months are inscribed in pairs on the faces and at the top of each of the three columns is a hole for the pin when in use. Two spots are marked below each hole.

To find out the time, the pin must be inserted in the hole appropriate to the month, and the dial must hang free facing the sun so that the shadow falls down its column. The higher spot will be reached by noon, and the lower at 9 a.m. and 3 p.m.

Hunting for Cosmic Rays

DR. ROBERT A. MILLIGAN, of the California Institute of Technology, has recently set out from Los Angeles on a cosmic ray hunting tour of the Equator and adjacent countries. His equipment will include the world's smallest radio station, and 225 balloons. The balloons are capable of reaching a height of 20 miles and they will be released in Australia, New Zealand, the East Indies, India and Egypt. The balloons will carry delicate recording instruments up to altitudes which receive the full force of the bombardment of this planet by the mysterious rays from outer space.

World's Broadcasting Stations

IT is estimated that there are about 36,000 broadcasting stations in the whole world. of which about 8,000 are land stations, and the rest are mobile installations in ships, etc. Of these 8,000 land stations, 1,800 are regularly used for entertainment, and the rest for communications purposes. Moreover, over two-thirds of these are American Stations.

Post Office Under the Sea

SEATED in a globular, glass-walled chamber in the heart of a marine fairyland a small company of officials and privileged guests recently witnessed an event unparalleled in history—the opening of the Bahamas Sea Floor Post Office, the world's first undersea postal depot. The actual size of the post office is 6 ft. by 10 ft., and it is a well ventilated chamber at the bottom of the sea.

Known as the Williamson Photosphere, it will also be used for broadcasting from the ocean floor, a powerful radio telephone making it possible to describe the wonders of the undersea as the sphere cruises through coral forests abounding in colourful submarine life. Mr. Ernest Williamson's submarine tube and Photosphere can thus be truly said to make the visions of Jules Verne come true. The mother ship for the photosphere is the "Jules Verne III," a strange craft from which is lowered the flexible tube and spherical chamber into the sea.

A specimen postal packet sent from the undersea Post Office, "Sea Floor, Bahamas"

The first coal gas-driven car in England since the start of the second Great War

A Gas-driven Car

AN illustration is shown on this page of what is claimed to be the first coal gas-driven car in England since the start of the second Great War. It has been converted for use with coal gas and Leeds Corporation have installed a special 4 in. gas main at their depot in readiness for users.

The car can be used for either gas or petrol. A switch has been installed in the petrol circuit and when gas is being used you just switch off the petrol, or if you run out of gas you just switch on the petrol. The owner of the car is having a crate made to fit on the roof so that the gas carrier will not sway about too much.

Bags have to be used as the Government will not pass the use of cylinders for a life of more than five years and the cost is too great as they are made of drawn manganese steel. There is also the estimated outlay by the gas companies of approximately £10,000 to instal gas compressors and in present conditions this is out of the question.

MASTERS OF MECHANICS

Instead of journeys, *people now*
May go upon a Gurney,
With steam to do the horses' work
By power of attorney.

Tho' with a load it may explode
And you may all be undone,
And find you're going up to Heaven
Instead of up to London !

THUS Tom Hood, the comic poet of a century ago, characteristically epitomised the credulous, suspicious and half-humorous attitude which the London public adopted towards the pioneering trials of Goldsworthy Gurney, the engineer and steam-coach inventor, to make practicable a steam vehicle which would be of service for ordinary road use.

There were, of course, plenty of people who were ready to say that a steam-propelled road-vehicle was impossible, that such an invention, even if it did materialise, could be nothing other than a highly dangerous contraption, and that such vehicles ought to be prohibited by Act of Parliament. But Goldsworthy Gurney and his few contemporary inventors heeded them not. Instead, they concentrated upon the problem of designing and constructing

Sir Goldsworthy Gurney, who invented a road carriage driven by steam

of metal tubes twisted roughly into the shape of a figure-eight. This boiler was only partially successful, but before long a second boiler was forthcoming, the tubes of which were not welded but butted together so that if any great internal steam pressure arose, the tubes simple came apart at their junctions. By means of such tubular boilers, Gurney was able to get up with safety steam-pressures of some 800 lbs., despite the fact that the average steam-pressure in his later road locomotives seldom exceed 120 lbs. sq. in.

In 1825, Gurney obtained his first patent for a road locomotive propelled by steam. It was a somewhat curious contraption, for its inventor endeavoured to work it without a crank, utilising a pair of oppositely-placed "legs," which, in the words of the inventor, "are set in motion as the carriage ascends a hill and move like the hind legs of a horse, catching the ground and thus forcing the machine forward." Such a steam-coach seems actually to have been run on the public roads in 1827, but a couple of years later, Gurney completed another steam carriage capable of accommodating twenty-one passengers. It, also, had "legs," but it possessed pistons and cylinders, these driving the two rear wheels.

No. 50. Sir Goldsworthy Gurney and the Beginnings of Road Locomotives

a steam-driven road vehicle of such power to enable it to ascend all ordinary road gradients fully laden and without difficulty.

His Early Career

Sir Goldsworthy Gurney—for he was knighted by Queen Victoria later on in his career—was a Cornishman, being born in the Dutchy of Cornwall in 1793. Of his early education and training we know next to nothing. He seems, however, like many other Cornishmen of his generation, to have been attracted to engineering at a very early age, for in his youth he made mechanical models which really worked, models of Cornish beam engines and the like, which power units had at that time attained a very important status in the engineering world of the day.

Although Gurney, during his younger days, was not actually the first to hit upon the now universal idea of the tubular boiler, he was one of the first to construct a light boiler made up entirely of tubes. In a tubular boiler, of course, the water is circulated through a series of heated tubes, an arrangement which permits of rapid and high-pressure steam-raising. Quite a number of engineers of Gurney's day had been against the principle of high-pressure steam when it was first introduced for locomotive purposes by Richard Trevithick, another contemporary Cornish genius. James Watt, for instance, whose present measure of fame is, to say the least, out of all proportion to the true facts concerning his career, was strongly opposed to all high-pressure steam systems. So, too, was his unscrupulous partner, Matthew Boulton. But Trevithick, Gurney and a handful of other locomotive pioneers and inventors persevered in the face of all obstacles and eventually created the railway locomotive and the road locomotive.

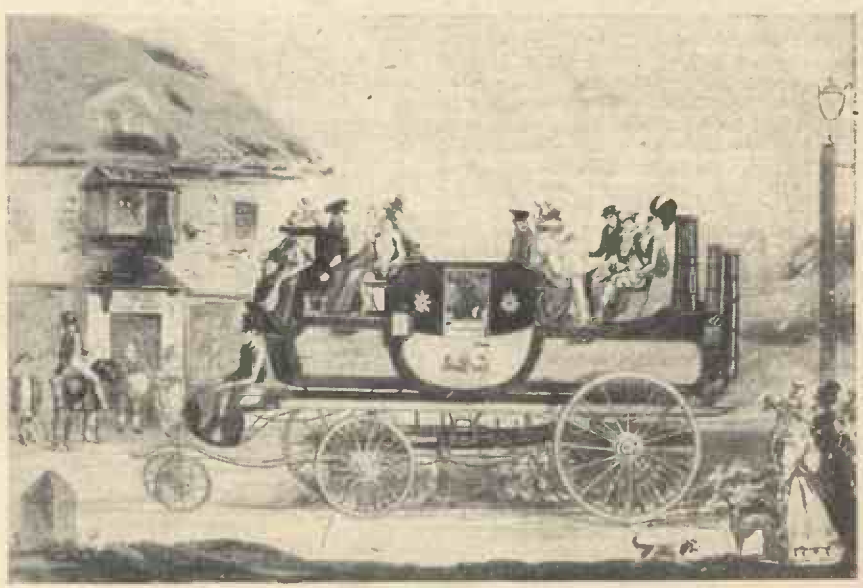
Heating Coloured Water

Gurney, at the outset, began by heating coloured water in a circular-shaped glass tube provided with an outlet vent for the steam. He showed that the convection currents caused by the heated liquid enabled the latter to circulate, and, from this observation, he constructed his first tubular boiler which consisted of a series

A Successful Carriage

This latter road-carriage of Gurney's was really successful. It made many appearances in the environs of London, and, on one occasion, it actually made a journey from London to Bath and back at an average speed of 15 m.p.h., a feat which, considering the times in which it was made, is truly astonishing.

Just, however, as the pioneer railway constructors encountered severe opposition to their labours, so, also, did Goldsworthy Gurney experience the same narrow par-



Gurney's steam-propelled road coach built in 1839 tisanship which arose and threatened to make an end of all his carriages. Indeed, on one occasion when Gurney was driving his steam carriage along a road near Bath, an attack was made upon the vehicle. Its occupants were actually stoned and Gurney himself was so badly manhandled that he lost consciousness and had to be conveyed back to Bath for attention.

"Gurneys"

Gradually, however, Gurney's activities in the construction of road locomotives prevailed. His vehicles—"Gurneys" they were popularly called—came, for a time, into regular usage. For instance, in 1831, a regular road service of "Gurneys" between Gloucester and Cheltenham came into operation four times per day. The average speed of these journeys, stoppages included, was approximately 10 miles per hour.

Other similar road-locomotives ran on regular services in London, and, for a relatively short time, Gurney appeared to be heading rapidly for the utmost success in his pioneering activities.

Powerful interests, however, combined together and eventually thrust the Gurney road-carriages and others from the roads. Such vested interests were by no means only those of the horse-owning and agricultural fraternities. Rather, the greatest amount of opposition to Gurney's schemes came from the railways, who, having, at that period, hardly established their position in the country, saw in the rise of the road-carriage a powerful competitor which would, if uncombated, defeat their interests and destroy their coming monopoly.

Extortionate Road Tolls

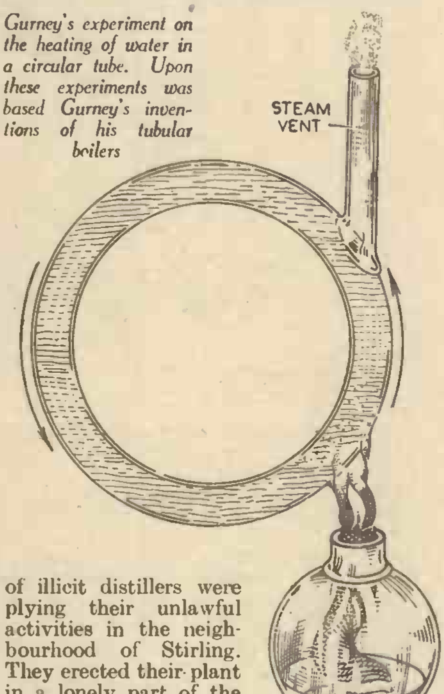
And so it was that all these interests combined together to pass through Parliament certain Acts which, by way of imposing extortionate and numerous road tolls, made it quite impossible for the road carriages of Gurney or anyone else to carry on with any commercial measure of success. Steam carriages and, indeed, all forms of mechanically-propelled vehicles were driven off the English roads until, towards the end of the century, the invention of the internal-combustion engine and its adaptation to a road-vehicle resulted in the rise of the modern motor car and the rapid removal of the various Parliamentary Acts which for more than sixty years had kept all power-propelled vehicles off the highways of Britain.

Disappointed as Goldsworthy Gurney undoubtedly was at the eventual lack of commercial success of his steam road vehicles, their failure did not break him. He ceased to construct steam engines at his own expense in 1832, although for some years afterwards he made efforts to float a public company for the construction and operation of such vehicles. This project failed, however, as, also, did the efforts which Gurney made to bring together a "ring" or association of contemporary road-vehicle inventors and steam-carriage proprietors, as, for example, the renowned Walter Hancock, who ran steam carriages in London, Francis Maceroni, the Manchester-born Italian who operated mechanically-propelled vehicles in the East End of London and many others. Gurney even made petitions to Parliament on behalf of his inventions, but the forces, opinions and interests of his day were entirely against him, and, so far as his road-locomotive activities were concerned, little else than unbelief and bitter opposition greeted his efforts at every turn.

Other Branches of Engineering

As, however, we have seen, Gurney refused to remain dismayed. He turned his attention to other branches of engineering, and, having more or less washed his hands of mechanical road vehicles and locomotive construction, he took up other lines of engineering interest, becoming eventually renowned as a consulting engineer of high repute, and ultimately meriting for himself the honour of knighthood.

Gurney attained some measure of fame as a mining engineer and as an ingenious inventor of a variety of mechanical devices. About the year 1854, for instance, a number of illicit distillers were plying their unlawful activities in the neighbourhood of Stirling. They erected their plant in a lonely part of the estate of the South Sauchie Colliery, near Stirling town. For a considerable period this "whisky gang" operated secretly and successfully, but one day their still boiled over, the alcohol vapours caught fire, and the burning liquor flowed in a stream down into the colliery workings. Here it met with fire damp. An explosion resulted, the illicit distillers flew from the place, and the result was that the colliery workings became the scene of an underground conflagration which, for years, refused to become extinguished.



Gurney's experiment on the heating of water in a circular tube. Upon these experiments was based Gurney's inventions of his tubular boilers

An Underground Fire

Much damage was caused to underground coal seams by this "burning waste of Clackmannan," as the area became known, until Goldsworthy Gurney, the engineer, was approached in the matter, he having previously successfully extinguished an underground fire at the Astley Collieries in Yorkshire.

Gurney's plan was to use a high-pressure jet of steam and, by means of this, to force down into the mine workings a large volume of "choke damp" of sufficiently low temperature to cool down the burning mass and at sufficient pressure to keep out the inflowing air.

To this end, a furnace was constructed above ground and over it was erected a high-pressure boiler. Flues and pipes conveyed the steam and gas to the underground workings. Carbonic gas, generated by the furnace, was flooded into the mine-workings under steam pressure for several hours every day, until, eventually, after several weeks of these operations, it was found that the subterranean inferno had been entirely cooled down and permanently extinguished.

As an engineer pure and simple, Sir Goldsworthy Gurney has long been forgotten. Indeed, it is only his pioneering steam-coach activities which has kept his memory alive. In such respects, however, Gurney undoubtedly exhibited many of the traits of genius. His tubular boilers, for instance, contribute greatly not merely to the making of road locomotives in general but also to rail locomotives. Stephenson, it is said, took several hints from Goldsworthy Gurney in respect of steam boilers for high and maintained steam pressures, and, doubtless, many another inventor became similarly indebted to this nowadays little-known Cornish engineer.

Goldsworthy Gurney died in Cornwall, the land of his birth, in March, 1875, at the ripe age of 82. He had lived a retired life for some time, but to the last day of his existence he evinced an amazingly keen interest in all things mechanical.

What judgment posterity will accord to the life and inventions of Sir Goldsworthy Gurney is difficult to prophesy. The earlier portion of his career is, of course, the one which most entitles him to a niche in the Hall of Engineering Fame.


Another contemporary steam coach

SOFT SOLDERING HINTS

A Practical Article on the Elementary Principles of Soldering

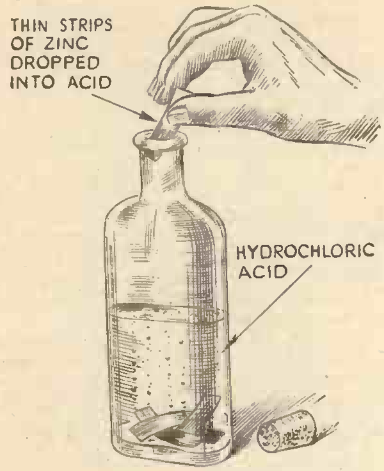


Fig. 1.—Chloride of zinc can be made by dissolving strips of zinc in hydrochloric acid. A porcelain vessel should, for preference, be used

SOLDERING is an easy process if one is skilled to the rules, but even so-called decent mechanics fail hopelessly on many soldering jobs. Cleanliness is the great thing, but not more important than a "hot" iron and the right "flux." It is natural that the parts to be united should be clean, and unreasonable to expect hot solder and flux to remove refractory material whose melting point is above that of the iron or at once oxidises when heated.

Oxygen is the enemy of all forms of uniting metals, as nearly all metals absorb oxygen readily on the temperature being raised, and it is to protect the metals from being oxidised that fluxes are used. An excellent flux for one metal is not so effective on another, or for some reason cannot be used owing to after effects which cannot be eliminated. As an instance, acid fluxes must not be used on electrical connections. The electrical flow sets up some form of electrolysis definitely aided by the minute imprisoned particles of acid, which particles are never entirely removed, however efficient the washing of the part in question.

The Main Fluxes

Chloride of zinc, resin, and Fluxite are the main fluxes used on repairs. The former is a liquid and resin is used powdered. The easiest way to make up chloride of zinc is to dissolve thin strips of zinc in commercial hydrochloric acid. Do this slowly in an open porcelain basin until the acid will no longer "act" on the zinc. When cool, the solution is ready for use, and it should not be adulterated with water. The action of this flux not only helps to clean the job, but the moment the hot iron touches it, it entirely covers the spot without further trouble. When cold, it rests on the surface in isolated globules, but the heating transforms it into a liquid coating, thus excluding oxygen from the air, that is unless the heat is too great and the flux is evaporated. As an iron too cold will not run the solder, so an iron too hot will counter the effect of the flux. A small iron over-heated will not, and cannot, take the place of a larger iron which, if anything, is on the cold side. This flux is used on all tinned goods and articles, such as petrol tanks, autovacs, lamp bodies and petrol pipes, which are "tinned" before soldering.

Don't try to solder chromium plating, as it cannot be done. The chromium must be removed before the solder will take, whatever the flux. Aluminium is only successfully soldered by the professional, and then with special solder and flux. It is not easy, and is often unsatisfactory. An excellent preparation based on zinc chloride is a good soldering fluid. It is better and cleaner than the home-made product and equally as cheap in the long run.

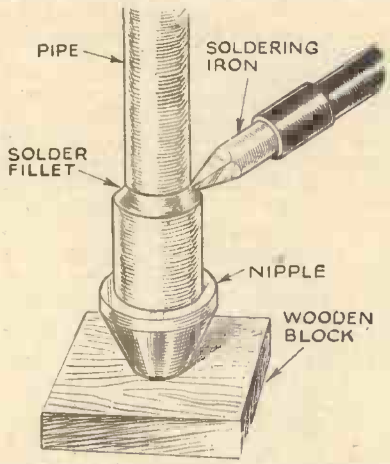


Fig. 2.—The correct method of soldering a nipple to a pipe

> **POINTS TO REMEMBER**
>
> *Make sure that you are using the right flux.*
>
> • • • •
>
> *Chloride of zinc, resin, Fluxite and Baker's Fluid are the main fluxes.*
>
> • • • •
>
> *Many failures are due to the iron cooling off before it can do any effective work.*
>
> • • • •
>
> *Always keep the iron well "tinned."*

Resin is a difficult flux at all times, therefore Fluxite (a paste) is far better for general use in every way, and is mentioned because it is based on resin and is ideal for all electrical joints.

When the Iron Cools

Many failures are due to the iron cooling off before it can do any effective work, the job carrying off the heat when the iron is applied. The larger the iron the better, as it must hold more heat, also repeated application of a small iron means that the applied heat is flowing away whilst the second heat is being added. Hold the iron still when once applied and watch the effect of the molten solder around it. The solder cannot be rubbed in—it must flow of its own accord. Solder has little strength as a metal, therefore always remember it as the "glue" that holds the work together only. Piling it on the job in the hope that it will overcome the difficulty or your poor workmanship is no use and only failure will result.

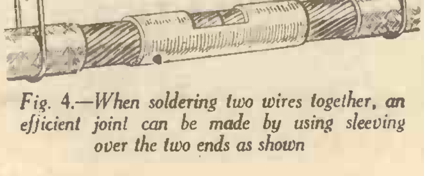


Fig. 4.—When soldering two wires together, an efficient joint can be made by using sleeving over the two ends as shown

Suppose a nipple is to be soldered on a copper pipe : first, the end of the pipe must be clean and really fit the nipple. The pipe should just slide into the nipple with slight pressure. Dip the end of the pipe into the liquid flux and apply some solder with the hot iron. It will now be "tinned" and will have cooled off somewhat. Again dip the end in the flux and tap on the nipple. This "tinned" end will act as a small iron and save the trouble of having to "tin" the small interior of the nipple. Hold the pipe vertically on a piece of wood with one hand and apply the iron with the other hand. As the iron has again been charged with solder, it flows from the iron on to the pipe, where it is already tinned, and so passes down between the nipple and pipe.

A Bad Joint

Should the pipe have been a bad fit in the nipple, the hot solder will not only have penetrated between the pipe and nipple, but up the inside of the pipe also, not being able to run out at the bottom on account of the wood acting as a washer. Should this happen, the pipe must be drilled and the shavings from the drill blown out. If too much solder is applied, it is possible to wipe it off before cooling, but it leads to "blobs," where they are not wanted, such as on the cone of the nipple, and perhaps a leaky union. With practice, the right quantity of solder can be gauged, and if not enough, the iron can, in this instance, be applied again the second time, such process doubly assuring a tight soldered joint.

A patch on a tank is also an excellent example of heat transmission by the soldering iron. As usual, clean the place on the tank thoroughly and "tin" the place to be

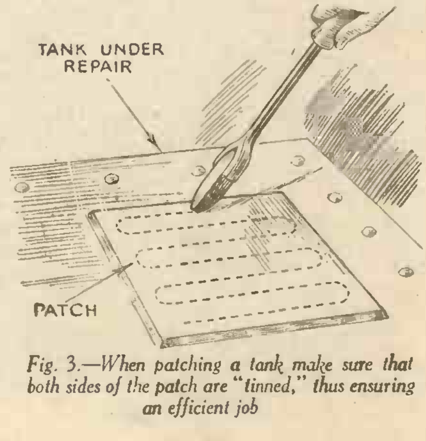


Fig. 3.—When patching a tank make sure that both sides of the patch are "tinned," thus ensuring an efficient job

operated upon about half an inch all round the patch to be applied. The patch should be tinned both sides, as the hot solder on the outside helps to convey the heat from the iron to the patch proper, and so to the solder under the patch. The hot iron, supplied with solder, should be slowly and systematically moved over the whole of the patch so that it sticks to the tank at every point, and towards the end the iron is applied to the edges, when, if there is still any air under the patch, it will be seen to bubble out through the molten solder. The iron should only be applied to the edges last of all, mainly to make a neat job and to prove the exclusion of all air. Again, the largest iron possible should be used, especially as it is not always possible to do the job with one application.

Electrical Repairs

In dealing with all electrical repairs, it is again pointed out that Fluxite or resin must be used and it is preferable to keep a special iron for such repairs. An iron continuously dipped in the liquid flux is bound to impart some of the acid to the electrical joint, eventually leading to trouble. Smear a little Fluxite on the parts to be soldered, as too much is not only a waste, but the surplus paste has a tendency to mess up the nearby insulation. Cleanliness here is a definite injunction, as the Fluxite has no cleansing powers like the fluid, and old wires that have become blackened through burned solder must be cleaned with fine emery cloth until they are bright. Dipping the wires in nitric acid is fatal for the same reason mentioned with the liquid flux.

A spliced joint is out of the question owing to the confines of the space allotted, also a sleeve-joint is far more efficient from an electrical point of view and occupies less space. Fig. 4 shows the sleeve, bored out so that the prepared wires just slide into the hole. The ends of the wires will be seen at the centre of the sleeve, where a slot has been filed so that the hot solder can be applied. Place a little Fluxite on the centre of the sleeve where the wires meet, and immediately the hot iron and solder is introduced, the Fluxite will run freely along the inside of the sleeve and between the stranded wires.

"Tinning" the Iron

To "tin" an iron with either acid or Fluxite, the bit should be cleaned up with a file until the copper is bright. Heat it on the gas-ring until the copper is about to change colour and rub with a stick of solder which has previously been dipped in the flux. Apply it quickly to all sides, afterwards wiping the solder over evenly with a piece of rag. The iron is now "tinned" and ready for use, but there is another method which is equally as good, and that is to have a small piece of tinned steel on the bench on which to rub the iron instead of wiping it with the rag. Both methods apply to both fluxes. When the iron is "tinned," it should still be carefully heated, as a "burned" iron ruins the tin on the surface, turning it into a very brittle dark mass that will neither convey heat nor hold the solder.

FLUXES FOR SOLDERING

Metals	*Fluxes*	*Fluxes generally used*
Iron	Chloride of Zinc	Chloride of zinc (killed spirit)
Steel	Sal-ammoniac	
Copper	Chloride of zinc	
Brass	Resin	
	Sal-ammoniac	Resin
Zinc (new) } Zinc (old) }	Chloride of zinc	
Lead (with fine solder)	Hydrochloric acid	
Lead (with coarse solder)	Tallow and resin	
Tin	Tallow	
Pewter	Resin and sweet oil	

COMPOSITION OF SOFT SOLDERS

Solder	*Composition*	*Melting point*
Fine	$1\frac{1}{2}$ parts tin, 1 part lead	334°F.
Tinman's	1 part tin, 1 part lead	370°F.
Plumber's	1 part tin, 2 parts lead	440°F.
Pewterer's	1 part tin, 1 part lead, and 2 parts bismuth	203°F.

A mixture of $1\frac{1}{2}$ parts tin and 1 part lead fuses at a lower temperature than any other mixed proportion of these metals.

COMPOSITIONS OF HARD SOLDERS

Solder	*Composition*
Hard brazing	3 parts copper, 1 part zinc
Hard brazing	1 part copper, 1 part zinc
Softer brazing	4 parts copper, 3 parts zinc, and 1 part tin

WOOD'S METAL

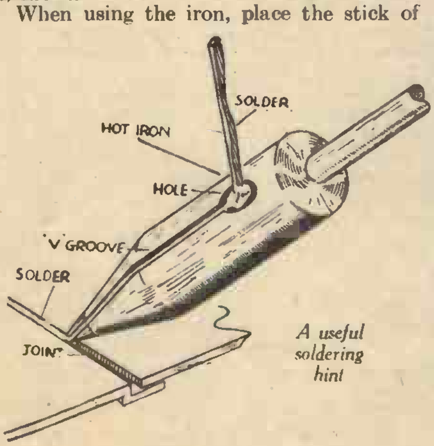
A special soft solder used for joining delicate pieces. It consists of 1 part tin, 4 parts bismuth, 1 part cadmium, and 2 parts lead. It melts at about 60 degrees C.

Two Useful Soldering Hints

A Workshop Wrinkle

If when making a soldering joint, difficulty is experienced in making the solder run into the seam, the following tip may prove useful. Clamp the bit in the vice, and drill a shallow $\frac{1}{4}$ in. hole in the middle of the iron. Now, with a three-cornered file make a groove from the hole to the tip of the iron as shown.

When using the iron, place the stick of solder into the hole, and it will be found that the solder will run down the groove into the hole.

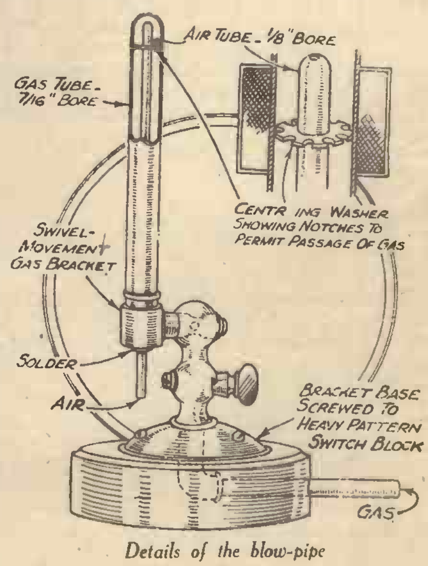


A useful soldering hint

* * * *

A Soldering Blow-Pipe

The accompanying sketch shows a soldering blow-pipe constructed from a gas bracket. The nipple ends, on the gas and air tubes, were formed by hammering, the tubes being supported on a hollow block during the process. When sufficiently reduced, the tube ends are reamered to size, the orifice of the gas-nipple being $\frac{3}{16}$ in. diameter, and that of the air-nipple $\frac{1}{16}$ in. diameter. Flexible tubes connect the gas and air tubes to their respective sources of supply. While soft-soldering can be executed by blowing the flame with the mouth, brazing requires the use of foot-bellows. When the air supply is derived from bellows, a cock fitted to the air tube will give better regulation of the flame.



