PRACTICAL MECHANICS AND SCIENCE

JAN 1963

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