Details of the blow-pipe

A DICTIONARY OF

Metals and Their Alloys

What this Dictionary Aims At

THE history of civilisation, and certainly that of industry, follows closely upon the history of metals and their alloys. Our modern age, both in peace and in wartime, is, without a doubt, a metallurgical age, an era whose multifarious activities are based to a very large extent upon the production and usage of various types and combinations of metals.

Yet, although metals have been known and used since history began to be recorded, it is a strange and significant fact that it is only within the last fifty years or so that the science of metallurgy has arisen. Formerly, the common metals were smelted from their ores by rule of thumb methods which had been known for hundreds, and in some cases for thousands, of years, and the few alloys which were of any practical import were, in like manner, produced by haphazard methods.

Necessity, however, is well known as the mother of invention, and it was virtually necessity coupled with the rise of applied science in the metal and engineering trades which was responsible for the enormous development in the science of metals and their alloys which has taken place since even the commencement of the present century.

In spite of this advance, however, the science of metals and their alloys is yet, in many respects, an infantile one. By no means have we penetrated anything like completely into the inner secrets of the metals. We do not know exactly why the alloy produced by the admixture of two or three simple metals may exhibit characteristics astonishingly different from any of the constituent metals. Neither do we know why a variation of as little as a tenth of one per cent. in the composition of steel may create an amazing difference in the characteristics and properties of the resulting metal.

Metals, in fact, are still, in many respects, a mystery to us, and much of the information which we have garnered about them is still of the rule of thumb kind.

Nevertheless, slowly but surely the science of metallurgy is creeping on, making new discoveries, nibbling away at the inner mysteries of metals, so that, in the time to come, we may look forward to an age in which metals of strength and properties very different from those of our present time are known and widely used.

The reader who uses this present dictionary, however, can rely upon having at hand a mass of modern information on the subject of metals and their alloys. Whilst the dictionary is no high-flown compilation got together for the benefit of advanced students, the information which it contains will be found of use to even the working scientist.

It is a remarkable fact that an alphabetical dictionary of metals and alloys has never before been published in this present form. Many treatises and handbooks on descriptive metallurgy are available, but not one of them is arranged in such a manner as to give straightforward information with the least possible amount of trouble.

This dictionary, therefore, aims at meeting this need. Its object is to enable the busy and mechanically minded reader of "Practical Mechanics" to put his finger *at once* on the information he requires. Information which, for the purpose in view, is useless has been rigorously excluded from this dictionary in order to keep it within reasonable bounds. Yet every known metal is included in the dictionary and almost every type of commercial metallic alloy.

Many very highly specialised alloys bear no specific name, these being simply represented by a series of code letters, as, for example, "P.66/7 alloy." Such alloys have been omitted from this present compilation, but in all cases the general type of alloy to which they belong has invariably been included. Thus, mention is made of the famous "R.R." alloys, yet their various "Code-number" alloys have necessarily had to be excluded in view of their great numbers.

Sometimes, also, the reader may note that the percentages of the constituents of an alloy do not add up to one hundred. In all such cases, the difference must be ascribed to the presence of impurities which usually accompany the alloying ingredients and which are not readily got rid of.

The dictionary is adequately cross-referenced. It is, in fact, a handy and straightforward compilation of salient and useful facts regarding all the known metals and nearly all the known commercial alloys, and, as such it is presented to the reader in the hope that it will long remain a quick-reference compilation of practical use, instruction and interest.

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

Abyssinian Gold.—See *Talmi gold.*

Acid Bronze.—An acid-resisting alloy, sometimes used for mine pumps. Composition: Nickel, 1.50; lead, 17; copper, 73.5; tin, 8 per cent.

Actinium.—A radio-active metallic element. Chemical symbol, Ac; At. No. 89; At. Wt. 227 (?). Discovered by Debierne in 1899 in uranium residues. Little is known about it but it is apparently intermediate in properties between calcium and lanthanum.

Admiralty Gunmetal.—A bronze having the composition: Copper, 88; tin, 10; zinc, 2 per cent. Has a tensile strength of 19 tons/sq. in.

Aeral.—An aluminium alloy of the composition: Copper, 3.5; magnesium, 1.8; silicon, 0.6; cadmium, 2.25 per cent—remainder aluminium. Tensile strength approximately 30 tons/sq. in.

Aerolite.—A light aluminium alloy of complex proportions. Composition: Aluminium, 91.93; zinc, 0.12; silicon, 0.45; iron, 0.97; copper, 1.15; magnesium, 0.38 per cent. Specific gravity, 2.74.

Aeron.—A modern aluminium alloy containing 4 per cent. of copper and 1 per cent. of silicon. Is hard and strong. Can be heat-treated, in which state it will develop a tensile strength of 25 tons/sq. in.

Afénide.—French jewellery metal composed of nickel or German silver.

Age Hardening.—The property which certain alloys possess of automatically hardening themselves when left for a few days at ordinary temperatures after having been quelched in water. Changes in the grain structure of such alloys underlie this phenomenon.

Aluminium-magnesium alloys and aluminium-copper-silicon alloys are particularly susceptible to age hardening.

Ageing.—Metallurgical term referring to the improvement in characteristics which some alloys undergo, particularly those of aluminium, after they have been kept for some time. It is a process of metallic maturing.

Aich's Metal.—Average composition : Copper, 60.66; zinc, 36.58; tin, 1.02; iron, 1.74 per cent. It is hard and tough, and, being resistant to sea-water, has been used as a sheathing metal for ship's bottoms. It has a golden colour.

Air-hardened Steels.—These are alloy steels in which a certain degree of hardness has been induced merely by air-cooling under controlled conditions.

Ajax Metal.—An anti-friction bearing metal. Composition : Copper, 87.24; tin, 10.98; lead, 7.27; arsenic (or phosphorus), 0.37 parts. The arsenic or phosphorus acts as a hardening agent.

Albata Metal.—Composition : Copper, 40; zinc, 32; nickel, 8 parts.

Alclad.—A metal consisting of duralumin with a coat of pure aluminium rolled on. It has good corrosion resistance.

Aldal.—An aluminium alloy of the following approximate composition: Copper, 4.0; magnesium, 0.5; manganese, 0.5; silicon, 0.6 per cent—remainder aluminium. Is hard and possesses a tensile strength of between 25 and 35 tons/sq. in.

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

Aldrey.—A modern aluminium-magnesium-silicon alloy. Composition: Magnesium, 0.5; silicon, 0.6 per cent.—remainder aluminium. In this alloy, the magnesium and silicon act as hardeners. The alloy can be heat-treated. Tensile strength, 20-22 tons/sq. in.

Alfenide Metal.—Composition: Copper, 60; zinc, 30; nickel, 10 parts; plus traces of iron. Similar to Albata metal. Is resistant to dilute acids.

Alferium.—A French aluminium alloy used in aero construction. Composition: Copper, 2.5; magnesium, 0.6; manganese, 0.5; silicon, 0.3 per cent.—remainder aluminium. Tensile strength about 30 tons/sq. in.

Alger Metal.—A tin-antimony alloy. Composition: Tin, 90; antimony, 10 per cent.

Algiers Metal.—A tin-antimony alloy, little used nowadays. Composition: Tin, 90; antimony, 10 per cent. Sometimes contains copper, also. It is white and takes a good polish.

Alkali Metals.—This well-known family of metallic elements comprises the following members: Lithium, sodium, potassium, rubidium, caesium. The name was so given on account of the strongly alkaline nature of the compounds (particularly the hydroxides) of these metals, as, for example, caustic soda (sodium hydroxide).

Alkaline Earth Metals.—These are the metals, calcium, strontium and barium—so-called because they are derived from "earths" (such as lime) which are alkaline in nature.

Allan's Metal.—A copper-lead alloy (or so-called "tin-free" bronze). Composition: Copper, 55; lead, 45 per cent. Used for Diesel engine piston rings.

Allautal.—This consists of the aluminium alloy, "Lautal," having a coat of pure aluminium rolled on to it. It is corrosion resistant.

Alloy.—A mixture and/or combination of two or more metals forming an apparently homogeneous mass. Alloys can be produced by the simple admixture of the molten metals, by the smelting of mixed ores, by electrolytic methods or by the compression of mixed metallic powders. Alloys containing mercury are called *amalgams.*

When metals are alloyed together they (*a*) dissolve in each other in any proportions but without actual chemical combination; or (*b*) chemically combine with one another, such resulting compounds in some cases dissolving in the excess of pure metal present; or (*c*) dissolve in one another to a limited extent; or (*d*) remain undissolved in one another, in which latter case they will tend to separate out in layers when the metal cools.

The general effect of alloying metals together is to lower the melting point and conductivity, increase the hardness, and sometimes the strength of the metal. Colour changes often are brought about by alloying, and in many other ways, the properties of the alloying metals are profoundly modified in the resultant alloys.

(The word "alloy" is considered to be derived from the Latin, *alligo*, to bind together.)

Alloy Steels.—These are varieties of steel containing considerable percentages of other metals, such as tungsten, chromium, nickel, manganese, etc., which have been added for the sake of increasing the hardness, strength or corrosion-resistance of the metal, or for some other special purpose. Such steels are also known as "Special Steels." They are detailed under their individual names.

Alluvial Gold.—Gold obtained from sands, gravels and grits occurring on the beds of ancient streams. The gold in such localities usually takes the form of small scales or rounded grains, and is known to the miners as "gold dust."

Almag.—An aluminium alloy. Composition: Copper, 2.5; magnesium, 0.7; silicon, 0.6 per cent., remainder aluminium. Tensile strength about 25 tons sq. in. Is very hard and enduring.

Almasilium.—A modern aluminium alloy of French origin. Contains: Magnesium, 1.0; silicon, 2.0 per cent.—remainder aluminium. Can be heat-treated and has considerable hardness. Tensile strength about 22 tons/sq. in.

Almelec.—A recent aluminium alloy containing magnesium (0.7 per cent.) and silicon (0.5 per cent.) as hardening agents. Tensile strength about 20 tons/sq. in.

Alnico.—An aluminium-nickel-cobalt steel used for making permanent magnets and magnet cores. It offers a maximum amount of magnetic energy per unit mass of metal and, in this respect, constitutes a great advance on the old magnet steels. Composition: Steel, 60; aluminium, 10; nickel, 20; cobalt, 10 per cent.

Alpax.—An aluminium-silicon alloy, originally invented by Aladar Pacz, after whom it is named. It contains 87 per cent. of aluminium and 13 per cent. of silicon. It is ductile and fine-grained, and has a silvery-white colour.

Aludur.—A modern aluminium alloy containing 0.6 per cent. of magnesium and 0.88 per cent. of silicon. It is heat-treatable and has a tensile strength of 20 tons/sq. in.

Alumel.—A nickel alloy used in electrical thermometers and thermo-junctions. Composition: Nickel, 94; aluminium, 2; silicon, 1; manganese, 2.5 per cent.

Aluminac—An alloy similar to *Alpax*, which see.

Aluminium.—Metallic element. Chemical symbol, Al; At. No. 13; At. Wt. 27; M.P. 657°C.; B.P. 1,800°C.; Sp. Grav. 2.58; Sp. Ht. .2253; Coef. Exp. .002313; Therm Cond. (Silver=100) 31.33; Elec. Cond. at 0°C. (Mercury=1) 20.97.

Chief ores: Bauxite, Cryolite and the various Felspars. Is a constituent of all clays. First isolated in 1828 by F. Wöhler. Given its name by H. Davy from the Latin, *alumen*, alum, on account of its presence in the various alums. Owing to difficulties in manufacture, the metal was not commercially marketed until about 1887.

Aluminium is a bluish-white metal capable of taking a high polish. Exposed to air, it becomes covered with a fine film of oxide. By suitable electro-chemical treatment it may be "anodised" or coated with an artificially-produced film of aluminium oxide, Al_2O_3, of great tenacity and fineness. This film may then be dyed, thus imparting a coloured surface to the metal. Aluminium is fairly ductile and malleable, particularly above 100°C. At 530°C. the metal becomes so brittle that it can be powdered. When ignited at high temperatures it burns brilliantly, an extremely high temperature being attained. Upon this fact is based the principle of "Thermite" welding. The metal is electrically positive. It dissolves in many acids and also in solutions of caustic soda and potash. Owing to its tendency to form and retain an oxide coating, the metal is difficult to solder. Aluminium forms a large series of alloys with other metals, many of which are nowadays of the greatest importance. Cast aluminium has a tensile strength of about 5 tons/sq. in; when rolled, of about 12 tons/sq. in.

Aluminium Amalgam.—This is prepared by adding fine aluminium filing to a half per cent. solution of mercuric chloride for two or three minutes, and afterwards washing the product with alcohol or spirits. The resulting amalgam decomposes water at ordinary temperatures, liberating a steady stream of hydrogen gas.

Aluminium Brass.—A variety of copper-aluminium alloys containing up to 5 per cent. of aluminium. Uses similar to those of aluminium bronze.

Aluminium Bronze.—A class of copper-aluminium alloys containing from 5 to 11 per cent. of aluminium. They are chiefly of use in circumstances in which it is necessary to increase the oxidation resistance of the metal. They have tensile strengths up to 38 tons/sq. in.

Aluminium-Chromium Alloy.—Alloyed with chromium, aluminium forms beautiful needle-like crystals. The alloy is brittle, however, and has no commercial applications.

Aluminium Gold.—A peculiar alloy having an intense ruby-red colour. Composition: Aluminium, 22; gold, 78 per cent. M.P. 1,060°C.

Aluminium Steel.—Aluminium is not usually alloyed with steel in order to form a special alloy, but in view of its deoxidising powers. Dissolved oxides in molten steel tend to form blowholes. Aluminium, however, removes these oxides and so contributes to the homogeneity and resulting strength of the steel.

Aluminium steels were first investigated by Sir Robert Hadfield in 1890. With steel containing, say, 0.2 per cent. of carbon, aluminium may be added in amounts up to 5 per cent. without influencing the tensile strength. The brittleness of the steel, however, increases with more than 2 per cent. of alloyed aluminium.

There is a curious alloy formed with iron and about 17 per cent. of aluminium. This is non-magnetic and heat-resisting.

Aluminised Yellow Brass.—A variety of brass containing up to 1 per cent. of aluminium. When aluminium is added in small quantity to a brass, the zinc content of the latter can be higher than when the aluminium is not added, thus making for a light-coloured brass. The following is an aluminised yellow brass made for saddlery and harness purposes: Copper, 55.25; zinc, 41.25; lead, 3; aluminium, 0.5 parts.

Aluminum.—The American rendering (pronounced "a-loo-mi-num") of our word "aluminium." It is, perhaps, the more logical word, since it more clearly indicates the fact that the metal is a constituent of alum.

Alumium.—An early name for aluminium suggested by Sir Humphry Davy in 1807.

Amalgam.—The name given to a solution of a metal in mercury or to an alloy of mercury with one or more metals. Most metals will form an amalgam with mercury, and often, as in the case of sodium and potassium, the amalgamation is accompanied by considerable rise of temperature. In other instances, as, for example, in the preparation of tin amalgam, there is an absorption of heat during the process of amalgamation.

Amalgams are much used in modern industry and arts, as, for instance, in the extraction of gold and for the filling of teeth.

American Gold.—American standard gold as used for coinage purposes contained 90 per cent. of gold and 10 per cent. of copper, thus being slightly harder than the English standard gold on account of its increased copper content.

American Nickel-Silver.—An old alloy. It contained: Iron, 1; cobalt, 1; silver, 2; tin, 2; manganese, 4; nickel, 24; zinc, 36; copper, 96 parts.

Ammonium Amalgam.—When a quantity of sodium amalgam is thrown into a dish containing a fairly strong solution of ammonium chloride (*sal ammoniac*), the mercury swells up enormously into a metallic-looking, soft, sponge-like mass. This is often called "ammonium amalgam," and it has been thought to consist of a true amalgam of mercury with the "ammonium" group or radical NH_4). It is now believed to comprise merely mercury, which is inflated by hydrogen gas, for, after a few minutes, the mass sinks down again, leaving metallic mercury at the bottom of the dish.

Amorphous Antimony.—A black powder produced by the electrolysis of a solution of tartar emetic in antimony trichloride. It consists of metallic antimony mixed with from 4 to 12 per cent. of antimony trichloride.

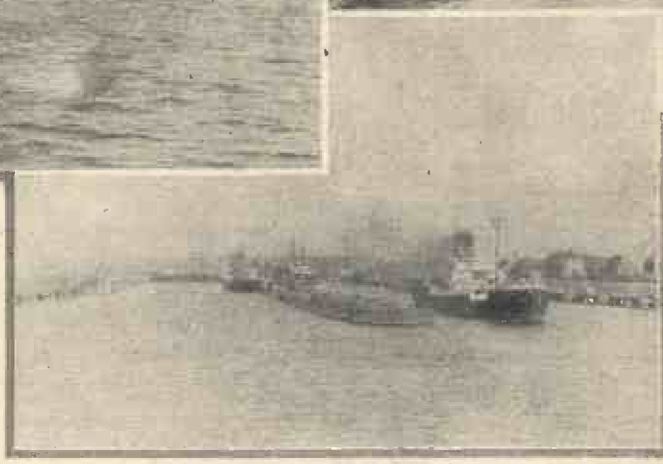
Amorphous antimony is unstable, and will return to the more usual crystalline form of antimony with explosive violence when merely scratched or given a slight blow. On this account, it is often known as "explosive antimony."

(*To be continued*)

The Kiel Canal in Peace Time

In Kiel Bay

The great lock, Brunsbuttel



Coming out of Brunsbuttel Lock into the canal

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

IN peace time the Kiel Canal was a very important engineering achievement worthy of comparison in size, but not in usefulness, with such great ship canals as Suez and Panama. When war broke out it was instantly transformed into a strategic waterway of the utmost importance. During the Great War it almost doubled the strength of the so-called German "High Seas" Fleet, by offering a safe refuge with exits on two seas. Our cartoonists dubbed it the "Kiel Kennel" and loved to picture it as an elongated funk-hole in which a frightened daschund was cowering. It is highly probable that it will assume still greater importance in the present struggle.

It is very significant that the Germans did not begin the Great War until the widening and deepening of this canal had been completed. The dates are very important. The canal was first built during the years 1887 to 1895, but when completed would only accommodate small craft. When the Kaiser planned to attack us, he first decided to widen and deepen the canal, and replace all low bridges by lofty viaducts 131 to 140 feet above the water, or by swing-bridges. This work was finished by June 1914, and Germany started the War in August !

Small Craft

It is interesting to observe that the small commercial canal as first constructed was amply large enough to accommodate all the ships which desired to use it, and cost only £7,800,000, but widening and deepening it for battleships cost *over* eleven millions *more*. Actually more than half the commercial ships using the canal are small coasting craft of four hundred tons and under. Big ships cannot afford to use it at all because the saving in distance by using the canal is so slight. The greatest saving on any voyage is from Hamburg to Bornholm, which is 250 miles by canal, and 610 by going round the Skaw, a matter of only 46 hours longer. As compared with this the Suez Canal shortens the journey from England to India by six thousand miles. The Panama Canal shows even more striking results. The voyage from New York to San Francisco is shortened by 5,262 miles, and from New York to Guayaquil by 7,405 miles. Some other comparisons may be of interest. The Kiel Canal is 61 miles in length. Panama is 42, and Suez 104. The locks on the Kiel Canal are 1,082 feet long, as against 1,000 at Panama. They are said to be the largest in the world, and this for a canal whose legitimate commercial traffic consists of small coasting craft under four hundred tons !

A Simple Job

The Kiel Canal was cheaper to build than the others, because the job was a simple matter of digging a ditch at sea-level through soft soil—not rock as at Panama, with a lofty mountain ridge to cut through.

The cost of the *original* Kiel Canal was £125,300 per mile, Suez cost £245,785 a mile, and Manchester £516,547. The Panama Canal was very expensive, the total cost being $539,200,000, which at the present rate of exchange is about one hundred and thirty millions sterling.

As against this the Suez and Panama Canals, by saving shipmasters thousands of miles, are able to charge large tolls, but Kiel can only exact small dues, and is unable to increase them, or to pay its way.

From an engineering and mechanical standpoint a voyage through the canal is very interesting.

When sailing there from England I entered the canal at the western entrance. This is Brunsbuttel Harbour with four huge locks, in one of which our small steamer seemed completely lost like a doll in a swimming-pool. The locks are necessary because there is a variation in tide level at the west end of ten feet, but as the Baltic is practically tideless the maximum variation there is only 1.7 feet, and this is due to wind. It is thought that if our gallant airmen could destroy the lock gates at both ends just before a high tide with a western gale, there is a chance that the rush of water through the canal might sweep the whole German Fleet out of its funk-hole once and for all.

The Canal Approach

The approach to the canal is through the narrow channel of the River Elbe for fifteen miles, which makes the Canal safe from naval attack. The shores are flat and muddy, and the waterway is protected by low earth banks. About four miles from Brunsbuttel we passed under the first of several remarkable high level bridges which vary between 130 and 140 feet above surface level. At nineteen miles we passed under the Grumental high level bridge which carries the road, and a single line of railway across the canal at a dizzy height. During the whole voyage we scarcely saw a ship, but a few motor boats and sailing yachts were encountered, and they—like the cyclists on the road beside the canal—all carried swastika flags.

Five so-called sidings were passed, these are deep widenings of the canal, where two big ships could pass, but were really made for the German battleships to hide away from Admiral Beatty.

At forty miles we entered Audorf lake, which is used as a turning-place for ships. This is the first of a chain of small lakes which extend for about five miles. The country now is more undulating and the cut of the canal passes through a number of low hills which are much prettier than the mudflats and marshes previously encountered. At Levensau we passed under another high level bridge, which carries a single line of railway, and a road. Three miles more brought us to the Baltic exit of the canal at Holtenau, and after passing through the mighty locks we sailed into the sparkling waters of Kiel Bay. The whole voyage took about twelve hours, as steamers are not allowed to travel fast in case of damaging the canal banks by the wash from their propellers.

Remarkable Facts

The building of the Kiel Canal links up with some remarkable facts in German history. The German militarists had long planned its construction, as a checkmate—as they believed—to the British navy. But two things stood in their way, firstly the line of the canal must pass through Denmark, and secondly the western outlet was commanded by the—*then*—British island of Heligoland. These difficulties were surmounted in typical Hitler fashion. In 1864 Prussia, in alliance with Austria, made an unprovoked attack on peaceful little Denmark, and stole the southern portion of the country. Two years later the robbers quarrelled and Prussia fought Austria, but *that* is another story. There remained the problem of British Heligoland, whose red rocks rise from the sea like a miniature Gibraltar opposite the approach to the Kiel Canal.

A New Pattern-Making Method

A Simple Method of Making Small Models with Plasticine as the Mould-making Compound

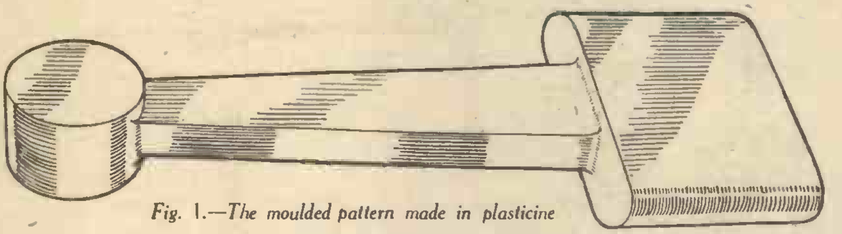


Fig. 1.—The moulded pattern made in plasticine

WHEN a number of small parts of somewhat intricate design have to be cast in any non-ferrous alloy, as is often the case in model making and in small light mechanical and engineering jobs, it becomes necessary to make a pattern. It is advisable that the pattern should be as exact as possible in order to facilitate machining, and in order to give a good appearance to the finished model or machine.

The making of small wooden models is delicate and a tedious process. The method here to be described avoids the troubles connected with such small wood working, and enables awkward shapes to be made easily and quickly ready for the foundry moulders. The plan is to use plasticine—the clay-moulding compound.

The part is fashioned with the plasticine to the size and shape of the finished article, and is allowed to dry thoroughly. This clay " pattern " (to use the founder's term) could be used directly to make the sand mould in the foundry, but it would not withstand continued use. It would be fractious and would also bend and become distorted with the ramming, and probably could only be used for one casting. To overcome this difficulty the plasticine pattern is used to make a plaster of paris mould, from which is easily cast a lead replica of the plasticine pattern, and this lead replica can be used as the pattern to be sent to the foundry and from which any amount of other pieces may be moulded and cast in the metal intended for the job.

The Pattern

In Fig. 1 we have a supposititious case, which shows the pattern moulded in plasticine. A box (it may be of cardboard) is filled to the level of the top with soft plaster of paris, and the plasticine pattern is laid in it while soft to a depth which will bring the plaster to a level a little higher than half of the depth of the pattern. The plaster is then, when nearly set, carefully scraped away so that its upper surface is level with the top of the box and half the height of the plasticine pattern, as shown in Fig. 2, and the plaster is allowed to set hard and the pattern lifted out.

The mould is next taken from the cardboard surround, carefully so that the latter is not injured, and at each side and at each end a slanting half-circular groove is cut down from the top surface as shown in Fig. 3. The top surface (which will be the parting surface) and the four slanting side grooves are varnished with a shellac spirit varnish which dries quickly. The cardboard box is now replaced on the plaster block so that it reaches high up above the surface (Fig. 4). The plasticine pattern is carefully replaced in the mould shape it has made and the whole remaining space is filled with fairly liquid plaster and allowed to set.

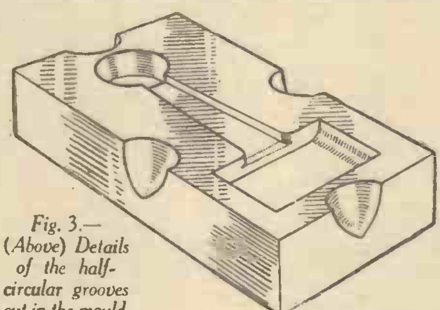


Fig. 3.—(Above) Details of the half-circular grooves cut in the mould

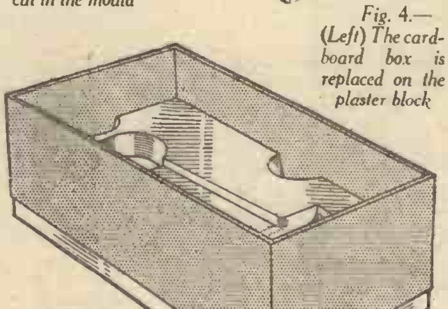


Fig. 4.—(Left) The cardboard box is replaced on the plaster block

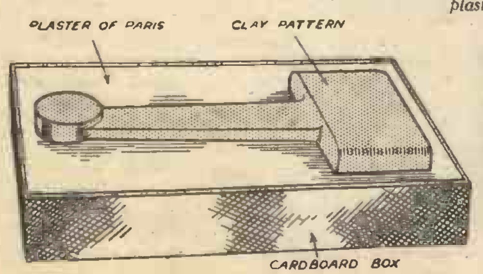


Fig. 2.—(Left) The pattern embedded in plaster of paris

Two Halves of the Mould

When hard, the surrounding cardboard box is removed and we have a plaster mould in two halves which will produce the original shape. The slanting grooves at the sides will have formed corresponding projections on the top block of the plaster. All that remains is carefully to drive (from the inside to prevent the drill breaking through into the mould) a runner hole for pouring the lead, and two vent holes to allow the gases to escape and ensure the lead filling the mould.

We now have a plaster of paris double mould (Fig. 5) with side lugs which locate the two halves accurately in position, and can weight down the top half, or clamp it with a clamp, and pour the lead in to form a strong lead pattern, an exact replica of the plasticine model, and can obtain as many as desired and send them to the foundry for casting the part we want, in any metal desired.

The lead pattern will stand up to the foundryman's handling, and since we can supply several and easily cast new ones if they get damaged or out of shape, we have a means of getting as many castings as we want, while the supplying of several patterns to the foundry facilitates work enormously when a good many of the same pieces are required, for the plaster mould remains intact. The same procedure can of course be followed whatever the first pattern is made of, and since the wood is at times awkward because of its grain making it friable in small intricate pieces it is often an advantage to cut out a rough wooden model with no great accuracy but of ample size. It can be used in the manner shown to get a lead casting. The lead casting should next be trimmed with files, etc., and used as a pattern for the foundry or as a pattern from which to make another plaster mould as described. Thus several patterns can be made at little extra work and expense.

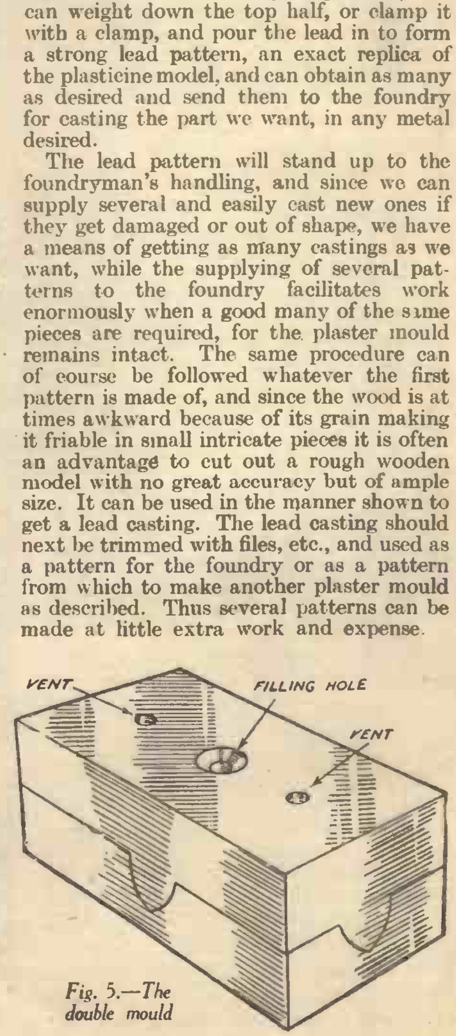
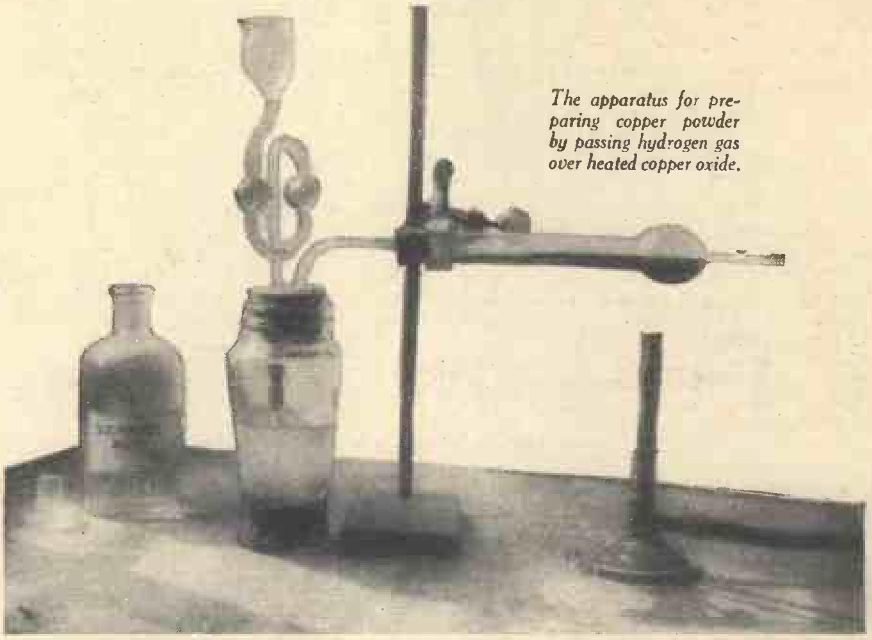


Fig. 5.—The double mould

Chemistry for Beginners

No. 8.—The Chemistry of Copper. Interesting and Simply-made Copper Compounds which can be inexpensively Produced in any Home Laboratory



The apparatus for preparing copper powder by passing hydrogen gas over heated copper oxide.

NEXT to iron, copper is, perhaps, the most valuable metal which we possess. It has also the distinction of being one of the oldest metals known to mankind. As an electrical conductor, copper is, next to silver, the most efficient of all metals. In order, however, that its conducting properties be not impaired, it is necessary for the copper used for electrical purposes to be of the highest degree of purity. Fortunately, by electrolytical methods of production, it is not difficult commercially to obtain metallic copper containing as little as 0.2 per cent. of impurity. Such "electrolytic copper," as it is termed, is nowadays employed for all electrical purposes. Hence, by using pieces of scrap copper wire for the experiments described in this article, the amateur chemist can prepare salts and other derivatives of copper which are almost perfectly pure.

An Interesting Metal

From the standpoint of the amateur chemical worker, copper is an extremely interesting metal, and many easily prepared compounds are to be obtained from it. Many copper compounds, also, are extremely useful substances. Copper sulphate, for instance, is a well-known fungicide, entering into the composition of countless horticultural compounds. Other copper compounds are employed in photography. Others, again, are used as pigments, whilst, through the agency of one copper compound, artificial silk becomes possible.

Practical Experiments for the Home Worker

In our preparation of a series of interesting copper derivatives, let us start with one of the simplest of these compounds. Obtain a few pieces of copper wire, cut it up into short lengths and place the pieces in an open-necked bottle. Add just sufficient water to cover the copper wire and then pour into the bottle a few drops of nitric acid. Immediately a chemical reaction will take place. The copper and the nitric acid will interact, giving rise to reddish fumes—oxides of nitrogen—which will escape from the bottle, and a brilliant blue solution of copper nitrate will be formed. When the action ceases, add a further quantity of nitric acid and keep adding the acid little by little until all or nearly all the copper has dissolved.

Now pour the blue solution into a clean evaporating basin and heat it with a bunsen burner or spirit lamp or by immersing the basin in a pan containing boiling water until a thick syrupy blue liquid remains. Then put the flask or basin aside to cool.

Copper Nitrate Crystals

If you are lucky, long crystals of copper nitrate will separate out after a time, but copper nitrate is a difficult substance to crystallise satisfactorily. It is, however, quite a simple matter to evaporate the copper nitrate solution carefully to dryness and thus to obtain the salt in a non-crystallised condition.

Copper nitrate is a very interesting salt. A 10 per cent. solution of it in water provides a blue light-filter used sometimes by microscopists and photographers for passing blue light only. Copper nitrate is, also, a powerful oxidising agent. If, for instance, a piece of blotting paper be saturated with a strong solution of copper nitrate and then warmed by holding it in front of a fire, the paper will often ignite spontaneously owing to the oxidising powers of the nitrate. Similarly, if a few pieces of copper nitrate be quickly wrapped up in tin-foil, the latter will rapidly become exceedingly hot and, often enough, will burst into flame, the tin-foil becoming converted into white tin oxide.

Canvas soaked in a solution of copper sulphate is rendered rot and mould proof.

From copper nitrate to copper oxide is a very simple step. The copper nitrate is merely heated, either in a porcelain crucible or in an old can or other suitable container. When strongly heated in this manner, the copper nitrate will give off red oxides of nitrogen—by the way, these fumes are fairly poisonous and should not be breathed—and a black residue of copper oxide will remain.

Well-known Oxides

There are two well-known oxides of copper, *cupric oxide*, CuO, which is black and which is prepared as above, and *cuprous oxide*, Cu_2O, a red powder, which is usually made by adding grape sugar to an alkaline solution of a copper salt. On heating, red cuprous oxide will be precipitated. The same red copper oxide can also be made by gently heating a mixture of sodium carbonate and cuprous chloride.

To return, however, to the more common black copper oxide. This is a most useful substance to have, for, using it as a starting point, a number of pure copper compounds can be prepared without difficulty.

For instance, the well-known copper sulphate is readily prepared in a state of high purity by dissolving black copper oxide in warm dilute sulphuric acid and by evaporating the resulting blue liquor down to crystallising point. Many amateurs endeavour to make copper sulphate by dissolving metallic copper in strong sulphuric acid. This, however, is not a good method. For one thing, choking fumes of sulphur dioxide are given off, and, again, copper is only soluble in hot concentrated sulphuric acid, forming a mixture of copper sulphate and copper sulphide, the latter of which is black and whose separation from the hot concentrated acid by filtration is difficult.

Crystallised copper sulphate, $CuSO_4.5H_2O$ possesses a beautiful blue colour. If, however, the crystallised copper sulphate is heated just above the boiling point of water for some time, the salt loses four of its loosely attached water molecules and it becomes converted into a pale bluish-white sulphate having the formula, $CuSO_4.H_2O$. If crystallised copper sulphate is heated more strongly, say at a temperature of 250 deg. C., it becomes converted into an hydrous (or water-free) copper sulphate, $CuSO_4$, which is a perfectly white powder.

Water Detector

Anhydrous copper sulphate is much used in chemistry for detecting the presence of water. Exposed to the air, it quickly absorbs water and turns blue. Added to liquids such as alcohol, benzene, petrol, the anhydrous copper sulphate will indicate the presence of the slightest trace of contained water by undergoing its remarkable colour-change from white to blue.

It is easily possible to obtain metallic copper from a solution of copper sulphate. If, for instance, a steel blade or an iron nail be plunged into a solution of copper sulphate the blade or nail will quickly become covered with a layer of red metallic copper which can generally be scraped away very readily. The solution can also be used for electro-plating. The article to be plated forms the negative electrode of the cell, and a bare piece of copper wire the positive electrode. Connect a flashlamp battery between the two electrodes and copper will immediately begin to be deposited on the article to be plated.

Copper sulphate solution is a powerful anti-fungus and anti-rot compound. Soak wood, canvas or other fabric in moderately strong copper sulphate solution and then allow it to dry out. Such material will then have high rot-resisting and anti-mould properties imparted to it.

If to a solution of copper sulphate or copper nitrate, or, in fact, to any soluble salt of copper a solution of sodium hydroxide (caustic soda) is added, a pale blue precipitate of copper hydroxide, $Cu(OH)_2$, will be formed. It will be advisable for the chemistry enthusiast to prepare a quantity of this copper hydroxide, because, by dissolving it in organic acids, as, for example citric, tartaric or acetic acid, the copper salts of such acids can be prepared without trouble. When adding sodium hydroxide solution to the solution of copper sulphate or nitrate in order to prepare copper hydroxide, only add the least possible quantity of the sodium hydroxide solution to effect complete precipitation of the copper hydroxide. If more sodium hydroxide solution is added, it will contaminate the precipitated copper hydroxide and will prove difficult to wash out completely when the copper hydroxide is collected by filtration.

Copper Carbonate

When copper hydroxide, $Cu(OH)_2$, is boiled with water it turns black, becoming converted into a compound having the supposed composition, $Cu(OH)_2.2CuO$.

If, instead of adding sodium hydroxide (caustic soda) solution to a soluble copper salt, a solution of sodium carbonate is added copper carbonate will be precipitated. This is a greenish-blue insoluble compound having, usually, when prepared in this manner, the composition, $CuCO_3.Cu(OH)_2$. Like copper hydroxide, copper carbonate is completely soluble in acids, and, when dissolving, it evolves carbon dioxide gas.

A form of copper carbonate constitutes the well-known greenish mineral, *malachite*. Artificial crystals of malachite can be made by immersing a flat piece of limestone in a moderately dilute solution of copper nitrate until the limestone is covered with a green layer and then by immersing it for a few days in a solution of sodium carbonate (or common soda) of similar strength.

Copper carbonate is also known as *verdigris*, and it is very slowly formed on the surface of metallic copper when the metal is exposed for prolonged periods to moist air containing considerable quantities of carbon dioxide.

Soluble in Acids

Copper carbonate and copper hydroxide, as we have noted, are completely soluble in acids with the formation of salts. If, for instance, we desire to make a quantity of, say, copper tartrate, all we have to do is to pour some strong tartaric acid solution into a flask and then to add either copper hydroxide or copper carbonate a little at a time. The hydroxide or carbonate will dissolve completely (in the latter instance, with much effervescence and evolution of carbon dioxide gas) and a bluish-green solution of copper tartrate will result. The copper hydroxide or carbonate is added to the tartaric acid solution until all action stops and until it ceases to be dissolved. The resulting solution of copper tartrate is then poured off and crystallised by evaporation. Copper acetate and copper citrate are made in the same manner, employing solutions of acetic and citric acids respectively.

If to a solution of any salt of copper we add a quantity of waterglass (sodium silicate) solution, a beautiful greenish fibrous precipitate of copper silicate will be obtained. Copper silicate is a most enduring substance. It occurs in mineral form as *Emerald Copper* and as *Chrysocilla*.

In a similar manner, if sulphuretted hydrogen gas or a solution of ammonium sulphide be added to a solution of a copper salt, black copper sulphide, CuS, will be precipitated. This is insoluble in water, but dissolves in mineral acids with the evolution of the evil-smelling sulphuretted hydrogen gas.

Another form of copper sulphide having the formula, Cu_2S (cuprous sulphide), is formed as a grey-looking mass when copper filings are heated with sulphur. The copper filings must be in excess over the sulphur, otherwise the black copper sulphide, CuS (cupric sulphide), will be formed.

Schweitzer's Reagent

One of the most interesting of all copper compounds is that which is known as *Schweitzer's reagent*. This consists of a solution of copper hydroxide, $Cu(OH)_2$, in ammonia. It has the remarkable property of dissolving paper or cellulose. It is most conveniently prepared by adding ammonia drop by drop to a strong solution of copper sulphate contained in a flask. The characteristic pale-blue precipitate of copper hydroxide will be formed. After the precipitation of the copper hydroxide ceases, the addition of the ammonia is continued. The liquid will then acquire a rick dark-blue coloration, due to the solution of the copper hydroxide in the excess ammonia. At this stage, the flask should be shaken continuously, the ammonia being added drop by drop. When the last of the precipitated copper hydroxide dissolves, add a few drops more of ammonia and the preparation of Schweitzer's reagent will then be complete. Cotton wool and good quality filter or blotting paper will dissolve in the blue liquid and, on the addition of a dilute acid, will be re-precipitated in a gelatinous form. Such a chemical reaction forms the basis of one of the methods of artificial silk production.

Preparing metallic copper in powder form by passing hydrogen gas over heated copper oxide

The deep-blue colour of the above liquid is due to the formation of copper ammonium sulphate. If methylated spirit is added to the deep-blue liquid and the latter allowed to stand for a few hours, deep violet-blue crystals of copper ammonium sulphate will be formed. These can be filtered off, washed with water containing ammonia (not with pure water, for they would dissolve in this) and then preserved in a hermetically-sealed tube. The crystals of copper ammonium sulphate cannot be preserved otherwise, for, in contact with air, they slowly give off their ammonia and change back again into copper sulphate.

Metallic Copper

Metallic copper is not satisfactorily soluble in hydrochloric acid. Therefore, copper chloride cannot be prepared by dissolving the metal in the acid. Copper oxide, hydroxide and carbonate are all very soluble in dilute hydrochloric acid, a deep green solution of cupric chloride being produced. Copper (cupric) chloride has the

chemical formula, $CuCl_2$. It can be crystallised from water, the crystals having the composition, $CuCl_2.2H_2O$. When crystallised cupric chloride is strongly heated, it gives off chlorine gas and is converted into cuprous chloride, Cu_2C_2, which is another well-known chloride of copper.

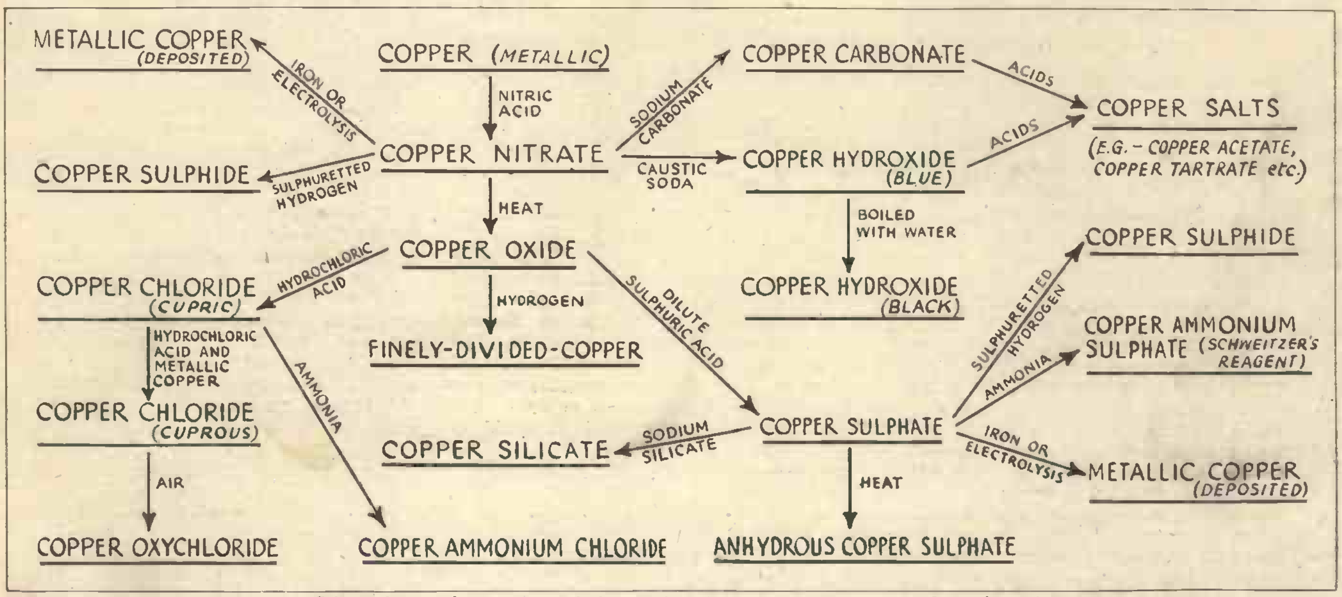
The terms *cuprous* and *cupric* are applied to copper compounds to denote their chemical composition. Copper forms two distinct series of compounds, to which the names *cuprous* and *cupric* are given. Thus, as we have already seen, there is a cuprous oxide and a cupric oxide, a cuprous chloride and a cupric chloride, and so on.

whereupon the cuprous chloride will be precipitated as a white powder.

Cuprous chloride is soluble in hydrochloric acid, ammonia, sal-ammoniac and common salt solutions, but its solution in any of these liquids cannot be kept for long, except in a hermetically-sealed tube. Fairly rapidly, these solutions absorb oxygen from the air, first turning brown and ultimately depositing a greenish precipitate of copper oxychloride, $CuCl_2.3CuO.2H_2O$.

Copper Powder

A most interesting substance is copper powder. This can be made by placing a quantity of copper oxide in a glass tube



Scheme showing the manner in which a number of interesting copper compounds can be made

Cuprous chloride, Cu_2Cl_2, is a compound which differs widely from cupric chloride, $CuCl_2$. It is best prepared by dissolving crystals of cupric chloride in strong hydrochloric acid and then by adding a quantity of clean copper wire cuttings to the liquid. The solution is now boiled until it becomes colourless or nearly so. During the boiling process, the hydrogen liberated as a result of the action between the hydrochloric acid and the copper converts the cupric chloride into the cuprous state. After the decolorisation of the liquid, the contents of the flask are poured out into a basin of cold water,

(such as a bulb-tube) and by gently warming it, at the same time allowing a stream of hydrogen gas (generated by the action of zinc on dilute sulphuric or hydrochloric acid) to pass over it. Slowly, the black copper oxide will turn to a brick-red shade, and then to an almost golden-red hue. The reddish material in the tube is no longer copper oxide, but is, in fact, metallic copper of an exceedingly high degree of purity. In its preparation, the hydrogen has chemically combined with the oxygen of the copper oxide, forming water, and leaving the copper behind :—

$$\underset{\text{(Copper oxide)}}{CuO} + \underset{\text{(Hydrogen)}}{2H} = \underset{\text{(Copper)}}{Cu} + \underset{\text{(Water)}}{H_2O}$$

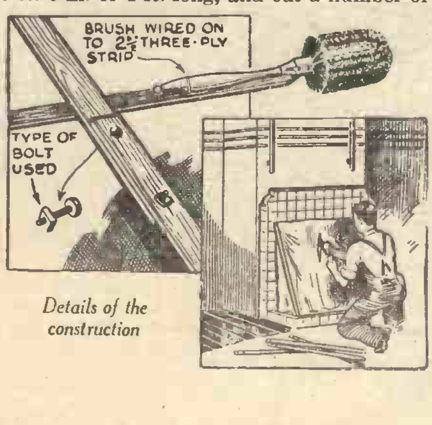
It is best to seal off the copper powder in tubes if it is desired to preserve the material, for the metal in this condition does not keep very well. Indeed, on occasions, the powder takes fire or heats-up spontaneously when shaken about in the air. This is due to its rapid oxidation and its conversion into copper oxide.

Finely divided metals which take fire in this manner are sometimes called "pyrophoric metals." Lead, for instance, is another metal which can be prepared by chemical means in the pyrophoric condition. Iron, again, is another such metal.

Copper in its powder or finely divided form does not differ in any way chemically from metallic copper as it is commonly known. Perhaps, however, the finely divided metal is rather more active. If, for instance, clean copper wire is placed in a flask and strong ammonia solution poured on to it, the liquid will, in time, become blue-coloured, owing to the action of the ammonia on the copper. With ordinary metallic copper, the action of the ammonia is very slow, but, employing finely divided copper, the production of the blue ammoniacal copper solution proceeds much more rapidly.

A Chimney-Sweeping Set

A REALLY efficient chimney-sweeping set can be made out of three-ply at a cost much below that of any marketed set. Obtain a piece of $\frac{5}{16}$ in. three-ply, 3 ft. 6 in. or 4 ft. long, and cut a number of 2½ in. strips from it to suit your requirements.



Details of the construction

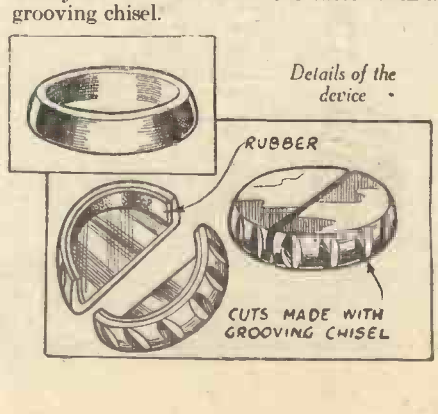
A 9 in. lap should be allowed, and ¾ in. bolt holes should be drilled 1½ in. from the ends of the strips, the two holes being 6 in. apart. Keep the drilling standard in order to facilitate assembly.

A circular brush, such as may be purchased for 6d., is secured with wire to the end of one section, and ¼ in. bolts 1 in. long (under head) are used for coupling the strips.

Removing Screw Caps from Bottles

TIGHT-FITTING screw caps on bottles and jars are often the cause of much waste of time and sore fingers : in most cases the grip or milling on the cap is insufficient to obtain a really firm hold. The illustration shows a useful gadget which can very easily be made from a hardwood caster and a piece of rubber.

Cut out a strip of the caster so that the two halves form an oval when placed together. Next secure a strip of rubber with rubber solution inside each half, and finally flute the outside of the caster with a grooving chisel.



Details of the device

A MODEL

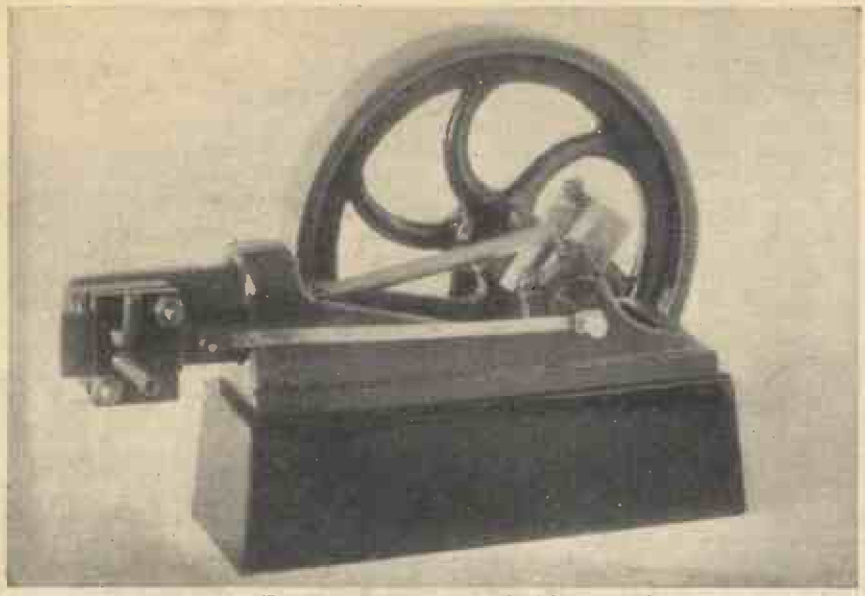


Fig. 1.—The completed engine showing the slide-valve mechanism

NEARLY fifty years ago, when I was an apprentice in the workshops of one of the old telephone companies, I designed and made a model steam engine of an unusual type. Actually there was no prototype driven by steam from which to copy and my model was made to follow the lines of a Crossley Gas Engine; the old pattern, of course, in which the gas admission valve was of the sliding form. Those were, I believe, the days before the introduction of poppet and mushroom valves. Anyway the engine, by which I was inspired and which I had seen many times at work, had a flat valve. So I set to work, made my drawings and from those the foundry patterns for castings.

First Serious Attempt

This was my first serious attempt at model-engine making and I have often wondered how the founder managed to cast my bedplate, since I made the pattern of exactly the same shape as the casting was required to be. Actually, I should have put a print on the cylinder end of the pattern so that the hole, which was to receive the cylinder, could be cored out. But I knew nothing about cores and core-boxes, and I suppose the good-natured founder, recognising that I was but a novice, and desiring to help me, stuck a long plug in the hole that I had bored in the wood and made a simple little round core to place in the mould. Most likely he explained to me what I should have done; I do not remember, but the result was satisfactory for my casting was as I wanted it.

One of the first thoughts which occurred to me, after I had tested its ability to work, was that its extreme simplicity made it an excellent subject for a beginner in model-making, so from my youthful effort I have made a fresh set of drawings for the use of the reader, and these are reproduced here.

Before making references to the drawings, I think that the reader would like to know what the general appearance of the engine is, and so I have taken two photographs of it, which are reproduced here in Figs. 1 and 2. They both show the slide-valve side of the engine, but are taken from opposite angles.

Uniflow Principle

I do not know whether my reader is familiar with the term "uniflow" in connection with steam cylinders. If he is he will know that some engines have valves of such a type and design that the steam always flows in one direction through valves and ports; that is to say, steam which has done its work of driving the piston is exhausted back through a different port from that through which it entered. The object of this arrangement is to avoid the cooling of the live steam passages by the lower temperature of the expanded steam. Now I do not anticipate for a moment that I knew at the time what I was doing, but I think it likely that my little model must have been one of the earliest to work on the uniflow principle.

An examination of the photographs will show that there are two pipes leading to the slide valve; one, the lower, is that which would be connected to the boiler; the upper is the exhaust. Both of these are in straight lines with ports in the valve cover-plate, in the valve and in the block on the cylinder. Steam enters through the bottom port and does its work in driving the piston from one end of the cylinder to the other; in the meantime the valve is moved by a small crank and this expanded or exhausted steam then passes out through the upper and somewhat larger port to the atmosphere.

Single-Acting

The simplicity of the engine lies in the fact that it is single-acting. Steam drives the piston in one direction only and the weight and momentum of the flywheel is depended upon to return it ready for another power impulse.

Obviously, size for size, such an engine is not so powerful, but it is easier to make a larger single-acting cylinder and valve than it is to make one of half the size which is double-acting, closed at both ends, for such closing at the end towards the crankshaft involves a stuffing box to make a steam-tight joint around a piston rod, a crosshead and its guides between the piston rod and the connecting rod, and a closed steam chest to contain the slide valve, which chest must have another stuffing box around a valve rod.

The Simplicity of this Engine Lies in the Fact that it is Single-acting. Steam drives the piston in one Direction Only and the Weight and Momentum of the Flywheel Returns it.

Turning to actual construction and detailed dimensions, I do not think that much need be said regarding these, for I have endeavoured to make description unnecessary by completeness in the drawings, of which Fig. 3 is a side elevation, Fig. 4 a plan of the whole engine, and Fig. 5 a drawing, the main object of which is to

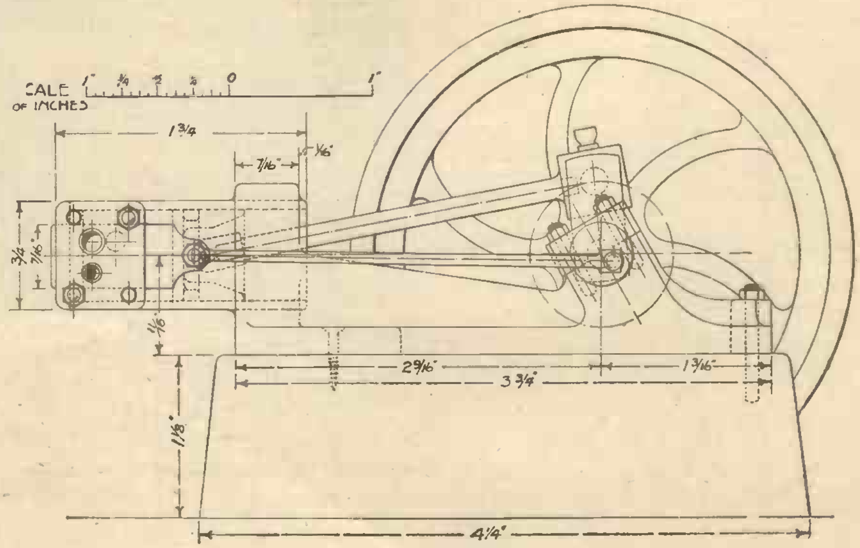


Fig. 3.—A side elevation

HORIZONTAL STEAM ENGINE

give the reader exact measurements for all radii in setting out the spokes and other details of the flywheel when making the foundry pattern.

The Bedplate Pattern

When the bedplate pattern is taken in hand, do not forget that either the cylinder

By E. W. Twining

end should be left solid, to be drilled and bored out to take the tube of the cylinder when the casting is received, or a print put on the pattern of the correct diameter so that the foundry-man can make a core of the same size to drop into the mould in the impression left by your print. A core-box will not be needed; he can make a cylindrical core without a box by ramming the core sand in a piece of tube.

The flywheel should be cast in soft iron which is easy to machine, but the bedplate must be in gunmetal because the cylinder is to be soldered in by sweating with a bunsen flame.

The cylinder is made from a piece of thick seamless brass tube which will dispense with the necessity for boring it out in the lathe; indeed, were it not for the piston, the cylinder cover and the turning of the flywheel, this model could be made without a lathe. It will be advisable to lap the inside of the cylinder, after it is soldered in the bedplate, in order to ensure that it is true and smooth and a good fit around the piston which may also be lapped into the cylinder after it is turned. The preliminary lap can be of wood, beech preferably, turned quite true and a nice sliding fit in the tube. Smear the lap with a little of the finest emery powder in oil and work this backwards and forwards with a circular or twisting motion until you see the whole inner surface of the tube bright, then wash the cylinder in paraffin and, if possible, leave it, placed vertically in paraffin, for a few days whilst some other part of the engine is being made. Lapping may then be completed by using the piston itself, the abrasive being a fine metal polish such as "Brasso." Wash this away with paraffin in the same manner.

Fig. 2.—Another view of the slide-valve mechanism

Hollow Piston

As will be inferred from Figs. 3 and 4 the piston is hollow, of the "trunk" type; it can, being quite small, be turned from a piece of ⅝ in. diameter brass rod. It has one groove to be filled with soft cotton packing. The crank shaft is of steel and is built up as shown in Fig. 4. The joints can, if it is so desired, be made by brazing instead of riveting and in fact this will, if facilities are available for doing it, make the better job, but it involves making a split big-end on the connecting rod; my own little cranks were not brazed, but the webs drilled so that the shaft and crank pin were a good driving fit, and the ends were just lightly riveted over. The flywheel also was a knock-on fit, the shaft being very slightly tapered with a dead smooth file in the lathe.

The cylinder cover is soldered in at the same time as the valve-face block. The little disc crank which serves as an eccentric is knocked on to the shaft end and made fast by drilling and screwing in the pin which drives the valve rod.

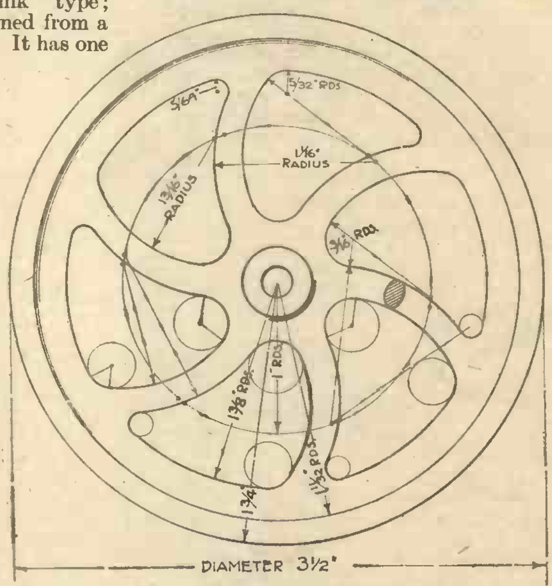


Fig. 5.—Details of the flywheel

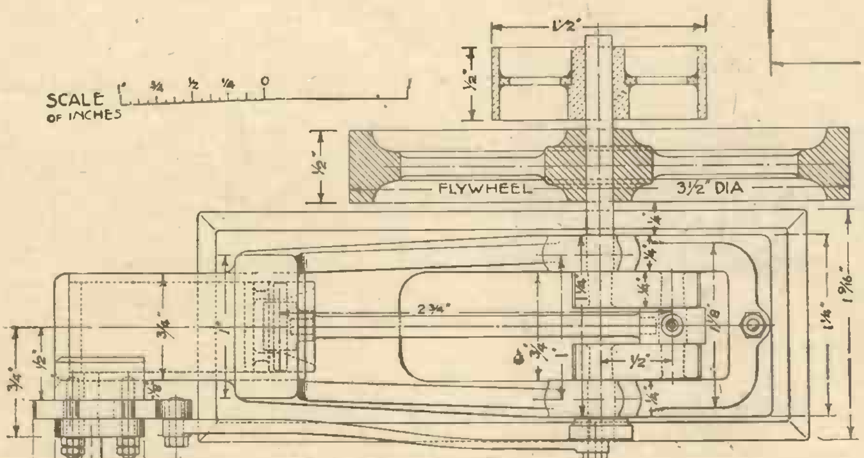


Fig. 4.—A plan view

The Valve Block

Details and measurements of the valve block or port face and cover plate will be clear from the drawings, particularly from Fig. 6, and I think it only necessary to mention two things; first that the nuts on two of the four studs may be placed on either diagonal and must be adjusted so that the valve is pressed well up to both working faces but not too tightly; second, that the steam and exhaust pipes are soldered into the cover plate and the steam pipe will need a union between the engine and the boiler, preferably close to the cover plate.

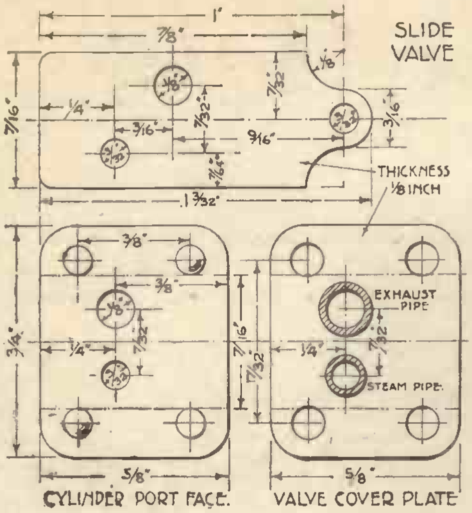


Fig. 6.—The valve block and cover plate

The cycle of operations in one revolution of the crank shaft, or as they are technically termed—the valve events—are set out in the diagram Fig. 7, where at A the piston has nearly completed its exhaust or forward stroke and the valve is just commencing to open the steam ports. B shows the steam port fully open with the piston nearly midway in the power stroke whilst at C the stroke is almost completed and the port has just closed.

In sketches D and E the exhaust port E is shown, where at D the port is just about to open and at E has just closed. An intermediate sketch would, of course, have shown the crank in the position diametrically opposite to that at B and the exhaust port fully open. Other reference letters in Fig. 7 are : V, the valve, P, the piston, MC, the main crank pin, and EC, the eccentric crank. The arrows, of course, everywhere, indicate the direction of movement : of the steam, of the exhaust, of the valve and of the crank shaft.

The Pulley

My own engine has no pulley upon the crank shaft but in the plan Fig. 4 I have drawn the shaft long enough, beyond the flywheel, to take such pulley, which the reader can add if he thinks fit. Pulleys can be made by casting from a pattern, or built up. I have shown the latter method because it will result in a lighter and neater job. The hub is turned from a piece of brass rod, the spokes are formed from a disc of brass plate, perforated and sweated with solder on the hub and the rim from a piece of 1½-in. diameter steel bicycle tubing also soldered.

I have only dealt with and drawn the model exactly as I made it, years ago, but I strongly recommend the reader not to copy the diminutive size but to make his engine twice as large as mine; he will then have a model which is not only more imposing to look at but which will be useful for driving other models of machine tools, etc. This he can quite easily do by doubling every one of the dimensions given in Figs. 3 to 6. But it will be very advisable to put a little more detail into one or two of the working parts. Thus the connecting rod big-end had better be in two parts, made of gunmetal, both separate from the rod, and the main bearings be fitted with brasses.

Changes Recommended

These alterations will necessitate a little modification in the main crank measurements. Fig. 8 shows the whole of the changes involved, or recommended, in making the larger model and it should be carefully noted that in this drawing all figured dimensions apply only to the double-size engine.

In both small and large models the connecting rod is of steel. In the first it is simply sweated into the brass blocks forming big and little ends, but in the larger the big end is shouldered and riveted into a steel plate which is bolted to the gunmetal portions as drawn in Fig. 8. The valve rod also of steel is rectangular in cross section; it can be filed up from a bit of strip and curved as shown in the plan Fig. 4. There is no need to fit brass ends to this.

The base or block on which the engine is mounted is a piece of hardwood, in my case mahogany. To this the bedplate should be secured with a stud and nut at the crank end and, immediately behind the cylinder, on the centre-line, by one countersunk wood screw.

With regard to finish; the rim of the flywheel, pulley, crank shaft, cranks, connecting and valve rods, should all be polished bright as also the gunmetal big-end and brass bearings. All the rest may be enamelled in colours to suit individual taste. On my own model the base block, the flywheel, the port face block and valve cover plate are black, the bedplate and cylinder a bright blue-green; as nearly as possible the colour which these parts of the Crossley gas engines are, or used to be, painted.

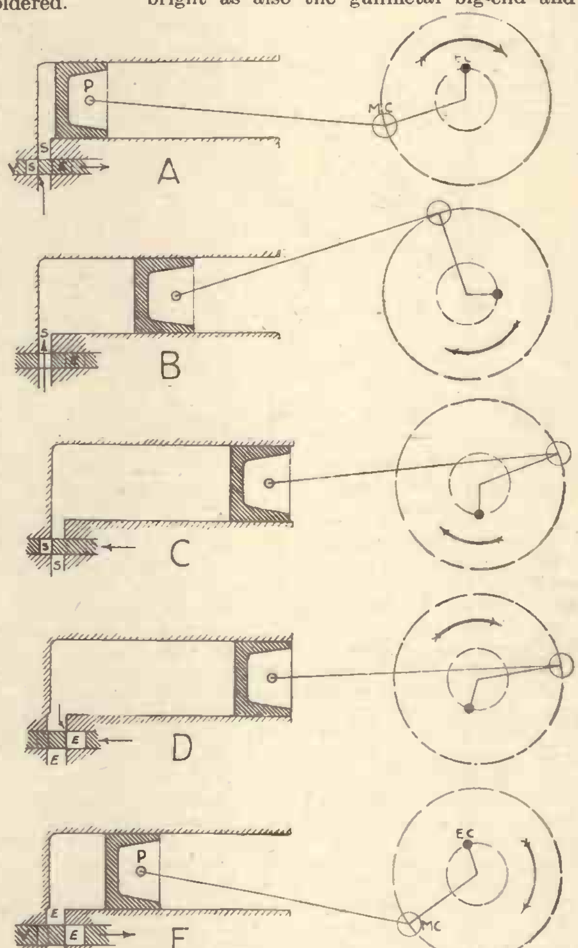


Fig. 7.—The cycle of operations in one revolution of the crank shaft

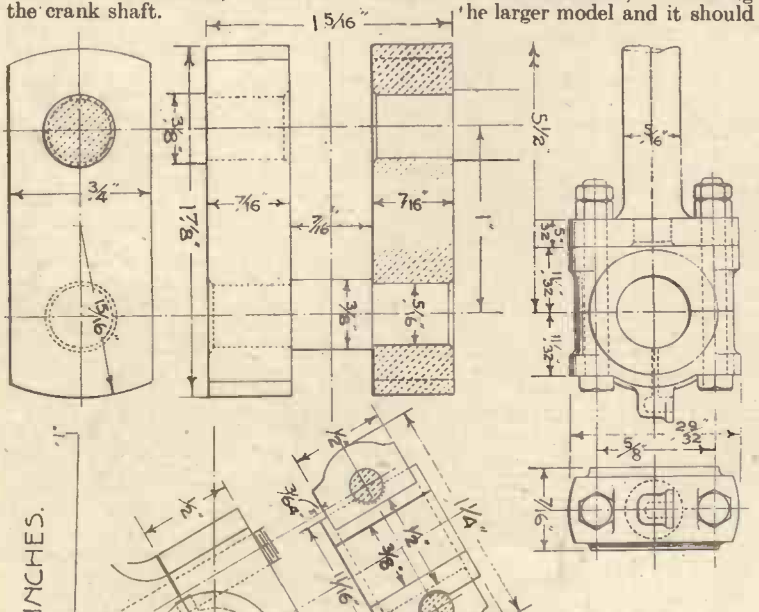
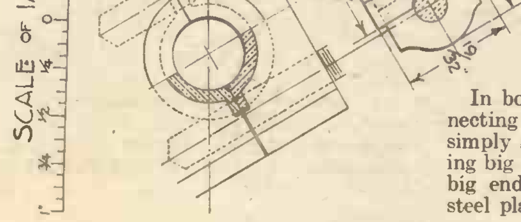



Fig. 8.—Details of the connecting rod, crank, and bearings

Since completing this article it has occurred to me that a greater number of young mechanics may be induced to build the engine if it were rendered possible for them to obtain the few necessary castings, already made and ready for filing up and machining; thus avoiding the necessity for making the foundry patterns. I will, if the demand warrants my doing so, make arrangements with a supplier; providing, of course, that the present critical war conditions render it possible to get the foundry work done. Only the larger, or double-size engine will be dealt with in this way.

All inquiries should be made through the Editor.

Undercarriages for Model Aircraft

Although the present trend in Model Aeroplane Construction is for large models and increased speed, the drag of the landing gear has, in consequence, been considerably increased. Therefore, the undercart must be designed to overcome this drawback, and below we give a few types that have been used successfully.

TWO or three years ago, when the "slab-sided" model was universal, the undercarriage was not considered to add very much to the drag created by the rest of the machine.

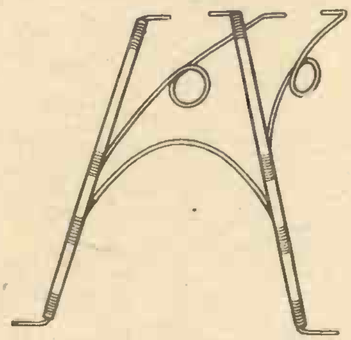


Fig. 1.—The bamboo and wire type of undercarriage

A conventional undercart on a modern model, however, contributes a much greater proportion than before, since with the increased Wakefield weight rules, the trend toward more powerful models, and in consequence, higher speeds, the drag of the landing gear has been considerably increased, whilst the streamlining now generally employed has kept the drag of the rest of the machine comparatively low.

The objects of an undercart are, of course, to assist in the take-off and landing of an aircraft. Unfortunately its use in these two functions is reduced to a hindrance whilst the machine is in flight.

Recently, models employing folding airscrews have appeared, and so the only stage in which the undercarriage is an essential in this type is the take-off. The ideal solution to this problem, of course, would be to use an undercart placed directly under the centre of gravity, which would automatically release itself from the model when the latter was off the ground.

No Detachable Parts

Unfortunately, we are prevented from doing this by the rules laid down for various contests, which state quite clearly: "no part of the model may become detached during flight." And no wonder! Were it not for this rule, modellers would be designing planes that not only would be releasing their undercarts, but, after power flight, throwing away their props, rubber motors and everything not necessary! Plus a bit of fin area that would then not be needed! Our landing gear therefore, has got to "stay put." We can, though, reduce the weight and drag to a minimum by using light materials, and making it well streamlined, or even retractable.

However, we must not forget in this quest for low drag and weight that it has to be strong enough to resist take-off and landing forces, and so let us first examine some of the different types of landing gear that have been used successfully. First there is the bamboo and wire type, which, undoubtedly, from a point of mechanical efficiency is one of the best ever devised.

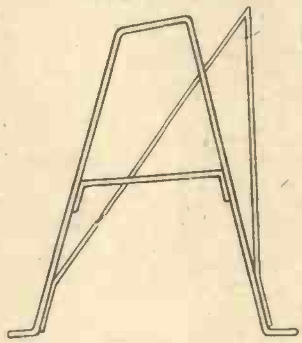


Fig. 2.—Another type of sprung undercart

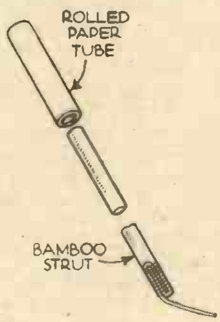


Fig. 4.—A rigid landing gear for lightweight models

Its aerodynamic efficiency, however, is, as will be seen from the sketch, rather poor.

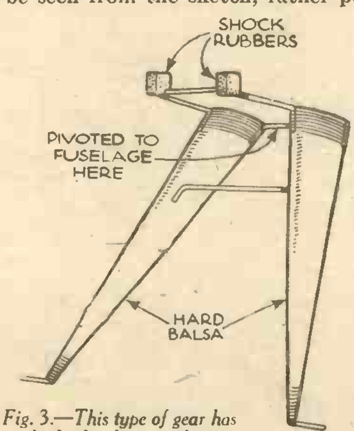


Fig. 3.—This type of gear has shock-absorbing qualities

Non-Streamlined Models

For light, non-streamlined models, this is, of course, an excellent type to use, since it acts as a model undercart should; that is, backward and upward. In spite of the much used phrase of models "settling to a perfect three-pointer" no model, with an orthodox landing gear, ever makes a three-point landing, but, if properly adjusted, hits the ground at its gliding angle. Therefore, the undercart will be subjected to a backward and upward blow. There are two ways of absorbing the impact. Either by mounting the landing gear rigidly, and thus allowing the shocks to be transmitted through the fuselage, or to use a sprung landing gear. In the case of the latter, the bamboo and wire undercart forms an excellent example.

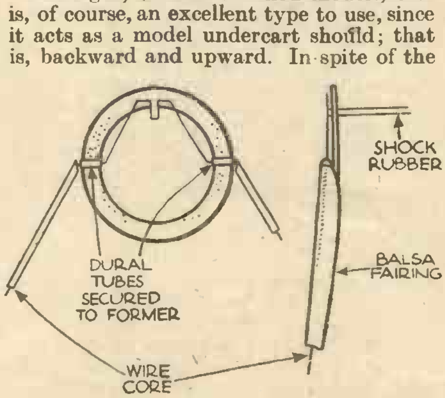


Fig. 5.—This type of undercart is suitable for almost any type of duration model

Another type of sprung undercart is shown in Fig. 2. This is a little better aerodynamically, than the previous type mentioned, but is usually a trifle heavier, since it has to be braced to the fuselage to prevent tearing out on extra hard landings.

The type shown in Fig. 3 has good shock absorbing qualities, and generally looks better than most other types, since it tends to disguise that "lankiness" generally associated with duration models. Its aerodynamical faults lie, not so much in head resistance, as in its effect on directional and lateral stability. The large side area of the struts tend to draw the centre of lateral area forward and downward of the centre of gravity, thus making a large and higher fin necessary.

Rigid Landing Gears

For rigid landing gears, the type shown in Fig. 4 that has been used for some time on lightweight models is one of the best.

This is the ordinary single-leg bamboo type, plugged into paper tubes. It has some distinct advantages, which account for its popularity for contest models. It is light in weight, has a reasonably low drag, and in competition models, where durability is not a governing factor, its strength is quite sufficient. Also, it is simple to construct, and being easily detachable, facilitates transport. The struts should, of course, be a little weak, in order that they may break first in a very bad knock, instead of damaging the fuselage.

Though typical of the types in general use, none of the four undercarts mentioned are ideally suited to a highly streamlined model, and so we must devise one or two types to meet our requirements. In Fig. 5

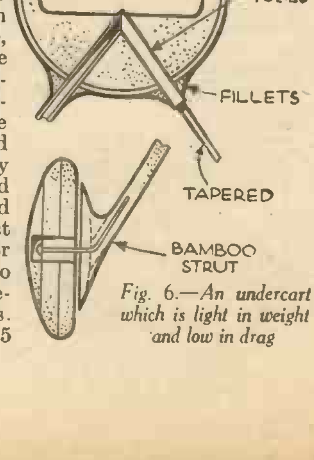


Fig. 6.—An undercart which is light in weight and low in drag

an undercarriage which should be suitable, not only to streamlined jobs, but for almost any type of duration model, is shown. It acts on the same principle as the landing gears in Figs. 1 and 3, and is constructed mainly from a single piece of steel wire (about 18 s.w.g. for Wakefield models).

The exposed length of wire is encased in balsa, to prevent it from bending and to preserve a good streamlined section. If the shock-rubber is made detachable at one end, it will be possible to fold the struts along the fuselage. This type of undercart has all the shock absorbing qualities of the bamboo and wire type, plus low drag and fairly light weight.

Another landing-gear which is light in weight and has low drag is shown in Fig. 6. This type has been used on a monocoque Wakefield machine with satisfactory results, even though no form of springing (other than that of the bamboo itself) is used. The bamboo struts are detachable and plug into tubes. These tubes are hollowed and shaped from balsa blocks, which are firmly bound and cemented to the bulkhead, this being braced with a strip of hard balsa from the apex of the tubes to the former in front.

Wheels

The wheels used on this undercart may be of interest to readers. They are made from four laminations of $\frac{1}{8}$ in. balsa, grain crossing, and turned to an elliptical cross-section. One outer lamination is then detached, and firmly glued and faired to the end of the strut, so that the axle pierces the exact centre About a quarter of an inch of $\frac{3}{16}$ in. birch dowel, drilled, and lined with duralumin tube, is then slid on to the axle, and the end of the latter bent up or a small washer soldered on. The remaining three laminations are then drilled so as to form a tight fit over the dowel, the end of the hole being capped or filled-in with a small disc of balsa.

The finished wheel is light in weight, yet quite strong, and the bearings will not wear loose, also it has a pleasing streamlined appearance and adds little drag.

If a folding prop. is used, the weight and drag of this landing gear can be even further reduced, since it can then be placed at a point farther from the nose and shorter strut used.

The Retractable Undercarriage

A retractable chassis is no advantage unless it can be made as light as a fixed type, since the extra performance to be gained in reduced drag, will be lost in added weight. Another point to remember is that the centre of drag (and centre of gravity in most types) is changed upon retraction. These two latter disadvantages do not have a serious effect, however, if the landing gear can be made to retract directly the model is off the ground, and before it has assumed a climbing angle.

The only way of ensuring a correctly timed retraction, it seems, is to use a mechanically controlled releasing-gear off the propshaft. From my experience, landing gears which are merely kept extended by the weight of the machine against the tension of a rubber band or spring are never very satisfactory. Should the model be thrown momentarily off the ground (by a gust of wind or irregularity in the take off surface) before it has gained sufficient speed to become air-borne, the undercarriage will probably retract with disastrous results.

Unfortunately, mechanisms for operating a retractable gear, usually add considerable weight. However, for those who feel disposed to experiment, we show in Fig. 7 a complete layout for a mechanically controlled undercart suitable for Wakefield type models, which should not add much weight, although, in fairness to the reader, it should be mentioned that we have not tried out this particular mechanism in practice.

The Propeller Shaft

Nevertheless, the design is quite simple and so no serious snags are likely to be encountered. The propshaft thread should have as fine a pitch as possible. A coarse pitch will necessitate a very long shaft, especially on models with a slow take-off. The nut should be easy running on the shaft, and must be securely soldered to the wire guide C, which is of 20 s.w.g. steel wire. The guide should be an easy sliding fit in the duralumin tube F, and in wire loop D.

Tube E is of dural or aluminium, and must be braced firmly in all directions. It should be of large enough bore, when flattened to allow wire D to slip through easily. The operation is as follows. The nut is first wound right up to its stop. Then, as the airscrew shaft rotates under the power of the rubber motor, the nut moves backward and withdraws the wire guide from tube F and finally from wire D. The struts are then released and will swing up into their recesses under the pull of the retracting rubber.

The nut will now have reached or be near to the end of the shaft, and with the guide C will then commence to revolve.

Test flying a model fitted with this type of undercart, will call for a slightly different procedure from that normally employed when testing a conventional model. The machine should first be hand launched with the landing gear retracted. All trimming to get maximum climb and glide should be made, and the various adjustments noted.

The undercart should then be fixed in the extended position (this may easily be effected by slipping a piece of wire through wire D in place of guide C) and the model made to rise off ground. With the aid of a stop-watch, the time between the moment of release, and when the model is in the correct altitude for retraction of the landing gear, is then noted.

Weighted Tail

The only trouble likely to be experienced here is in the fact that the adjustments made with the undercarriage up are not likely to have the same result when the undercarriage is down, since the centre of gravity will be farther forward and the centre of drag lower. It should be advisable, therefore, to add a little weight to the tail temporarily, until the model assumes a good glide again upon being hand launched. Having found the approximate take-off time of the model, the release mechanism is then adjusted to retract the chassis after the correct period.

With the adjustments found best during the hand launched flights, and the undercart set to retract after the given time, the model is then allowed to R. O. G.

It is now possible that the model will take-off slightly quicker, thus making it necessary to adjust the release gear to operate a little earlier (this is easily accomplished by slightly shortening the horizontal portion of guide C).

In the construction, particular attention should be paid to the bamboo strut bearings. Make sure that the hinge parts are firmly bound and cemented in their respective positions, and that the brass tube is a smooth but not loose fit on the wire part. Also note that the position of the bamboo strip between formers A and B allows the retracting rubber to have a straight pull. This ensures that the struts will fit cleanly into their recesses.

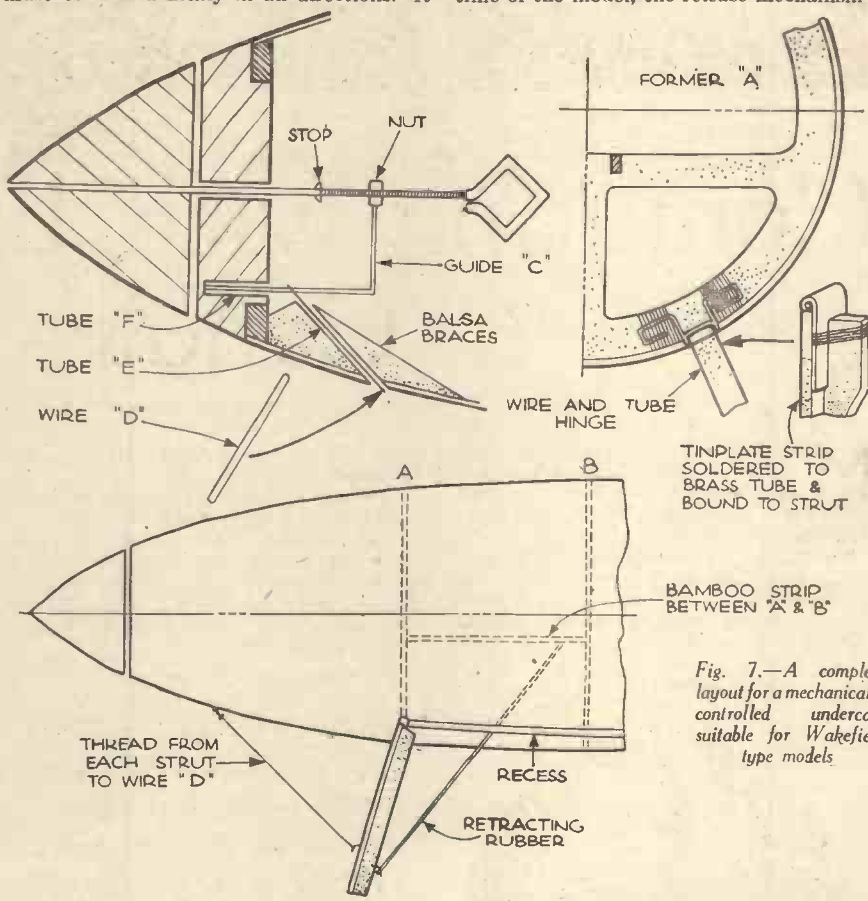


Fig. 7.—A complete layout for a mechanically controlled undercart suitable for Wakefield type models

Fig. 1.—A vanishing lamp showing how the body of the lamp collapses into the tray. The shade folds up like an umbrella. Fig. 11 (centre) Changing a candle to a handkerchief. The candle is hollow and fits closely into the metal case while the handkerchief is concealed inside it. Fig. 15.—(Right) A colour-changing candle. A metal shell representing a white candle is drawn down into the candlestick, revealing a red candle in its place

Conjuring with Lamps and Candles

Interesting Secrets of Some Puzzling Feats of Magic

MAKING a large lighted lamp suddenly disappear is a performance calculated to surprise any audience. Fig. 1 shows one of the ways in which it can be done.

The lamp is permanently fixed to a square tray. The body of the lamp is constructed of hinged leaves of metal in much the same way as the folding lanterns sold for Christmas decorations. In the lamp illustrated the body is formed by two separate groups of metal leaves fixed one on top of the other. When not supported these leaves hinge and the entire lamp body collapses flat into the tray.

Fastened to the top of this collapsible lamp body is a square wire frame the same size as the tray. The tray and this wire frame are covered with fabric of the same pattern. It will thus be evident that when the lamp body is folded down into the tray the fabric-covered square completely hides it and the tray appears to be empty.

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

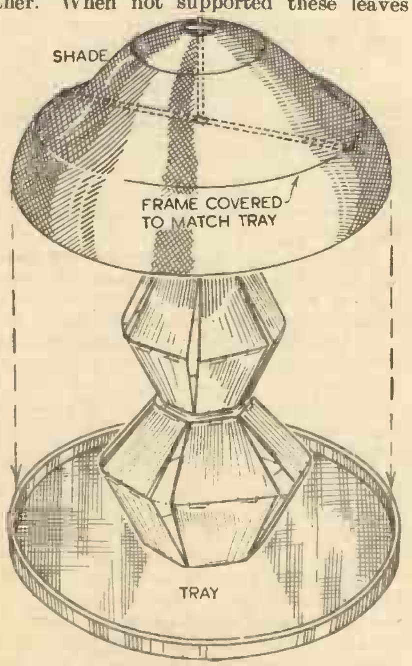


Fig. 2.—Details of the shade and tray

The Lamp Shade

This consists of a folding meat cover made on the same principle as an umbrella. The fabric is taken off the cover and replaced with bright coloured silk. A deep fringe is added round the lower edge. The measurements of the tray are such that when the shade is opened it will fit neatly over the wire frame on top of the lamp body. The appearance of the complete lamp in this condition is shown in Fig. 2.

The lamp is held erect in its open position by a thin wooden rod attached to the inside of the lamp shade. This rod goes down inside the lamp body and props it up as shown in Fig. 3. It is only necessary to pick up the shade by the wooden knob on top to cause the rod to be pulled away and the metal body of the lamp to collapse and remain hidden in the tray.

Finally, light for the lamp is provided in the simplest manner possible by attaching a pocket electric torch to the inside of the shade.

The Cloth

To perform the trick, take a large cloth of moderately opaque but not too heavy material. Throw the cloth over the lamp. The cloth should be translucent enough to permit the light of the torch to show through, but not so thin as to permit the actual lamp body to be seen through it.

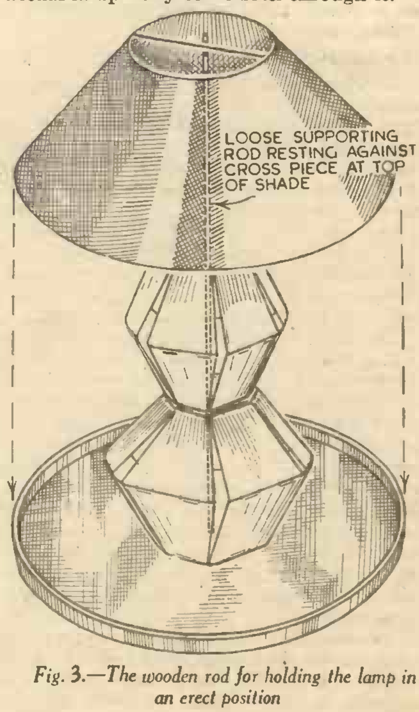


Fig. 3.—The wooden rod for holding the lamp in an erect position

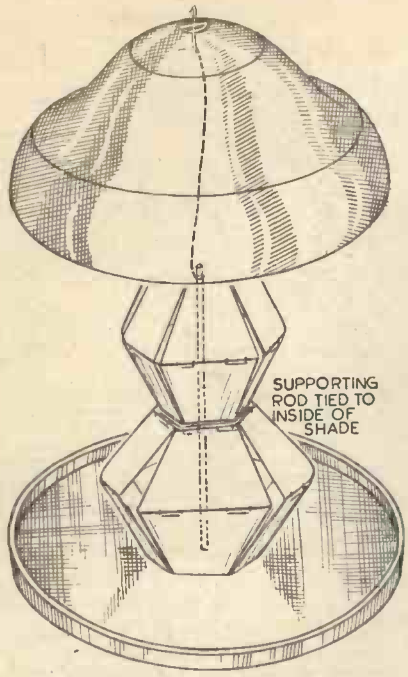


Fig. 4.—The thin metal rod attached to the shade

Now, steadying the top of the lamp with one hand and with it grasping the knob of the shade through the cloth, place the other hand under the cloth as though to pick up the lamp. Gently pull the shade upwards and as the lamp collapses, ease it down into the tray quietly. Move away carrying the cloth. The shade keeps it extended as if the lamp were still beneath it. Now with one hand switch off the light and with the other press the centre plug through the knob of the shade. The shade will collapse and is tossed aside in the cloth. I have not given details of the shade because these folding square meat covers can be bought for a few pence almost anywhere.

A similar lamp which vanishes suddenly without any covering is built, as far as the body is concerned, in the same way. The shade consists of a large and small ring of wire with silk sewn between. There is no wire square on top of the lamp body, but the lower ring of the shade is fastened to the top of the body instead.

The Base of the Lamp

This lamp is supported by a thin metal rod passing through the centre of the tray and up to a wire soldered across the top ring of the shade as shown in Fig. 4. Fig. 5 shows an enlarged detail of the base of the supporting rod. A strip of metal working on a pivot under the tray keeps the rod in position. To make the lamp vanish the end of the lever is pressed aside by the hand holding tray, the rod drops through the tray and the lamp collapses.

In this version the collapsed lamp is hidden by a spring blind the same colour as the tray. The blind and its roller are built into the edge of the tray. The roller on which the blind is wound is not a spring roller but simply runs free. On the opposite side is a spring blind roller from which the ratchet has been removed so that it will revolve as soon as released. One end of the blind is fastened to each of these rollers. The blind is rather more than twice the length of the tray and a piece almost the size of the tray is cut from the end nearest the spring roller. The result is shown in Fig. 6. The spring roller being at tension a catch is arranged so that the descending lamp will release it. As soon as the blind is released the portion with the cut out space winds rapidly round the spring roller, drawing the solid part of the blind across the tray, concealing the collapsed lamp.

A small pocket lamp globe can be connected to a battery under the tray and a switch arranged so that the light is extinguished as soon as the lamp starts to collapse. The vanish of the lamp is disguised by making a tipping movement backwards with the tray at the moment that the release lever is pressed.

Another sensational lamp trick consists of shooting a silk handkerchief into the lamp globe. For this purpose a special pistol is used, the details of which will be explained in a later article, which vanishes the handkerchief by winding it up on a spring inside the dummy barrel. The appearance of the handkerchief, really a duplicate, inside the electric globe is managed as shown in Figs. 7 and 8. Fig. 7 shows a small metal container something like a pill box with a hole in the lid. This container is attached to the lamp standard by a length of wire terminating in a ring so that the ordinary shade ring may be screwed down over it to fix it to the lamp holder. The handkerchief is tucked into the metal box and a generous corner is left protruding.

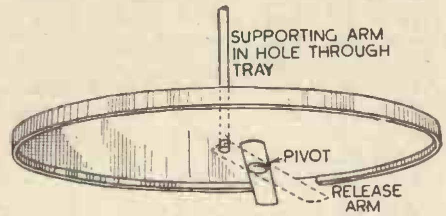


Fig. 5.—An enlarged detail of the base of the supporting rod

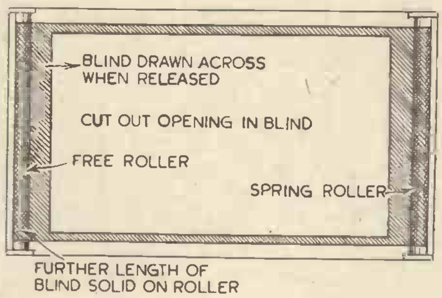


Fig. 6.—The blind and roller built into the edge of the tray

At the beginning of the trick the lamp is alight and a shade is in position over the globe. The container is at the back of the globe. The shade is removed but owing to the dazzling effect of the naked lamp the spectators are unable to see the container behind the globe. The upper part of the lamp standard works on a pivot actuated by a spring. When a release lever is pulled by means of a thread in the hands of an assistant, the upper part of the lamp makes a half turn, bringing the handkerchief container to the front (Fig. 8).

The release of the lamp is made to coincide with the report of the pistol and the handkerchief appears to have been shot straight into the lamp. Again the dazzling rays of the light prevent the container from being seen, but the brightly coloured corner of the handkerchief is quite visible. The handkerchief is now drawn out of the container, coming apparently from inside the lamp.

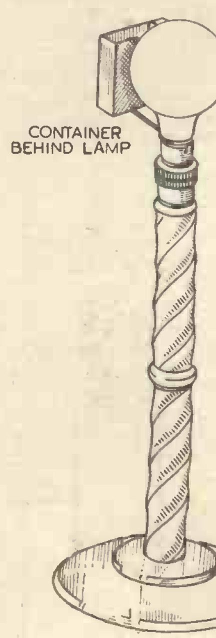
This principle of using the dazzling light from a bare lamp to conceal an object can also be employed for an effective production trick. In this case a shaded lamp is brought forward and the shade removed and shown to be empty. The shade is then replaced and a large number of flags are produced from the top of it with the lamp still alight.

Fig. 9 explains the secret. A fairly large black container, open at the top, is fixed behind the lamp. This container is packed with silk flags and the shade is put over lamp and load container. As long as the container is kept at the rear it will throw no shadow on the shade that can be seen by the audience. The shade may safely be removed, shown empty and replaced as long as the lamp, which should be a fairly powerful one and of clear glass, is kept alight. The rays of light dazzle the eyes and completely mask the container. The shade is then replaced and the flags are produced from the container, through the top of the shade.

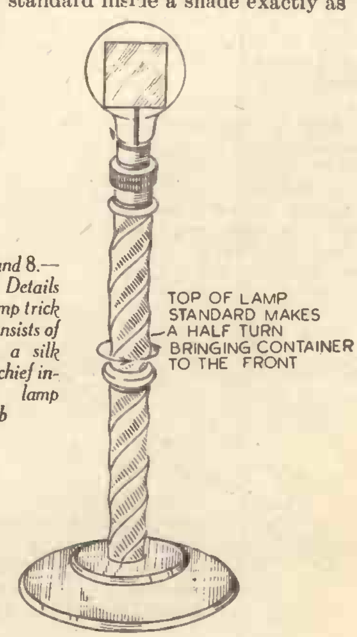
For the final lamp trick, here is a somewhat uncanny feat in which the performer removes a lighted electric lamp from its socket and it remains alight in his hands. He then causes the lamp, still alight, to float about the stage.

The secret lies in the use of a specially prepared lamp. The glass globe portion is carefully removed from a fairly large electric lamp of the pearl variety. A small pocket torch battery lamp and case is then inserted into the globe and fixed into position with sealing wax or modelling wax or plastic wood. The switch of the torch should be fixed permanently in the "on" position and the cap at the base of the case may be loosened when the lamp is to be extinguished.

This self-contained electric lamp is now put on a standard inside a shade exactly as



Figs. 7 and 8.—(Left) Details of the lamp trick which consists of shooting a silk handkerchief into the lamp bulb



if it were a genuine lamp and by tightening the cap it may be lit when required. It can of course be removed and passed from hand to hand while still alight. Note that the lamp holder of the torch should be removed and the reflector inverted before being inserted into the electric globe, so that the torch lamp projects beyond the case. See Fig. 10B. Fig. 10A shows the complete self-lighting globe.

Causing the lamp to float about the stage is simply a matter of a length of black cotton across the stage with an assistant either side and a tiny hook on the base of the lamp to engage in the thread. Full details of this method of causing objects to float in the air apparently without support will be found in a previous article of this series.

Fig. 11 illustrates a simple piece of apparatus for turning a candle into a handkerchief. The candle is a metal tube suitably painted and plugged at one end with a piece of genuine candle. This tube fits snugly into another metal tube. This second tube is polished and has a lid at each end. One of these lids is shown on the table in the illustration. Each lid is a moderately tight fit.

The candle having had a silk handkerchief tucked inside, is put into a candlestick and lit. To perform the change the candle is blown out and slid into the case, the wick end going in last. The lid is placed on and pressed home. When next the case is opened the other lid is removed, the handkerchief taken out and the case shown empty. The hollow candle cannot be distinguished from the inside of the case.

The trick can be made up in various forms. A cheaper method is to use a cardboard candle and a cardboard case. This is illustrated in Fig. 12. Note the rim at one end of the case to prevent the hollow candle from falling out when the handkerchief is withdrawn. Sometimes the metal candle and case is constructed so that the candle fits so closely into the case that it cannot be withdrawn except by the use of a key that screws like a plug into the open end of the shell (Fig. 13).

Instead of changing the candle into a handkerchief the handkerchief may be vanished and found inside the candle. This is accomplished by using a prepared candle. This consists either of a genuine candle with a hole drilled down the centre to accommodate the handkerchief, or of a fake candle made from two pieces of metal or cardboard tube with white paper pasted round, the two tubes joining end to end as shown in Fig. 14. Notice that the join is not a straight cut, but unequal. The handkerchief having been concealed inside, the candle is in due course broken across the centre and the silk extracted.

Fig. 15 shows a candlestick for changing the colour of a candle. The candlestick is hollow and a dummy red candle made of wood is attached to the base, passing up inside the hollow candlestick and projecting from the top the normal length of a candle. There is a white shell, made of thin metal tube, fitting loosely over this red candle. This shell is just the height of the candlestick and when fully raised completely hides the red candle but when allowed to drop into the candlestick, falls right out of sight. A metal stud soldered near the bottom of the shell slides in a slot cut the full length of the candlestick at the back. The change can thus be made from white to red or vice versa by raising or lowering the shell while the candle is hidden by draping a handkerchief over it. The shell is maintained in its uppermost position by giving it a slight turn so that the stud rests on top of the candlestick.

A neat trick of an unusual nature is possible with this apparatus. A small white silk handkerchief is laid over the red candle and the white shell raised to conceal both. In front of the audience the candlestick is shown as containing a white candle. Over this is draped a small red silk handkerchief. A dark cloth is draped over the candle for a moment and when it is removed the handkerchief is seen to be white while the candle is red.

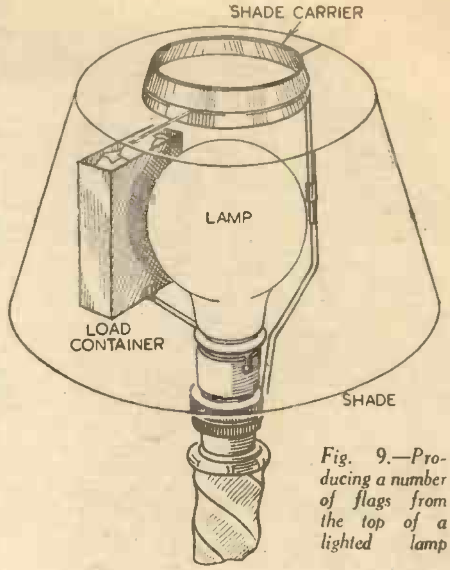


Fig. 9.—Producing a number of flags from the top of a lighted lamp

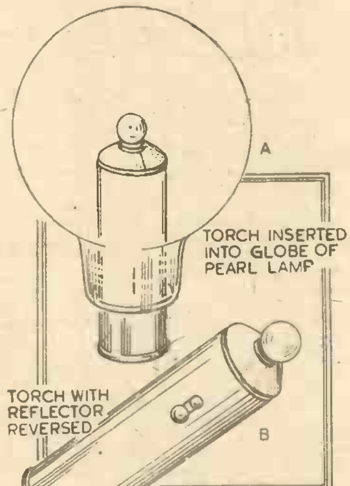


Fig. 10.—Details of the self-lighting bulb

The trick is performed by drawing down the shell; thus hiding the white candle and revealing the red one. The red silk is taken away with the covering cloth leaving the white one visible.

A candle which lights itself and goes out again on the command of the performer is another amusing trick. The candle is again a metal tube painted white. Inside is a small oil container and wick which slides easily up and down but is prevented, by a flange at the top of the candle, from coming out. A weak spring under the little lamp keeps it normally at the top of the tube where its flame is visible. A thread attached to the oil container and passing through the foot of the candlestick to an assistant permits the lamp, still alight, to be drawn down into the hollow candle, thus apparently extinguishing the candle. A few small holes must be drilled at the back of the hollow candle near the top to allow air to reach the flame, otherwise it will go out when the lamp is drawn down.

Another effective and very easy trick consists of lighting a whole row of candles by passing the empty hand in front of them. Apart from the candles all that is needed is a fake consisting of a tiny metal tube with a spirit soaked wick. The tube is clipped to the base of the second finger.

The trick is usually performed by first lighting all the candles and then blowing them out. After that the hand is passed along the line and the candles light again. The miniature wick in the fake is lit just before the candles are first extinguished. It is then an easy matter to re-light the candles by passing the open hand in front of them. The fact that they have only just been put out will cause them to light again readily. If the candles are to be lit by means of the fake without any preliminary lighting and extinguishing, the candle wicks should be touched with petrol or paraffin.

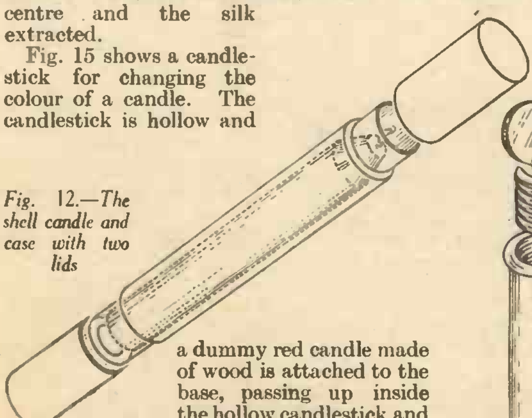
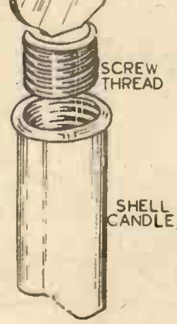
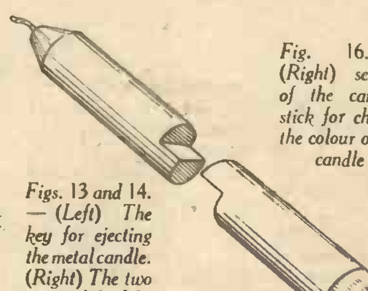


Fig. 12.—The shell candle and case with two lids





Figs. 13 and 14. — (Left) The key for ejecting the metal candle. (Right) The two parts of the fake candle

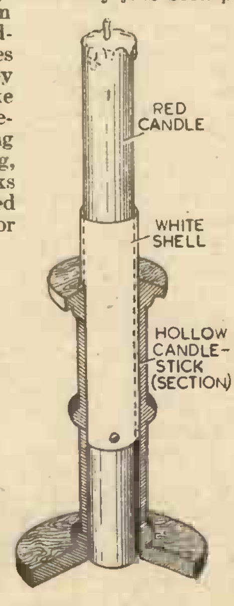


Fig. 16. — (Right) section of the candlestick for changing the colour of the candle

WORKSHOP WRINKLES

By "MECHANIC"

Useful Hints that Save Time and Money

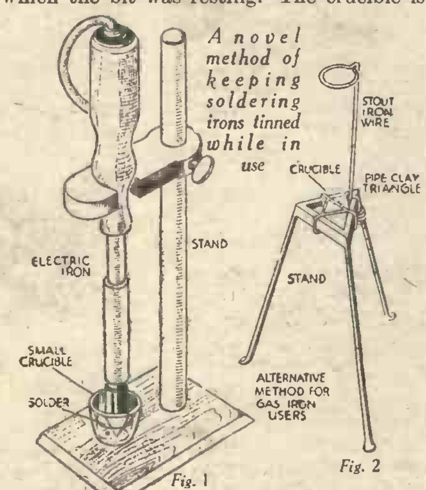
A Neat Hydrometer Drip Stand

THE accompanying sketch illustrates a rather novel hydrometer stand. A strip of mild steel constitutes the main support, and to this is soldered a brass clip made from a strip of $\frac{3}{32}$-in. brass. The main support is recessed into the base, and four small rubber feet, screwed on as shown, prevent the stand from slipping. The small jam jar is also recessed to the depth of three thicknesses of ply, and its fitment into the base in this manner should be tight, yet providing ease of removal when required.

Keeping Soldering Irons Tinned

ELECTRIC soldering irons sometimes get a little too hot, and the solder on the iron becomes covered with a coating of oxide. This nearly always happens when the iron is left for a short while, so to prevent this I kept the copper bit immersed in solder. How this was done is illustrated in Fig. 1, and the tinned part of the bit is thus kept covered with the molten solder, and remains well tinned.

Before I used an electric iron I heated my old bit with the point in the solder. This was done by heating the crucible in which the bit was resting. The crucible is



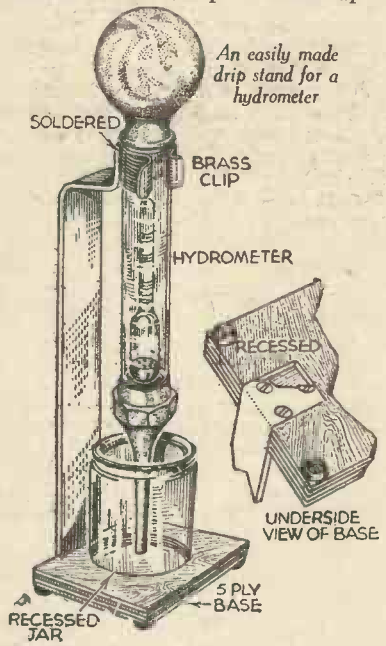
A novel method of keeping soldering irons tinned while in use

Fig. 1 *Fig. 2*

a narrow one, to avoid wasting the heat. The crucible is held in place by a pipe-clay triangle (Fig. 2). A piece of thick wire is twisted round the iron support with the loop for holding the handle of the iron. I heated the crucible with a blow lamp, but any convenient source of heat is suitable. This method also keeps the iron nicely tinned. The crucibles can be obtained from any chemist.

A Workshop Light

THIS device consists of a piece of piano wire stretched between the walls of the shed, and this supports a metal fitting which carries a lamp in such a way that the lamp may be raised or lowered, and by manipulation of a screw it can be clamped to the wire, or moved along it. The lamp is fed by a length of flex, and the slack in this flex which is produced by the movement of the lamp is taken up by

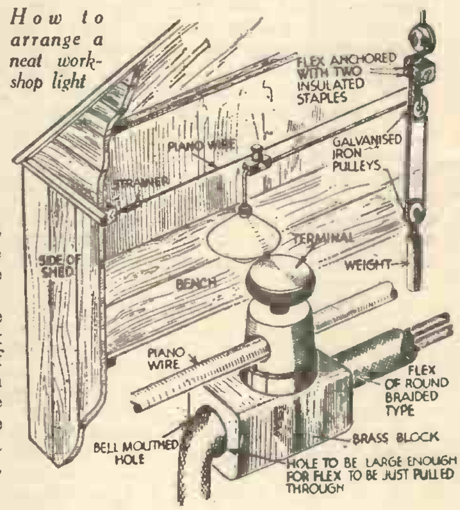


An easily made drip stand for a hydrometer

a simple system of pulleys and a weight so that there is a constant tension on the flex which is just sufficient to take up the slack.

The sketch is self-explanatory, but one or two points may be detailed. The flex must be of the round braided type; if ordinary twisted flex is used, the insulation will wear off at the corners and give rise to trouble. There is, actually, very little wear on the round flex. I have had a length in use with this system of pulleys, etc., for two years, and the flex is only just beginning to wear, but will last for another year yet.

The lead weight can be cast by pushing a broom-handle into clay for about 9 in. depth and pouring molten lead in, while the lead is still liquid the end of the pulley with the hole in it can be pushed in, and when the whole is cool, the pulley will be found to be firmly fixed in the lead. A turnbuckle or wire-strainer is essential, as the piano wire must be kept very taut.



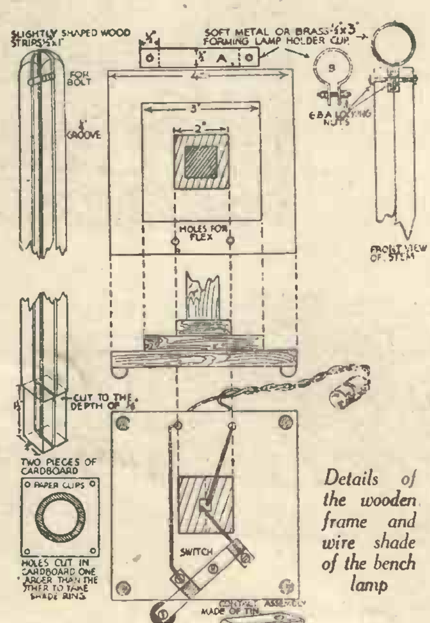
How to arrange a neat workshop light

A Useful Bench Lamp

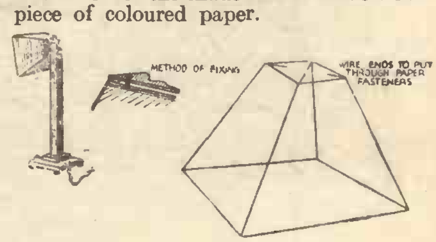
THE accompanying diagram shows a very handy and inexpensive bench lamp. The stem consists of two lengths of ½ in. by 1 in. wood, with one side slotted to take the flex, and both tops are slotted to receive the clip. The base is three pieces of wood glued together, with a ¾ in. by 1 in. hole in the centre.

The clip A is folded round the lamp holder and fixed by means of a 6 B.A. held by two nuts on either side B. After securing the holder, with the flex wired in, run the flex down the slotted stem as shown. The base of the stem is tightly fixed into the base itself, thus holding the wire secure. Any switching arrangement may be used but the one shown is very simple.

The shade is made of 18 s.w.g., and the only point to remember is to leave the four wires protruding 1 in. Now cut two pieces of cardboard and cut a hole in the centre of each. One hole should fit the lamp holder exactly, and the other hole should be a ¼ in. larger. Place the card with the larger hole underneath the four wire ends and the other card on top, and secure with wire or glue. The cover for the shade can be made from a piece of coloured paper.



Details of the wooden frame and wire shade of the bench lamp



"MOTILUS" PEEPS INTO THE MODEL WORLD

It is up to the Amateur Model Maker and Owner to Keep Interest Alive in this Vital Hobby—for it is one which may be Badly Hit by Poor Trade.

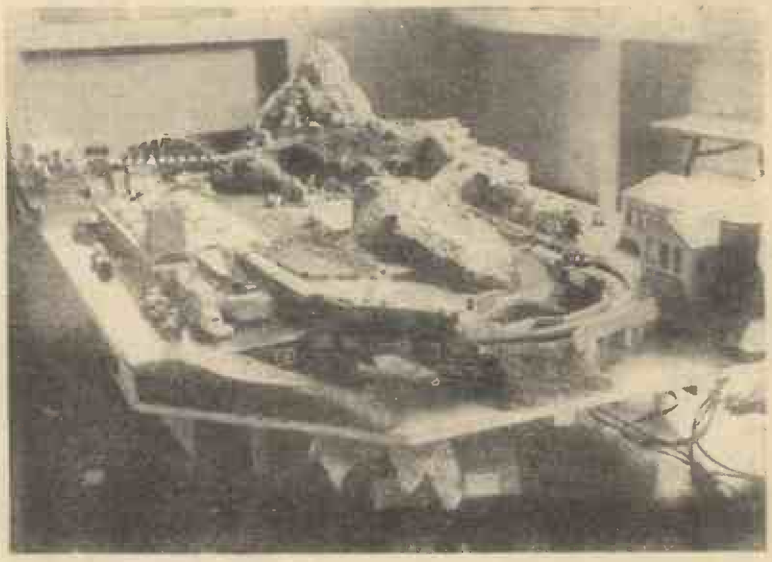
Our Model Fan with his Camera Finds News of Wartime Model Making.

The new tug boat "Mary"

WELL, fellow modellers, now is the time when indoor modelling should be at its height. Let us hope this year it will be the same as ever, for it is up to us all to carry on. This month I bring you news from a model railway enthusiast in British Guiana, Mr. A. Smith, of Berbice, who sends this picture of his scenic railway layout. "It is an enormous attraction at our house," says Mr. Smith, "and is besieged with visitors of all ages. Also it has made money as a side show at bazaars, etc., with the operator of the distant controls hidden behind a screen." As you have already guessed no doubt, the railway is a Twin Train Table Railway, with the scenery carefully painted to represent the natural colourings. This cannot be seen to best advantage in a photograph, but Mr. Smith has developed a technique of papier mâché, coated with sand and sawdust which gives a realistic representation of bushes and grass in this scale. The roads are painted to represent tar macadam, the rocks are real stones, and all the buildings are lit up. To prevent the whole being too sombre the arch facings and buildings are painted in unnaturally bright shades because "after all" (in the words of the owner) "the layout is a toy and not a model and this gives the happy finish." Personally I feel it has many "model" points!

A New Tug Boat

I wonder how many of you have seen the new tug boat placed on the market by Lines Bros. It is constructed of one of the new plastics and the detail, even in the small life boat on deck is amazing, and just goes to demonstrate the possibilities of this type of manufacture when large quantities of a model can be placed in work. It is 7 inches long by 2 inches wide and houses an efficient little clockwork mechanism. The hull is black with white deck and brown deck houses. The funnel is red and black. Fittings include the aforesaid dinghy on deck, ventilators, bollards, capstan, bridge with steering wheel and two starboard engine room telegraphs, two lifebuoys, port and starboard lights, etc.—quite a collection! The cost of the model at the moment of writing is 7s. 6d., but with the outbreak of hostilities there is almost certain to be an advance on this. It can be obtained from Messrs. Hamleys, Bassett-Lowke's, Lucas of Liverpool, and at many of the leading toy shops in London and the provinces, and also a set of finished parts is available at 3s. 9d. the set.



The model railway layout of Mr. Smith, of British Guiana.

"Cock of the North"

I was in London last week and noticed that Messrs. Bassett-Lowke have in their shop a very fine unpainted model of the L.N.E.R. type of locomotive "Cock of the North," ½ inch scale, 2½ inch gauge. Those interested in high-class hand-made steam models should call in and see this piece of work by expert craftsmen, as they may be able to get some ideas from it.

Of recent times Bassett-Lowke have begun to cater more and more for the owner requiring a special Gauge "O" hand-made model in clockwork or electric, made up at a reasonable price using standard parts. Mr. Gilbert Thomas, the well-known writer and critic, who has now removed from London to Teignmouth, has just added to his line a G.W.R. 4-6-0 "Pendennis Castle." He told me that he is now well on with the

The G.W.R. "Pendennis Castle"

re-erecting of his gauge "O" railway, and that the price for the detail work of this special hand-made "Pendennis Castle" was 13 guineas all told, which appears to be very reasonable. He seemed to think so for he is ordering another G.W.R. locomotive, the "Llanfair Grange," No. 6,285, from the same firm. I am showing a picture of the "Pendennis Castle" model. Its prototype you will remember holds the remarkable record of making better times on a lower coal consumption than one of the 92 ton "A1" class Pacifics on the L.N.E.R., in the "exchange" trials of 1925. Incidentally the Castles are 80 ton expresses and they have been more extensively built than any other G.W.R. passenger type. They are responsible for many important duties such as the 71.4 miles-an-hour "Cheltenham Flyer" and the 67.6 miles-an-hour "Bristolian," the fastest trains on the line.

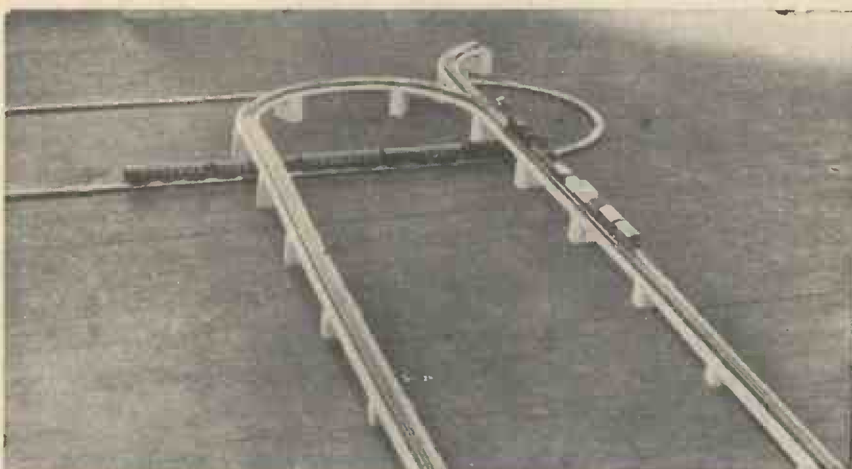
Model Aeroplane

Model aircraft is in the picture again, and in Northampton I was lucky to see a batch of civil aeroplanes and flying boats they were making for the New Zealand exhibition, to show the progress of British commercial aircraft in recent years. The eight 'planes were made of African white mahogany wood, silver lacquered to give a metal finish and were made over a period of five weeks. The engines and nacelles were of metal and the machines modelled were the D.H. 91 "Albatross" G-AFDI, the D.H.95 "Flamingo" G-AFUE, Armstrong Whitworth "Ensign" G-ADSR (shown in this picture), Short "G" class flying boat, short "S.30" class Flying Boat G-AFCI, Fairey "F.C.I.," Handley Page "Hannibal" and the famous Mayo Composite 'plane.

At work on the Armstrong Whitworth Ensign G-ADSR model

"Gradients"

Each month I like to give you news of some new gauge "OO" development, and this time it is "gradients." Some of you, I dare say, have visited Bassett-Lowke's at High Holborn and seen their working display of the Twin Trains in the basement. This layout now includes gradients for high level tracks, and this novelty in gauge "OO" is proving so popular that they have worked out a standard set which provides for a gradient of 1 in 30 in a length of 8 ft. 6 ins. At the top this gradient gives a 3 inch clearance. Fellow modellers will realise the big possibilities of this gradient set—the number of high and low level roads they can arrange by using these standard fitments, which consist of straight and curved sections, special sections for points and piers of varying heights. I had the opportunity of examining a set of these gradient parts. The sections and supports are all made of African white mahogany free from knots and shakes and finished in a matt colour to represent modern concrete construction. If you want brick piers, it is a simple matter to cover these with brick paper, which can be obtained in all types and colours as low as 3d. a sheet. My picture shows a typical under and over road, with a T.T.R. goods train above and the new L.M.S. "Coronation Scot" passing on the under road. The standard "Lowko" set as it is called consists of: 2 tapered track bases, 6 piers of varying heights and 5 straight track bases $14\frac{1}{2}$ in. long x $2\frac{1}{2}$ in. wide. The two tapered track bases carry the track from zero to 1 inch and the piers lettered A to F continue the graduation from that height to $3\frac{1}{2}$ in. to the top of the track base, making a total length of 8 ft. 6in. Complete set costs 15s. 6d., and parts are obtainable separately.



The new gauge "00" gradients for the T.T.R. railway

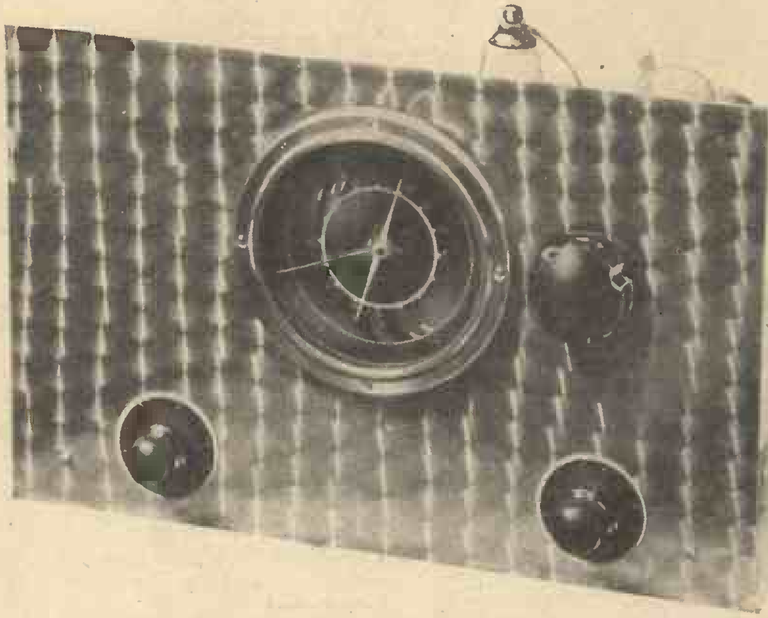
Famous Motor Yacht

In these times of stress, it is pleasant to remember the yacht racing synonymous with the name T. O. M. Sopwith. I have recently come across this picture of an excellent model of his famous motor yacht *Philante*, modelled for the makers, Messrs. Camper and Nicholson of Southampton. Designed by C. E. Nicholson, M.Inst. N.A., the *Philante* was launched at Southampton on February 11, 1937, and underwent successful trials at the end of May of that year. Her principal dimensions are overall length 263 feet, extreme breadth 38 feet, tonnage (Thames measurement) 1,612 and cruising speed 14 knots. In my opinion this vessel is the ideal of what a steam pleasure yacht should be. At the time of her trails she was the largest yacht built in the United Kingdom, while her M.A.N. Diesel machinery, which develops 3,000 total B.H.P. on normal fuel setting, gives her a very useful turn of speed. The model shown here is to a scale of $\frac{1}{4}$ inch to one foot.

A $\frac{1}{4}$ in. to the ft. model of the motor yacht, "Philante"

P.M. Short-wave Three

A short-wave Receiver of the "Straight" type Designed to Satisfy the needs of those Enthusiasts who Require an Efficient yet Simple Installation



A three-quarter front view of the receiver

MANY have been the requests for a superhet receiver designed for battery operation, and for short-wave reception.

Quite a goodly number still favour a good straight receiver something along the lines of what is often affectionately called by the old timers "old faithful," or, in other words, a circuit of the single H.F. type followed by an efficient detector, and one or two stages of L.F. amplification according to individual requirements.

A circuit of this type has much to recommend it for every short-wave enthusiast's consideration; it is invariably reasonable as regards price, simple to construct and, once its operating characteristics have been rendered more or less perfect, quite pleasant to operate, and reasonably consistent in performance.

We are not overlooking the fact that in these days of station-swamped ether, one has to face the ever-increasing problem of selectivity and we fully realise that the super-het, plus or minus a crystal gate, goes a very long way towards eliminating the bug-bear of interference. While giving all due respect to these items, it cannot be denied that such outfits are not within the range of every reader's pocket, and it would not be any exaggeration to say that the mass of short-wave listeners have to be content with something rather more modest than a receiver embodying all the refinements suggested above. It is, therefore, in an endeavour to provide a good all-round receiver that this set has been designed.

The Circuit

The theoretical diagram shown in Fig. 2 depicts a three-valve circuit.

The initial aerial circuit consists of an Eddystone three-winding coil, one of which is used for aerial coupling, another for the grid input circuit, and the other one for the reaction. It will be noted that no bad spreading, in the ordinary sense, is provided. This was found to be unnecessary as the special type of mechanical drive used in the slow-motion tuning gear, provides an identical effect with the advantage of definite dial recordings.

The grid coil, which is tuned by an Eddystone .00016-mfd. variable condenser, type number 1131, feeds the detector via the usual leaky grid coupling condenser. As sensitivity and gain are important factors, it was decided to use an S.G. valve in this position, as it not only gives a greater output on a weak signal but it also allows a very efficient form of reaction to be obtained.

The output from the detector is fed into the first L.F. stage by means of a resistance-capacity coupling, and it will be noted that a volume control has been fitted across the grid circuit of the first L.F. to enable the ultimate output volume to be regulated so that headphones or speaker can be used as desired.

The coupling between the first L.F. valve and the output stage is provided by an L.F. transformer of the Varley Niclet type, but, to prevent the primary receiving an excessive current load, it is arranged in the normal parallel-feed method which, incidentally, also provides a certain degree of decoupling.

The output valve is a Cossor 220 H.P.T. pentode which is quite capable of providing

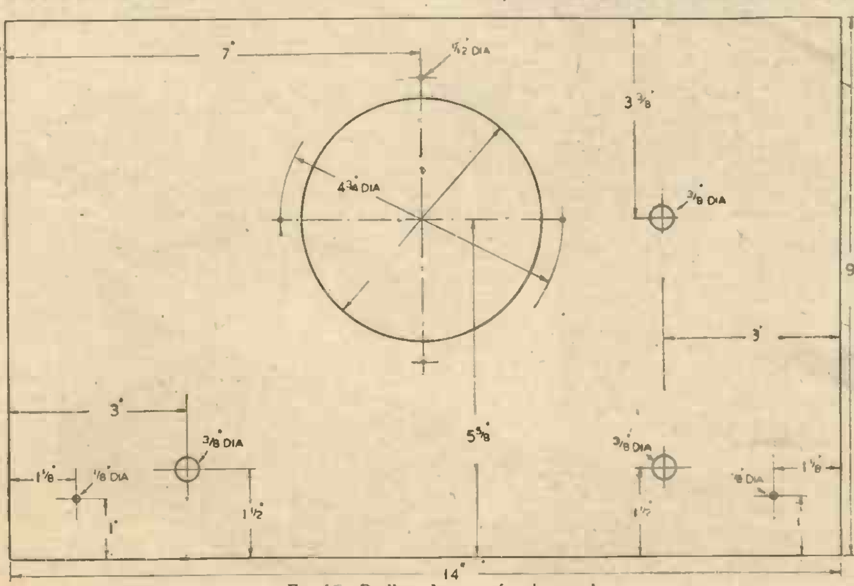


Fig. 1.—Drilling diagram for the panel

LIST OF COMPONENTS

- One Eddystone type No. 1131, 160 m.mfd. var. condenser.
- One Eddystone type No. 969 six-pin coilholder.
- Two Eddystone type No. 949 four-pin valve-holders.
- One Eddystone type No. 950 five-pin valve-holder.
- Two J.B. .0001 mfd. var. condenser, type No. 2146.
- One Bulgin H.F. choke, type No. H.F.3.
- Fixed Condensers—Dubilier: Type 4601/S: One .0001 mfd.; one .01 mfd. Type 4602/S: One .05 mfd. Type 4603/S: One 0.1 mfd. Type 4608/S.: One 0.5 mfd. Type 4609/S: One 1 mfd. Type 3016: Two 2 mfd.
- One chassis (Peto-Scott), 14 x 9 x 3.
- One panel (Peto-Scott), 14 x 9.
- Fixed resistances—Erie. ½ Watt: One 1 meg., one 0.25 meg., one 10,000 ohm; one 0.1 meg., one 50,000 ohm, one 20,000 ohm, one 100,000 ohm, one 15,000 ohm, one 30,000 ohm.
- Potentiometers—Erie: One 0.25 meg., one 50,000 ohm, with switch.
- L.F. transformer. One Varley Niclet D.P.21.
- L.S. panel (Clix).
- A1, A2, and E socket strip (Clix).
- Valves, Cossor 210 S.P.T., 210 H.L., and 220 H.P.T.
- Coils—Eddystone: 22-47 metre, No. 959.6Y.

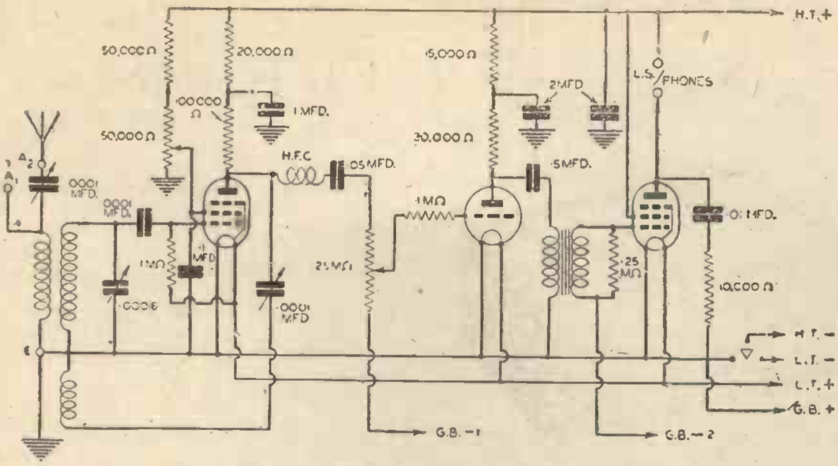


Fig. 2.—Theoretical circuit diagram for the short-wave three

adequate output for all normal purposes and, providing the volume control is used in the manner intended, it will handle all the input necessary for full output.

It will be seen from the above description that there is nothing fanciful about the circuit, and that no unnecessary components or gadgets have been embodied; therefore, it should present no difficulties to any enthusiast as regards its construction; in fact, it is quite a safe proposition for a keen beginner to consider.

Layout

The plan drawing of the chassis, Fig. 3, shows that a very clean and clear layout has been obtained, and it should also be noticed that no attempt has been made to sacrifice space to make the overall dimensions smaller.

The main tuning condenser, together with its mechanical band-spreading drive, is located in a dead central position, which not only gives a pleasing appearance to the panel but also allows the controls to be placed at the most convenient operating points.

As a steel chassis was used in the original model, it was decided to use the special low-loss baseboard-type valve holders produced by Eddystone, and, as each valve-pin socket on these holders is made in one piece, the possibility of contact noises is considerably reduced.

By employing a chassis, the majority of the components are housed out of sight and well protected, while the wiring is considerably simplified as is evident by the plan drawing of the underside of the chassis.

To avoid the use of plugs and jacks the special Clix switching output panel is employed and, for convenience' sake, it has been fitted on the right-hand side of the chassis when it is viewed from the front. This simple device allows a most rapid change-over to be made from headphones to loudspeaker, and, when housing the completed set in a cabinet, no difficulty should be experienced in making a suitable aperture for access to this component.

Assembly

Before proceeding with any drilling, lay out the components to be mounted on the top of the chassis on the actual metal chassis and carefully mark off the exact positions for the holes to be drilled, after making *quite* sure that all the components are in the positions indicated by the plan drawing. After drilling, clear all holes of burrs, and then repeat the procedure for those parts which have to be mounted inside the chassis. Don't attempt to fix anything down until all drilling is finished, otherwise damage might be caused to certain components which will not only spoil the appearance of the completed assembly, but also possibly affect the efficiency. Particular care must be taken when setting up the bracket which supports the main tuning condenser, and the locating and fixing of the slow-motion drive. Don't try to rush this part of the work. Remember that the drive is dead central along a horizontal line of the panel, and that the distances of its fixing, and that of the condenser bracket from the front panel, are very important.

For satisfactory fixing of all parts bolts should be used, and, for a thorough job, use shakeproof washers under each nut.

The Panel

This can be purchased, the same as the chassis, from Messrs. Peto Scott ready drilled but, if you wish to do it yourself, check all drilling points before starting that operation. The large hole for the dial should be scribed on the metal, and then cut out with a fretsaw, the edges being smoothed off with a small file.

When handling this part of the assembly, see that the bench is free from all metal filings, and covered with two or three layers of stout paper, otherwise the fine polished finish of the panel will soon be marred. It is attention to these little details which makes all the difference in the appearance of the set when completed.

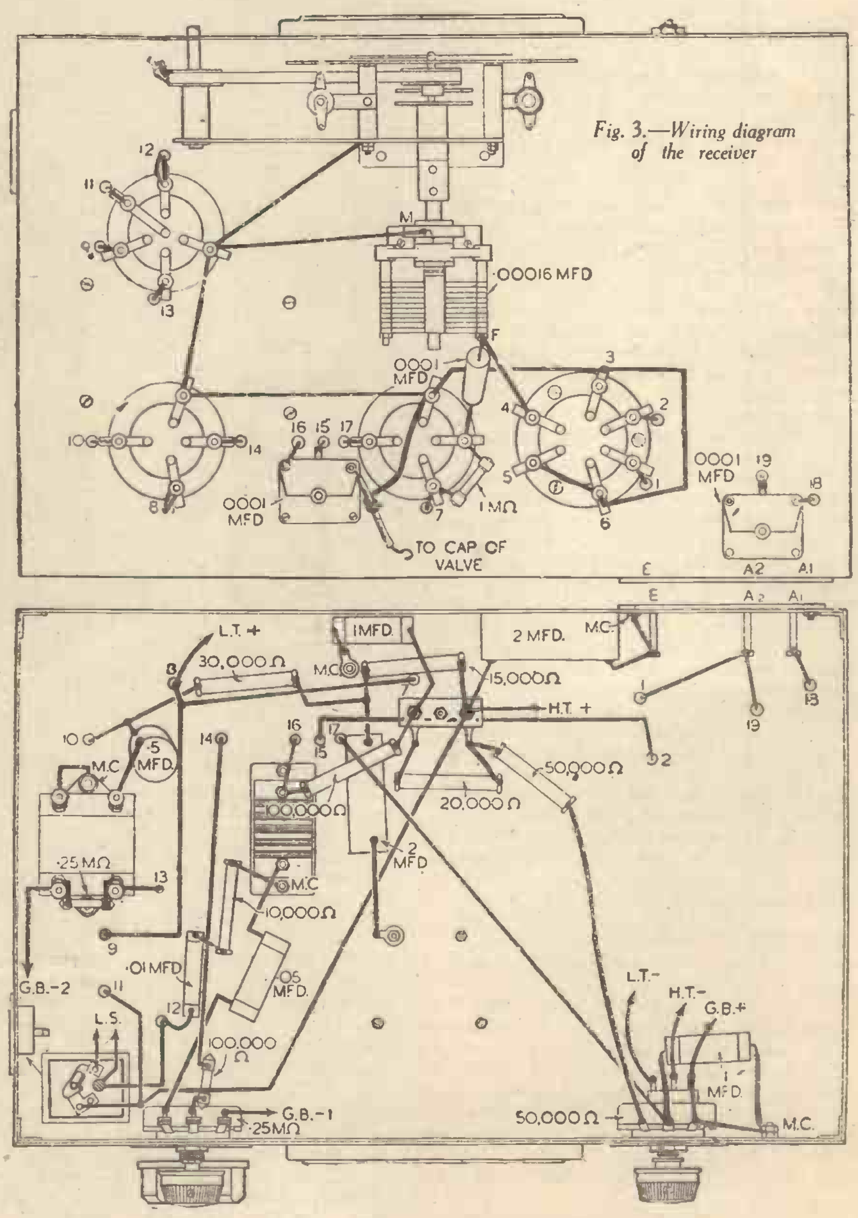


Fig. 3.—Wiring diagram of the receiver

PHOTO-ELECTRIC EXPERIMENTS

A Number of Simple and Easily Performed Photo-electric Experiments which Demonstrate the Underlying Principles of the Photo-electric Cell.

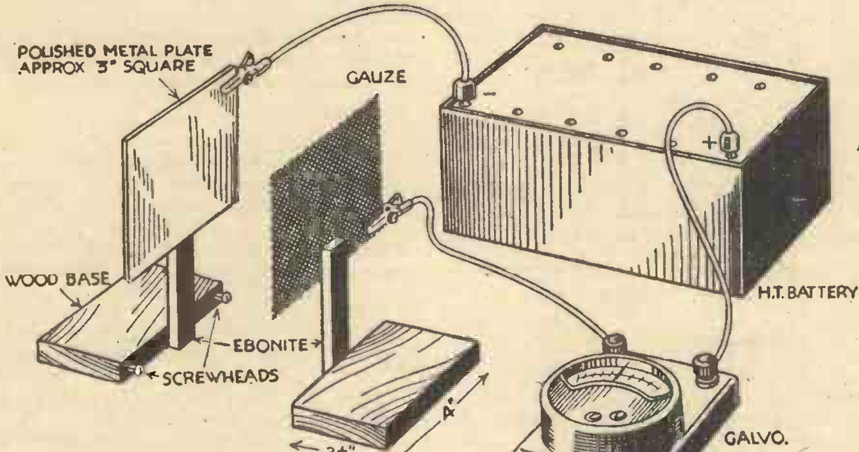


Fig. 1.—A simple apparatus for demonstrating the photo-electric effect

IT is known by all television amateurs that the modern photo-electric cell owes its origin to the discovery made in 1888 by Hallwachs, a German physicist, that areas of certain metals, when strongly illuminated by violet, or, better still, by ultra-violet rays, lose almost immediately a charge of negative electricity which has been previously imparted to them. This effect is usually known as the "Hallwachs effect."

In addition to the above, however, it was discovered also that an uncharged insulated metal plate is able to acquire a positive charge when ultra-violet rays fall upon it. Such phenomena were studied by a number of scientists, and, eventually, they gave rise to a device of supreme practical importance—the photo-electric cell.

It is possible for the amateur to make a number of interesting experiments based upon the early observations of Hallwachs and others. Such experiments are easy to carry out and they are of value in view of the fact that they illustrate in a very definite and striking manner the fundamental principles of the photo-electric cell.

In the first of these experiments construct the apparatus shown in Fig. 1. It consists of two small wooden bases, approximately 4 by 2½ in. in area. Each base has an ebonite upright. To one of these uprights is secured a piece of coarse wire gauze. To the other upright is fixed a metal plate, the plate being fastened by means of a lump of plasticine or a dab of sealing-wax placed at the back. The metal plate should be about 3 or 3½ in. square, the area of wire gauze being about the same dimensions also.

Preparing the Plates

A number of plates of different metals should be provided, such as plates of copper, zinc, sheet iron, tinned iron, aluminium and brass. It is absolutely essential that these plates should be brought to a high polish on one side. A mirror-like surface is not essential, but the plates should be rubbed over first with coarse and then with fine sandpaper (with the exception of the tinned iron) in order to expose a fresh and untarnished surface to the light action.

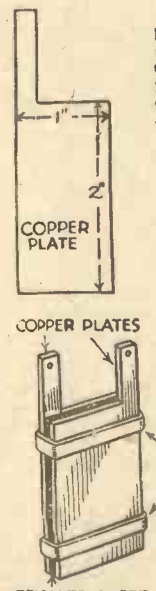
Connect a wire to the gauze and connect up the other end of the wire to one terminal of a galvanometer or other current-indicating instrument, the more sensitive the better.

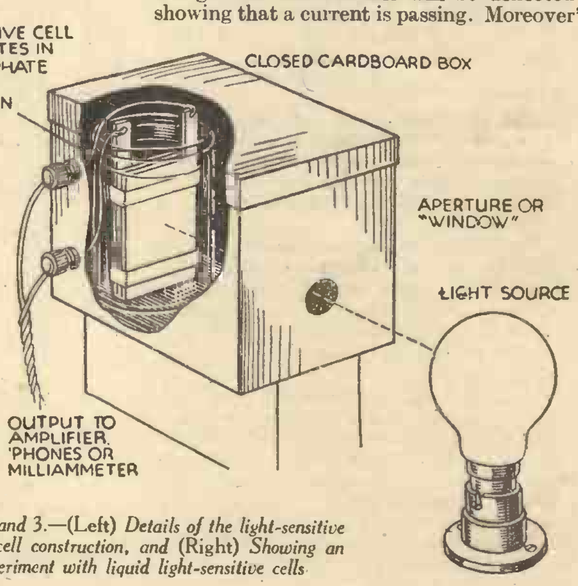
Next connect another wire to the metal plate and the other end of this wire to the *negative* terminal of a radio high-tension battery which should possess an E.M.F. of the order of 100 or 120 volts. The positive terminal of the H.T. battery is connected to the galvanometer, thus completing a circuit from metal plate to metal gauze.

Before making these connections be sure that all the apparatus (H.T. battery and galvanometer excepted) is perfectly dry. If you have any doubts upon the matter it is best to place the wooden stands supporting the metal plate and gauze for half an hour in a warm oven in order to drive off traces of moisture which would very probably ruin the experiments.

Having fixed up the apparatus as shown at Fig. 1 and described above, move the wire gauze assembly up to the metal plate so that the gauze faces squarely up to the plate and is separated from it by a space of about ⅛ or ¼ in. (not more). On no account, however, must the gauze actually touch the plate, otherwise the H.T. battery circuit would be completed and the galvanometer probably ruined.

Note now the galvanometer reading. It will be seen that no current flows. Now take a few inches of magnesium ribbon and burn it in front of the metal gauze and at a distance of about 6 in. away from it. The burning magnesium will flood the metal plate with ultra-violet rays. Instantly the galvanometer needle will be deflected showing that a current is passing. Moreover' as the burning magnesium ribbon is moved up to the wire gauze the galvanometer deflection will increase, whilst if the magnesium ribbon is withdrawn from the gauze the galvanometer needle will show a decreased deflection, thus proving that the current-generating property of the ultra-violet light is proportional to its intensity at the metal surface—a law which governs rigorously the functioning of all light-sensitive devices.





Figs. 2 and 3.—(Left) *Details of the light-sensitive copper cell construction, and* (Right) *Showing an experiment with liquid light-sensitive cells*

The Effect on the Plates

Repeat the above experiment with the various metal plates. It will be found that a zinc plate gives the best results. After zinc comes aluminium. Copper, brass and tinned iron show a very considerably decreased effect and sometimes, if they are not highly polished, they do not show it at all.

What is the explanation of the above effect? It is not difficult to grasp. The metal plate, being connected up to the negative pole of the H.T. battery, is negatively charged. When the plate is acted upon by ultra-violet rays it loses a portion of its charge. Thus the equilibrium of the battery circuit is disturbed and a small current flows.

It will probably be found that any given metal plate will only show the photo-electric effect in this manner a certain number of times—say, half a dozen times. After this it will undergo a species of "photo-electric fatigue." This is due to the slight tarnishing or surface oxidation undergone by the plate. If the plate is rubbed over thoroughly with fine sand-paper so as to expose a fresh surface, it will be found to show the photo-electric effect as well as ever.

The underlying cause of the photo-electric effect is readily grasped. When a light ray of a certain vibration-frequency—a ray of ultra-violet light, in the above case—falls upon a polished metal surface, it knocks away from one of the surface atoms one or more electrons, the electrons being shot off from the metal surface in a manner similar to that in which they are emitted from a heated valve filament, although less copiously. The H.T. battery simply supplies a "driving potential," the electrons being caught by the gauze screen, the circuit thus being completed.

The photo-electric effect is best shown by the alkali metals, potassium, sodium, rubidium and caesium. Such metals, although they enter into photo-electric cell construction, cannot be employed in the above experiments because, in contact with air, the surfaces instantly become covered with a layer of oxide. In photo-electric cells such metals remain bright indefinitely on account of the absence of air in the vaccum cells.

Besides metal plates certain crystals are light-sensitive and can be made use of in the above experiments. If, for instance, instead of a polished zinc or aluminium plate we employ a crystal of galena, the well-known wireless rectifying crystal of former days or, better still, a piece of molyb-denite, the same effect will usually be obtained with the apparatus described. Not all galena crystals are sensitive in this manner. Their sensitivity depends upon some unknown factor. Hence, the experimenter who has a quantity of galena crystals available will have to play the game of trial and error with them until he hits upon a crystal which displays strongly the photo-electric effect.

Other crystals which are similarly photo-electric are chalcopyrite and iron pyrites, both of which were formerly well-known as radio rectifiers.

Liquid Light-Sensitive Cells

These cells provide a large field for amateur experimentation. One of the simplest cells of this type is seen at Fig. 3. It comprises two copper sheets, approximately 2 x 1 in., which are cut with an attached lug, to which a connection may be made. The copper sheets should be well cleaned by rubbing them over with strong soda solution, then by rubbing them with coarse and, finally with fine sandpaper. A suitably-sized piece of ebonite sheet separates the copper plates which are attached to it by means of two rubber bands.

Make up a 1 per cent. solution of copper sulphate (about 5 grains of copper sulphate in an ounce of water is the right proportion) and stand the copper plates in a vessel containing this solution. Preferably, a three or four days' immersion should be allowed and the immersion should be carried out in the dark.

After a few days the cell will have "formed." A fine coating of copper oxide will be present on the surface of the plates, this thin film being light-sensitive.

Now obtain a cardboard box sufficiently large to contain the cell. Make an aperture in the side of the box so that light passing through this "window" may fall upon one of the copperplates of the cell, the other being unillumined. Connect leads from the copper plates to a pair of headphones or to the input terminals of a radio amplifier equipped with a loud-speaker.

On holding a bright light-source near to the "window" of the box and interrupting the light more or less rapidly by jerking a sheet of cardboard up and down in the path of the light rays, a series of clicks will be heard in the 'phones or loudspeaker, these clicks being generated by pulses of current from the light-sensitive cell.

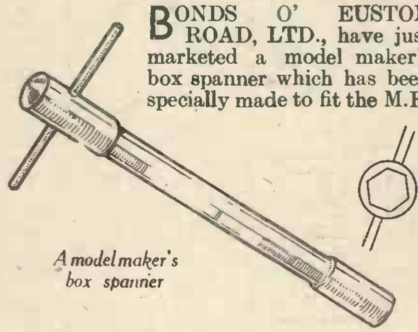
A cardboard disc provided with radial slots will, when revolved in the path of the light rays, give rise to a humming noise in the phones of speaker. Also, if by any chance a miniature arc-light can be obtained, it will be possible to listen-in to the irregular pulsations of current passing through the arc.

Needless to say, all these effects may be studied by substituting a sensitive micro-meter in the external circuit of the cell in place of the phones or radio amplifier. Micro-ammeters, that is to say, instruments which read down to a few millionths of an ampere, are costly articles, however, and not many experimenters possess them.

AROUND THE TRADE

Model Maker's Box Spanner

BONDS O' EUSTON ROAD, LTD., have just marketed a model maker's box spanner which has been specially made to fit the M.E. size Whitworth nuts and hexagon bolts, which as readers know are smaller across the flats than the standard Whitworth sizes.



A model maker's box spanner

Spanners can be supplied for 1/16-in., 3/32-in., 1/8-in. and 5/32-in. M.E. sizes of nuts. The price per box spanner is 9d., plus postage.

A.R.P. Handlamp

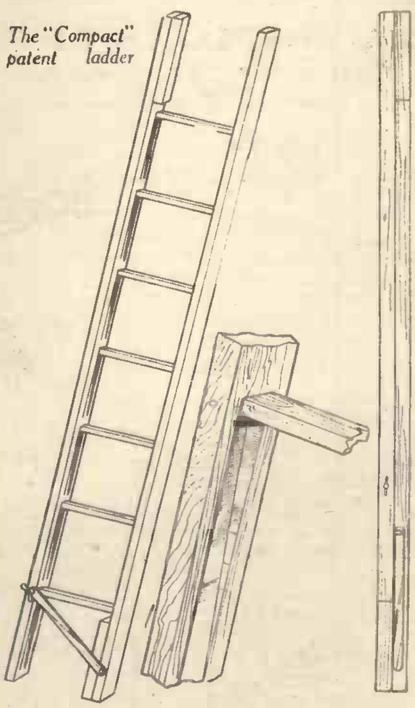
EASCO ELECTRICAL SERVICE have recently marketed a portable hand-lamp which has a number of uses. It is constructed of 18 S.W.G. metal, has a swivel handle and a hinged lid fastener.

The inside of the box is painted with anti-sulphuric paint, whilst the outside of the case is black crinkle. The photograph shows the neat and novel appearance of the lamp. The light is fixed on top of the lid and the 6-volt bulb is a double pole, dual filament which gives an even diffused light. It is worked from a 6-volt "Dagenite" unspillable accumulator and the terminals of the battery are insulated and cannot short circuit. The lamp will give a continuous bright light of 12-watt candle-power for 9 hours or a continuous dim light of 3 watt candle-power for 20 hours. Using an intermittent light it will give 250 hours' service. The lamp costs £3 19s. 6d.

A portable hand lamp suitable for A.R.P. workers

The "Compact" Patent Ladder

THE Southern Ladder & Step Co., have recently produced an ingenious type of ladder which actually shuts up. It differs from the ordinary folding or collapsible types and has been designed for easy carrying and convenient storage. As will be seen from the sketch, it takes up the minimum of space when closed and when open is held rigid by means of a metal bar and a wing nut. The uprights are made from selected well seasoned timber and the rungs are made from oak. When closed the rungs fit into special grooves cut into each side of the uprights. The ladder is 8 ft. high (open) and costs 25s. A 10 ft. ladder can be obtained for 5s. extra.



The "Compact" patent ladder

"That's an odd way to work,"
remarked Blewitt,
"Are you sure, dear old boy,
you won't rue it?"
Said Brown, "That's all right,
See! I'm using FLUXITE.
So you see, on my head I can
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See that FLUXITE is always by you—in the house—garage—workshop—wherever speedy soldering is needed. Used for 30 years in Government works and by leading engineers and manufacturers. Of Ironmongers—in tins, 4d., 8d., 1/4 and 2/8. Ask to see the FLUXITE SMALL-SPACE SOLDERING SET—complete but substantial complete with full instructions 7/6. Write for Free Book on the ART OF "SOFT" SOLDERING and ask for Leaflet on CASE-HARDENING STEEL and TEMPERING TOOLS with FLUXITE.

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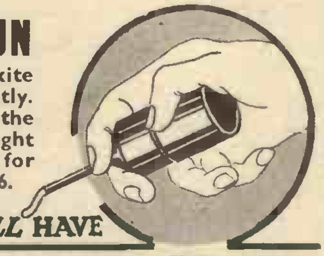

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Steel Rail, sheradised finish per yd. **1½d., 1/3** doz. yds.
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Cast Chairs ... ... per 100 **1/4**
Steel Chairs ... ... per 100 **1/4**
Fishplates ... ... per doz. **3d.**
Sleepers, Wooden ... per 100 **8d.**
Electric Raised Chairs ... per doz. **8d.**
Pins ... ... **3d.** packet

PRICES. Standard Gauge "0" Parts

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Brass Rail ... ... per yd. **4½d.** 4/3 doz. yds.
Cast Chairs, slide-on fit ... ... per 100 **1/2**
Electric Raised Chairs ... ... per 100 **2/-**
Fishplates ... ... per doz. **3d.**
Sleepers, stained correct colour ... per 100 **2/3**
Battens, ½-in. x ¼-in. section per yd., **2½d., 2/3** doz. yds.
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Our Busy Inventors

By "Dynamo"

Ink Detective

THE inquisitive person—vulgarly known as "Nosey Parker"—will have his or her curiosity baulked by a new steam-sensitive ink. When printed on the flap of an envelope, this ink, under the influence of steam, changes colour. Consequently, a printer's inkling is given that the envelope has been tampered with by some Paul Pry or his feminine equivalent.

Non-slip Bowl for Pets

IN taking its food from a vessel placed on the floor, an animal is apt to push it about and spill the contents. A new non-spill combination food and drink bowl for dogs and cats has been contrived. This vessel will not slip nor tip on the smoothest waxed linoleum. A patented rubber base prevents it from skidding. The bowl has two compartments, each holding a quart. And this receptacle being made of Bakelite, there is no fear that Bonzo will have chips with his fish.

Anti-drip Gadget

WHEN the umbrella has been on duty in a pelting shower, it has a bad habit of treating the floor of a room as an umbrella stand. Therefore, an anti-drip catching attachment, which has been patented in the United States, will be acceptable. It consists of a hollow, resilient, cylindrical arrangement affixable to the umbrella in the neighbourhood of the ferrule.

Paper Bibs

THE bib has for many a long day shielded the dress of the babe from wayward diet. A patent for a newly-devised paper bib has been granted by the United States Patent Office. The bib has extensions arranged to encircle the neck of the juvenile, and glued on it are straight narrow strips of reinforcing paper. The youngster would be intrigued were this dress protector decorated with pictures of Jack Horner, Little Red Riding Hood and other characters dear to the natives of the nursery.

Medicine Musket

THE giving of medicine to children and animals requires a blend of coaxing and coercion. As regards the horse, the veterinary surgeon used to employ a bottle or a horn, which he inserted in the side of the horse's mouth. The contents of this container were sometimes evenly distributed between the internal economy of the sick quadruped and the sleeve of the operator.

But the modern horse doctor can avail himself of a veterinary dose gun, which has been patented in the United States. This comprises a tubular nozzle and a piston, and the medicine is fired, so to speak, into the throat of the four-legged patient. In using this medicine musket, the "vet" administers what may be termed a gun-powder.

Puncture Alarm

WHEN a tyre on a motor trailer goes flat, it is not at once apparent to the driver of the preceding vehicle. To summon attention to this defect, there has been devised a metal clacker which gives a definite warning to the driver that one of the tyres on the trailer has declined from its normal rotundity. The clacker is mounted on the rim, touching the tyre. As the tyre is deflated, it presses against the clacker and, with each revolution of the wheel, no uncertain sound informs the driver that something untoward has happened.

Brow Mop

THE primal curse upon the ground, making it necessary for man to earn his bread by the sweat of his brow, was a blessing in disguise. And the beads of honest sweat which bedew the forehead of the village blacksmith are intrinsically of greater value than the jewels that gem the crown of a monarch. But this sweat, which our refined Victorian forbears termed perspiration, is at times inconvenient. For instance, tennis players and other folks engaged in vigorous sport, not to mention the horny-handed sons of toil, find the tiny rivulets which meander across the features are apt to blur the vision. To dam these streams, a sweat pad has been devised and patented in the United States. This absorptive mop for the brow will prevent perspiration from cascading down the countenance.

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

Diffused Air-raid Warnings

IT is contended that the effective range of air-raid warnings, even when powerful, are limited. Less strident and more numerous alarms are said to be preferable. Acting upon this belief, an application has been made to the British Patent Office to protect an idea embodying the principle in question. It is pointed out that, when air raids are expected, normal lighting is extinguished. The lighting fittings are then available for audible alarms, and devices for these alarms may be adapted to be readily substituted for lamps. The alarm device is provided with a cap to co-operate with the lamp socket in a street-lighting fitting. And it is so constructed that it can be worked by the supply of electricity to which the socket is connected. One cannot predict that the arrangement will be generally adopted, but an important company has sponsored this alarming invention.

For the Modern Cicero

PUBLIC speakers are of two sorts. There is the born orator, whose eyes are not glued to a manuscript. He prepares his thoughts but relies upon the inspiration of the moment for the language with which he clothes them. Like an artesian well which bubbles up scintillating in the sun, his fountain of sparkling words rises to the delectation of the enraptured audience. But he is the exception. The average speaker, if he does not actually read his speech, depends upon notes, to which he makes frequent reference.

To help the latter type of spokesman, an invention has recently been submitted to the British Patent Office. It happens to be the conception of a subject of the German Reich, and is an apparatus for facilitating reference to a manuscript by a speaker. Lecturers generally use manuscripts which are either horizontal or upwardly inclined on their desks. From time to time, the lecturer glances at his manuscript. In so doing, his gaze is diverted from his audience. This means some loss of power over his hearers, as the eyes of an orator have a magnetic influence upon the rapt hearers whom he addresses. And his voice is less audible when he is looking down at his manuscript, because the sound direction naturally changes.

These difficulties, it is maintained, are overcome by the new appliance. The method consists in the manuscript being reflected into the direction of gaze of the speaker. It appears between the speaker and the audience in a reflector which neither hides him from the latter nor hinders him in any way. As a result, the manuscript can be read in the reflector without the lecturer having to turn his direction of gaze or speech from the audience during the whole speech.

Eloquent Reflections

AT this point the intelligent reader will naturally object that a reflected manuscript would appear in reverse. He is quite correct: the words would run like the writing Alice saw in the looking-glass. So, if there were only a single reflector, the manuscript would have to be written or typed like Hebrew, the lines of which read from right to left, in the manner that printers set up type. To obviate this, the inventor suggests that, as an alternative to the manuscript being à la mirror-writing, an auxiliary, reversing reflector may be interposed.

And so with this apparatus the speaker can administer to the public powerful reflections.

Fountain-Pen Seal

IT has been said that a bad workman quarrels with his tools. But an efficient tool is a necessary factor in first-class work. For example, Robinson Crusoe, with crude implements, could not produce the finished work of the well-equipped craftsman. This is certainly true of the pen. Take care of the pens and the writing will take care of itself, is a slogan which, if original, I present to "His Nibs" the pen manufacturer.

An improved self-filling fountain pen of the piston type has recently been patented. It is characterised by a piston adapted to slide in the barrel of the pen with a close and easy fit. Fluid tightness of the piston is secured by means of a groove containing mercury. With such a seal, it is stated that a much greater suction is obtained with a shorter stroke than is the case with a piston having the ordinary packing.

And so that tiny tubular pocket inkpot happily named the fountain pen, will not only resemble the shape of the column of the thermometer, but will also contain that sprightly metal commonly called quicksilver.

(*Continued on page 92*)

A STEAM-DRIVEN SPEEDBOAT

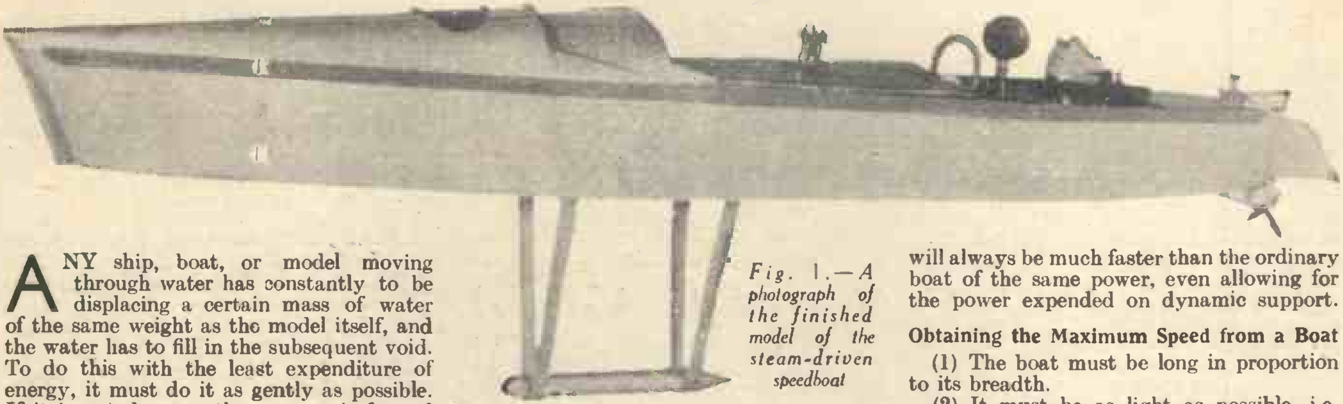


Fig. 1.—A photograph of the finished model of the steam-driven speedboat

Many Interesting Experiments can be carried out with this novel Speedboat, which incorporates a number of ingenious features in Design

ANY ship, boat, or model moving through water has constantly to be displacing a certain mass of water of the same weight as the model itself, and the water has to fill in the subsequent void. To do this with the least expenditure of energy, it must do it as gently as possible. If it is not done gently, a wave is formed on either side, indicating that energy is being wasted in raising the water above its normal level. These waves cannot be eliminated entirely, but it is the business of the naval architect to reduce them to a minimum.

In addition to this displacement resistance there is the resistance due to what is known as skin friction per square foot of wetted surface, and this resistance is proportional to the amount of wetted surface. It varies with the nature of the skin, i.e the substance of which it is made or with which it is coated. This resistance in the case of destroyers has been found to be:

At 12 knots	80 per cent.
At 16 „	70 „ „
At 20 „	50 „ „
At 30 „	45 „ „

These figures are taken from a standard work on marine engineering.

An Experiment with a Rotating Disc

A gyroscopic disc (with a certain string pull) was rotated for five and half minutes in air. With the same pull in water it spun for ten seconds only. The disc was then coated with a film of paraffin wax; it then rotated for twenty seconds. This experiment shows in a very striking manner how great this resistance can be, and how it can be lessened.

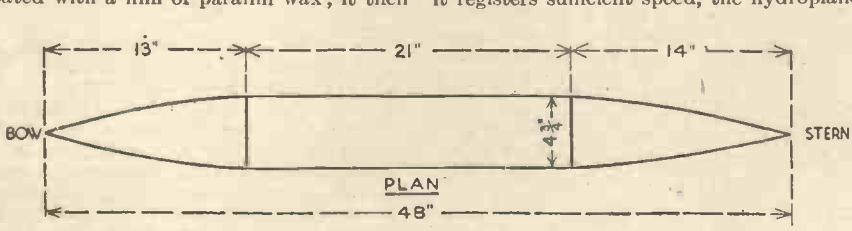


Fig. 2.—A plan and elevation of the sheer of the speedboat shown above

Hydroplanes

Why are hydroplanes so much faster than ordinary boats?

A hydroplane, or skimmer, is so constructed that it lifts itself out of the water when running, and actually displaces very much less water and has far less wetted surface than when at rest. To enable the boat to lift from the water, it must have a speed of about 16 knots, and unless this is the case this type of broad, flat-bottomed boat is not nearly so easy to drive through the water as the long and narrow type—say, the racing eight—whose length is from twenty-four to twenty-seven times its breadth. Water offers very little resistance to bodies moving slowly through it, but this resistance of inertia increases very rapidly with the speed; at high speeds (above 16 knots) it behaves more like a solid than a liquid.

The advantage of the hydroplane over the ordinary boat is greatly increased speed. In the boat, the power is employed in wave making and overcoming skin friction. The hydroplane, when travelling at speed, may have its wetted surface reduced by as much as two-thirds, leaving only one-third to produce skin friction—the displacement resistance having lessened in the same proportion. Thus, provided it registers sufficient speed, the hydroplane will always be much faster than the ordinary boat of the same power, even allowing for the power expended on dynamic support.

Obtaining the Maximum Speed from a Boat

(1) The boat must be long in proportion to its breadth.

(2) It must be as light as possible, i.e. displacement must be at a minimum.

(3) Its shape must offer minimum resistance, i.e. it must have a sharp cutting edge and a tapering form of stern to fill up the void without turbidity.

(4) Its centre of gravity must be as low as possible.

What type of boat best fulfils these conditions? In all probability (with the exception of No. 4) an eight-oared racing boat.

This type of boat has, of course, a high centre of gravity, and is balanced by the long oars of the rowers, but there is an easy method by which this can be overcome.

The Three Models

Three types of boat are dealt with in this article. The smallest one is 3 ft. long and has a maximum width of 4 in.; a cylindrical boiler, 12 in. long and 1½ in. in diameter; a special vapour lamp (to be described in detail later); and a Stuart Turner "Meteor" engine. It is carefully "lagged" to prevent steam condensation.

The torpedo-shaped body beneath is the keel, and all three models have such keels.

The long, narrow model is 5 ft. long and 3 in. maximum width. The plan, or horizontal section, is that of a racing eight.

The third model has a maximum width of 5½ in. and is 4 ft. long. It has a boiler, 1 ft. long and 2 in. in diameter; a Whitney engine, ⅜ in. bore and ⅜ in. stroke double-acting; and also a Stuart Turner lubricator and steam tap.

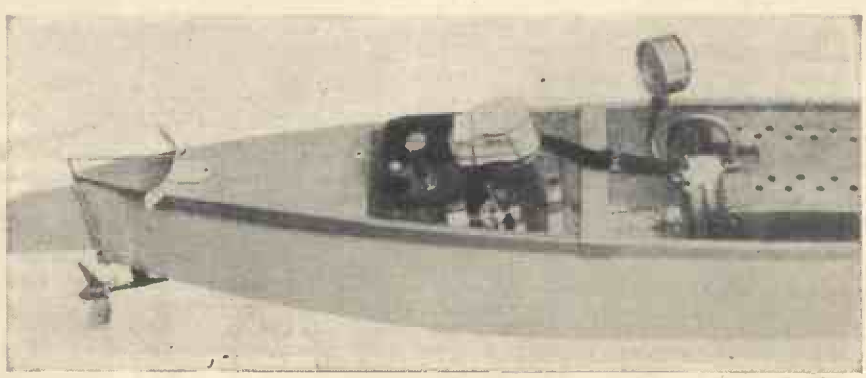


Fig. 3.—A close-up view of the engine of the steam-driven model

The long, narrow model is electrically driven by means of two 4-volt accumulators and an 8-pole motor geared down about 1 to 6.

The idea underlying the design of these keels is to lower the centre of gravity the necessary amount—on the principle of the lever—with the minimum of weight, a 1-lb. weight 4 in. below boat bottom being equivalent to 4 lb. 1 in. below it. Their torpedo shapes offer minimum resistance.

Results

Let us take the electrically driven model first. Various motors were tried and various dry cells. Finally the plant described above was installed. Unfortunately this was very heavy—each accumulator weighed 1 lb. and the motor $1\frac{3}{4}$ lb.—$3\frac{3}{4}$ lb. in all. The balancing-keel weight was $\frac{1}{2}$ lb., and had to be placed $6\frac{1}{2}$ in. below the boat. The hull weighed $\frac{1}{2}$ lb., and the result was that the boat was too deeply immersed for good results. Nevertheless, with freshly charged accumulators, using 8 volts, and favourable conditions, a speed of between 6 and 7 miles per hour was obtained.

The smaller of the steam-driven models, at a steam pressure of 80 to 100 lb., was capable of a speed of 8 to 9 miles an hour. This model, although not so deeply immersed as the long electric one, obviously suffered from an insufficient floatational capacity. The larger steam-driven model was capable of practically the same speed as the smaller, at a pressure from 60 to 80 lb. per square inch.

Its general behaviour was, moreover, far superior to the smaller one. So far as is known, these speeds are in excess of anything hitherto reached with a similar type of plant and size of boat.

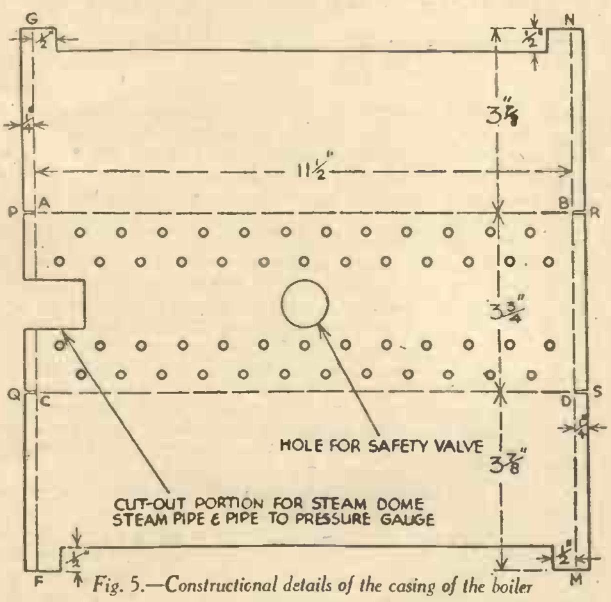


Fig. 5.—Constructional details of the casing of the boiler

Constructional Details of the Hulls

In the case of the steam-driven models the bottom is a piece of ordinary $\frac{1}{8}$-in. three-ply, cut to the shape shown in Fig. 2. The sides are $\frac{1}{16}$-in. three-ply, glued and fastened to the bottom with small gimp pins. At the bow and stern, V-shaped pieces of wood are fitted, to which the bottom and sides are glued and pinned. Round the top of the sides, from end to end, a strip of $\frac{1}{8}$-in. three-ply, $\frac{1}{2}$ in. broad, is fastened. The hull is further strengthened by one or two transverse pieces of L-shaped tin fastened to the sides. The hulls were given three coats of varnish and two of aluminium paint. Paraffin wax was run round the inside edges and V-shaped pieces at the prow and stern to make them thoroughly watertight.

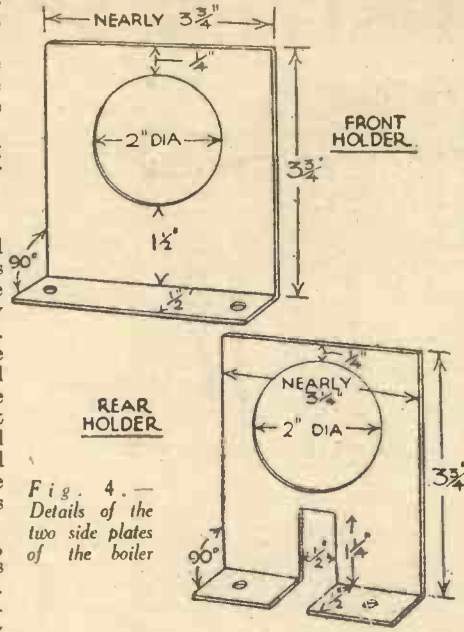


Fig. 4.—Details of the two side plates of the boiler

The hull of the long electrical model had a backbone or keel of wood, 5 ft. long with tapering ends, $\frac{1}{4}$ in. broad and $\frac{1}{2}$ in. deep. To this was fastened ribs cut from $\frac{1}{8}$ in. three-ply, and the shell was of three-ply, $\frac{1}{32}$ in. thick. A piece of $\frac{1}{8}$-in. three-ply, $\frac{1}{4}$ in. deep, was fitted to the top, on each side, from end to end. V-shaped pieces were placed at prow and stern. In every case V-shaped pieces of tin capped the bow and stern to give a knife-edge. Boats constructed as above are much stronger than would be supposed.

The Torpedo Keel

Having decided on the weight to be used, a piece of thin brass tubing should be cut and filled with molten lead (excepting $\frac{1}{4}$ in. at either end). Three small holes are drilled very near the two ends of the tube, having equal circumferential differences, and into these are fitted suitable turned or shaped pieces of wood to give the tapering forms at prow and stern. Screws through the holes as described above fix them to the tubing.

In the case of the electrically-driven model the tube was $\frac{5}{8}$ in. in diameter, total length 9 in., distance from bottom of boat $6\frac{1}{2}$ in., and weight $\frac{1}{2}$ lb.

In the smaller steam-driven model the tube was $8\frac{1}{2}$ in. long and $\frac{3}{8}$ in. in diameter; distance below boat $8\frac{1}{2}$ in., length 7 in., weight $\frac{1}{2}$ lb.

For the larger model the tube diameter is $\frac{3}{4}$ in., total length 7 in., distance below boat 7 in. and the weight, 1 lb. From a minimum resistance-point of view the first has the best proportions.

The Power Plant and Lamp

After considerable experimenting, two lamps of different design were constructed, both of which gave very good results. The first lamp, however, did not give quite so low a centre of gravity for the boiler, was not so easy to start, but had the advantage of simplicity. A vertical section of the lamp is shown in Fig. 6, and its construction is quite simple.

Obtain a piece of thin tin, $11\frac{1}{2}$ in. by $2\frac{1}{4}$ in., and bend a piece of thin sheet copper to the shape and dimensions shown in Fig. 6. Solder the two edges of the latter to the edges of the strip of tin (note the central rectangular portion must not quite touch the tin) and solder two rectangular strips of tin, one at each end, to the central rectangular portions of the copper. Make the joints fluid-tight, and then solder a piece of thicker copper over each end, having previously drilled two small holes, one at each end in the bottom of the copper. When spirit is poured into the central trough it will run through and partly fill the entire chamber. A number of small holes are drilled from end to end on the upper outside edge of the trough, and when the spirit in the trough is ignited the copper, a good conductor, is soon heated. Spirit vapour is thus formed, and, issuing from the holes, at once ignites. This lamp is to be preferred to any form of wick lamp and gives a far more intense heat. Owing to the narrowness and depth of the trough, the spirit is troublesome to ignite (especially in cold weather) unless it is poured in hot. It is heated by standing the container in boiling or very hot water.

The second lamp is shown pictorially in Fig. 6. It contains three distinct parts: an ordinary spirit lamp with wick, E; a chamber, F, in which spirit is boiled and evaporated, and from which a pipe leads to a piece of brass or copper tubing of rectangular $\frac{1}{2}$-in. section, closed at both ends. This tubing rests on the bottom of the boat, thereby giving the lowest possible centre of gravity for the boiler. In the top of this tube is drilled a large number of holes (fifty to sixty in number), using a 69- to 75-twist drill. They commence at A and continue to B, as shown. This lamp gives a steadier flame than the previous one, and

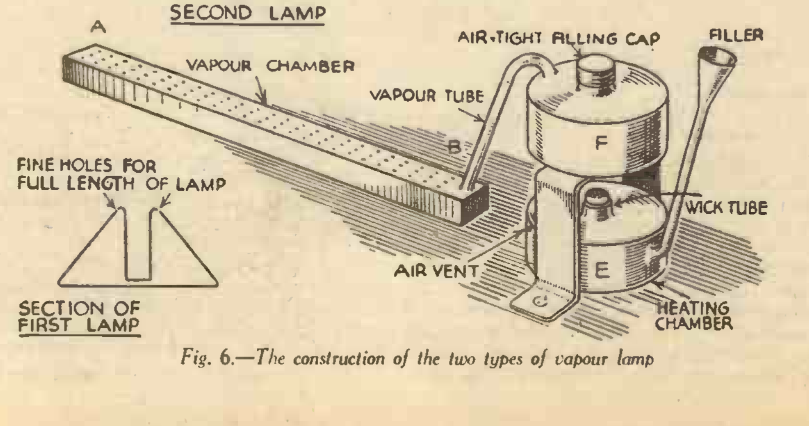


Fig. 6.—The construction of the two types of vapour lamp

can also be regulated by the flame of the heating lamp. It has only one disadvantage, however, for if the heating lamp wick is blown out it very quickly ceases to function. With this lamp, when once started, 6 oz. of cold water has been raised to a steam pressure of 60 lb. in ninety seconds. It generates steam sufficiently fast to keep up the pressure for the "Meteor" engine and for the larger ⅝ in. bore and stroke, the pressure falling very slowly with both engines going all out, and using a 2-in. propeller in both cases. The tins used for the lamps were made out of lower parts of old fruit tins, and only soft soldering was used throughout.

The dimensions of the various parts are as follows: For the larger model (see Fig. 6), the container, E, is 3 in. in diameter, 1 in. deep; container, F, 3 in. in diameter, 1¼ in. deep, and for the smaller model, E, 2 in. by ¾ in., F, 2¼ in. by 1½ in.

The actual amount of spirit to put in each is best found out by a few experiments, but E needs but little, and should not go on heating F after all the spirit is evaporated. There is very little actual pressure and no safety valve is needed; soft soldering alone will answer—but silver soldering makes the best job.

The Boiler

This must be brazed. Obtain a piece of copper or brass tubing of about 18 gauge and of a suitable length. Blanks are required for the ends, a heavier gauge should be used for these, say 16, or even 14.

To provide the dry steam you must have a steam dome and a safety valve. They can be bought from 3d. up to 5s. 6d. and it is certainly advisable to use a good one. The same hole into which this screws is, of course, used to fill the boiler, which should be filled not more than two-thirds full. A 2-in. boiler, 12 in. long, holds 16 oz. of water. A pressure gauge is essential and if using a vertical engine it is essential to use a lubricator.

To mount the boiler cut two pieces of thin tin to the dimensions shown in Fig. 4, and bend as shown. The 2-in. hole can be cut with an ordinary 2-in. centre bit. They are then placed one at each end of the boiler, allowing about ½ in. to protrude. They should be a good fit, their upturned portions being screwed to the bottom of the boat.

The Casing or Cover

This is of thin tin cut to the dimensions shown in Fig. 5 and bent to shape. It is essential to line the sides with thin sheet asbestos inside. A similar sheet of asbestos is placed on the top of the boiler—slightly curved and with the necessary holes for the safety valve, etc. Any additional corner or end pieces of tin that may be necessary to thoroughly shut in the flame must be fastened on with very small nuts and bolts; soldering is useless.

The safety valve (if spring is external) must be protected from the flame or its temper may be spoilt. Asbestos-lined caps should be fitted over the ends of the boiler to prevent radiation.

To obtain the best results, careful lagging of the pipe conveying steam from the boiler to the engine and of the engine itself is essential. To do this, place pieces of asbestos in a saucepan containing a small amount of water and boil, at the same time pounding the asbestos to a pulp. Now squeeze it in a cloth and apply round the pipe, etc., afterwards binding with tape. The slide valve and cylinder of the engine should be similarly treated.

The boiler and container F, especially the bottom, soon become coated with a deposit of carbon—a powerful non-conductor of heat; therefore they must be frequently cleaned.

OUR BUSY INVENTORS

(*Continued from page* 89)

Accommodating Leg-wear

A SWISS citizen has applied for a patent in this country for an invention relating to trousers. The specification describing his device states quaintly that it is meant for "sports people," i.e. cyclists, mountain climbers, gymnasts, walkers, etc., who possess both long and short trousers. It adds that there are "sports people" who, for financial reasons, can acquire only one of these two kinds of trousers. The inventor provides trousers which will play the role of both the abbreviated and the elongated variety of nether garments. The legs are divided, and can, consequently, be used as shorts. But, if desired, an additional length may be affixed. The connecting means may be slide fasteners or hooks and eyes.

Station Indicator

SOME time ago I stressed in these columns the desirability of an indicator in railway coaches to inform the traveller at what point the train had arrived. There has now been patented in the United States a station indicator comprising a movable web having thereon the names of the stations in the order in which they appear. An electric motor causes this indicator to function. It should relieve the oft-puzzled passenger from the necessity of picking out the name of his destination amid the crowd of advertisements which surround it.

Stream-lined Turkeys

CHRISTMAS is coming. The season is festive but, from the point of view of the turkey, it is tragic. It seems that the full-sized bird is too huge for many small ovens. To overcome this difficulty, I learn from an American source, that, instead of seeking an expanding oven to suit the varying dimensions of the turkey, it is the aim of certain breeders to produce a bird of less ample proportions. The object is to cater for families which are not so large as that of the lady whose residence was a shoe.

A Wooden Hat

THE present year is the centenary of the death of William Murdoch, the inventor of gas for illuminating purposes. After arriving in England from Scotland, where he was born, he altered the spelling of his name from Murdoch to Murdock on account of the inability of Englishmen to give it the true guttural pronunciation. In his early days Murdoch, in the course of an interview with a prospective employer, owing to nervousness, dropped his hat upon the floor. The peculiar sound made by the fall excited the curiosity of the gentleman he was interviewing. Murdoch then revealed the fact that the hat was made of wood. He had turned it on a lathe of his own making. But, although his hat was made of wood, his head was not composed of that material, for his ingenuity conceived many valuable inventions.

* * * *

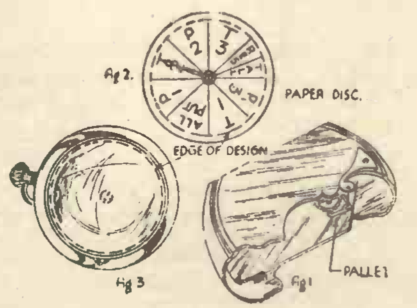
Tilley Products

NOW that restrictions have been placed on electricity and coal, the Tilley paraffin radiator will prove ideal for warming small rooms and is especially useful where heat is only temporarily required. As it is portable and independent of connections, it can readily be moved from room to room, and being a radiant heater, its effect is felt immediately. It will give six hours' heat for one penny per burner, and the container holds sufficient paraffin for ten burning hours. The radiator is 17 in. high, has a 12½-in. reflector and weighs 3¾ lb. It costs 37s. 6d. If you require a larger size of heater, there is the Tilley two-burner radiator costing 72s. 6d.

This firm also have a large range of paraffin lamps, an interesting line being the storm lantern at 36s. It is strongly made with no parts to rust or corrode, burns steadily, and is unaffected by weather however severe. The burner hood has a small reflector which prevents rain falling on the globe.

A Watch "Put and Take"

THE materials required for making this simple device are a cheap watch, a sheet of thin notepaper, and some water colours. Remove the back of the watch and carefully remove the escapement (see Fig. 1). This will allow the hands to spin round when the watch is wound up. Next remove the front of the watch, take off the hands, and remove the dial. A circle should then be cut from the notepaper (the size of this circle being effected in accordance with the size of the original dial, and ruled off into eight sections as shown. These sections should then be coloured and the printing



A novel game made from an old watch

done in accordance with the illustration. P represents the word "put" and T "take." Res. means "re-spin" and T. All being "take all." It is advisable to paint the sections up to the dotted line as in Fig. 2, the reason being apparent on referring to Fig. 3. Now stick the paper disc on the front of the watch (after making a small hole for the hand "drive"), replace the minute hand only, and finally the casing.

Should the watch have an unbreakable celluloid cover (not glass), this will be an asset, since by slight pressure of the thumb (to prevent the hand turning), a good wind can be affected and consequently a good spin attained on removing the thumb.

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

A Special Enamel

IS it possible to make an enamel capable of resisting the action of sulphuric acid, and would this need any special undercoat if used on wood?—N. J. (Essex).

UNFORTUNATELY, you do not say to what strength of sulphuric acid you wish your enamel coatings to be resisting. It is impossible to obtain an enamel which will resist the action of concentrated sulphuric acid over long periods, but with sulphuric acids of lower strengths (say up to thirty per cent. or even more) any enamel containing bitumen will be sufficiently resisting. You can prepare such enamel by making up a strong solution of bitumen in turps and by adding it to any ready-prepared enamel in such quantity that it does not thin down the latter too drastically. The woodwork should be given three or four coats of this enamel, each coat being allowed to dry thoroughly before applying the next.

"Anti-sulphuric enamel" of this type is a commercial commodity and may be obtained from the leading photographic supply houses, as, for instance, Messrs. Jonathan Fallowfield, Ltd., 61-62, Newman Street, London, W.1. or from Messrs. May and Baker, Ltd., Battersea.

The enamel prepared as above will not need any special under-coating, although a preliminary thin coat of priming paint will do the woodwork no harm.

We would warn you not to expect too much of these anti-acid enamels. They are, of course, quite satisfactory for dilute acids, but strong mineral acids quickly attack them.

Zinc Oxide Adhesive Plaster

WHAT is the recipe for the zinc oxide adhesive plaster used on surgical tape?—K. A. (Middlesex).

YOU can make zinc oxide plaster for spreading on tape in two ways :—

(a) Make up a mixture of olive oil and zinc oxide, employing somewhat more olive oil than zinc oxide. Allow it to stand overnight and then heat it on a water bath for two hours. On cooling, it will set to a white adhesive mass.

(b) Dissolve 1 oz. of powdered Castile soap in 20 ounces of water and add this to a moderately strong solution on zinc sulphate. A white precipitate, consisting mainly of zinc oleate will be formed. This should be filtered off, washed with cold water and allowed to dry. It can be spread on tape and will retain its adhesive condition indefinitely.

Remember, when spreading the plaster material on the tape, that only the thinnest possible layer of it is required.

A Direct Explosion Pump

I HAVE designed and built a direct explosion pump to work on coal gas, but so far I have not met with any success as I could not get the gas to ignite. I am using the hot-tube principle for ignition and the gas is at atmospheric pressure. I am certain that once I can get an explosion, the valve I have designed for controlling ignition and inlet gas will work.

Could you suggest any reason why the gas does not explode, or any other means of ignition?—G. G. (Hull).

THE failure of the gas to explode in your pump must be due to one (or both) of two reasons: viz.—the gas-air mixture may not be of the correct proportions and the ignition tube which you are employing may not be hot enough.

For an effective coal-gas explosion you require a mixture containing about twelve parts of air to one part of coal gas. If the mixture is too rich in coal gas or too deficient in it, it will not fire. Also, the ignition tube must be heated to a bright cherry-red heat. Preferably, it should be made of nickel alloy, or, better still, of platinum, which enormously facilitates the ready ignition of the mixture.

Without being acquainted with the design of your engine, it is practically impossible for us to offer detailed suggestions concerning it, but we incline to the opinion that you would have more success with it, if you could discard the hot-tube method of ignition and rely upon electrical ignition by means of a spark derived from an induction coil or a high-tension magneto. Possibly, though, you may have very special reasons for sticking to the hot-tube method of ignition.

In general, however, provided that your gaseous charges have an approximately correct composition and, also, provided that your ignition tube is maintained at a sufficiently high temperature, you should certainly experience no difficulty in getting the gas to explode.

IMPORTANT NOTICE

Owing to the restriction of paper supplies in war time, readers may find it impossible to get "Practical Mechanics" each month unless they give their newsagent a regular order for their favourite magazine, now.

Wastage of surplus copies in the shops must be avoided, and readers can be of the very greatest help if they will fill up the Order Form given on page 88 and deliver it to their usual newsagent or bookstall. An order of this sort ensures regular delivery during war time, and the Editor asks every reader to help in this way.

PLEASE ORDER "PRACTICAL MECHANICS" NOW AND USE THE ORDER FORM ON PAGE 88

Colouring Concrete

I HAVE some pure white cement which I wish to tint blue and grey. Can you tell me of a non-fading blue or grey pigment to use?—E. H. (Bucks.)

YOU do not mention the exact purpose for which you wish to use the coloured concrete. Hence, we cannot advise you upon the precise details of its mixing. However, an average mixing of dry Portland cement and fine sand (approximately equal proportions of each) may be coloured by incorporating with it a suitable insoluble pigment in amount proportional to the depth of colour required.

For black or grey colourations, ordinary lampblack mixed with a little finely-powdered pyrolusite or manganese dioxide will give the effect required, this pigment being absolutely permanent.

The most permanent blue pigment which you can employ is Cobalt blue, which has a rather greenish shade and which is expensive. Ultramarine is a good blue, but is not resistant against water containing traces of acids. Lime blue is a cheap pigment and may suit your needs. None of these blues, of course, possesses the same degree of permanence to light and other influences as common lampblack, and for use as a concrete pigment in an exposed position we should say that an absolutely permanent blue does not exist.

"Catalyst"

I UNDERSTAND that a "catalyst" is a metal that has the power of assisting other chemicals to interact, merely by their presence, without entering into the reaction themselves. Is this correct?

Assuming that the above is right, could you give me a list of metals that have "catalytic" properties?

Could you give me an address or addresses where I could obtain such metals?—F. M. (Hants).

A "CATALYST" is a substance, not necessarily, but usually, a metal in "finely-divided" or powder form, which initiates or accelerates a chemical reaction, but, so far as we can tell, does not itself actually take place in the reaction. Your definition of "catalyst" (which, incidentally, is itself a pretty meaningless word) is correct.

As a typical example of a catalyst, let us take platinum, in finely-divided form. When oxygen and sulphur dioxide are heated, they do not combine. When, however, these gases are passed over heated platinum in a finely-divided form, they combine almost completely, forming sulphur trioxide, which can afterwards be combined with water to form sulphuric acid. This is a very important example of catalytic action and forms the basis of the present-day "contact process" for the manufacture of sulphuric acid. Note, however, that iron oxide has a similar catalytic effect and hence that a catalyst need not necessarily be a metal.

The metals which are most used on account of their catalytic properties are platinum, palladium, tungsten, mercury, iron, nickel, vanadium. All these are employed in "finely-divided" form. Well-known non-metallic catalysts are iron oxide, nickel oxide, ammonium vanadate, manganese oxide, manganese sulphate.

You can obtain any of the above materials (to order) from your local branch of Boots the Chemists or from a chemical supply firm such as Messrs. Harrington Bros., Ltd., City Road, London, E.C.

D.C. Motors on A.C.

IS it possible to run a 200 volt, 0.5 amp, continuous current motor on a 240 volt alternating current circuit?

I understand that A.C. can be used to drive ordinary D.C. motors so long as they are not very large. My attempt to do so with a motor of the specification given above has, however, proved unsuccessful. It may be that the motor itself is faulty.—H. W. (Bethnal Green).

WHETHER a direct current motor will run on alternating current depends upon the type of winding. A series-wound commutator-type direct current motor will operate on A.C. fairly well, but will not develop the same amount of power, and the speed characteristic will be much steeper, that is the speed will fall off more rapidly with increase of load than when used on D.C. Also it is essential that both fields and armature should be laminated, otherwise considerable overheating is likely. With a shunt wound D.C. motor, however, the case is different. Since the armature and the field circuits are independent of one another and the self induction of the field winding far greater than that of the armature, the lag in magnetisation of the fields is so considerable that armature and field currents do not arrive at their maximum value at the same time, one being near zero value while the other is at maximum, consequently there is little or no torque.

Wind Motor for Fountain

I intend to erect a wind pump for the purpose of pumping water up into a tank of 28 gallons capacity and 9 ft. in height.

The wheel consists of twelve vanes, each having an area of 15 square in. and being included to the plane of motion at an angle of 35 degrees. The total diameter of the wheel is 30 in. and it will be 9 ft. high. The water from the tank will be used to work a small fountain. Could you let me know the following :—

1. What size pump (single acting) this mill would work?

2. Whether this size pump will keep the tank supplied with water?—H. G. (Doncaster).

IT is always difficult to estimate the power available from windmills of the type shown in your drawing, not only because of the variable nature of the wind velocity but also on account of the suitability of the site chosen and presence of any deflecting obstructions. One cannot expect very much from a wind vane 30 inches in diameter on a tower only 9 ft. high, but the nearest estimate that can be given as to the pumping capacity assuming a moderate wind velocity of 20 miles per hour with a pump of 2 in. bore and 4-in. stroke would be approximately 60 gallons per hour. Whether this would keep your 28-gallon tank fully supplied depends entirely upon the discharge rate from the fountain jet, a matter for experiment alone. According to "Molesworth," a circular vane-type mill of 12 ft. diameter working in a wind velocity of 15 miles per hour would only develop ¾ h.p., and on the assumption that the power developed is approximately proportional to the square of the respective diameters of the wheels the ratio would be 144 to 6.25, indicating that the maximum output from your 30-inch mill would only amount to a trifle over one hundredth horsepower.

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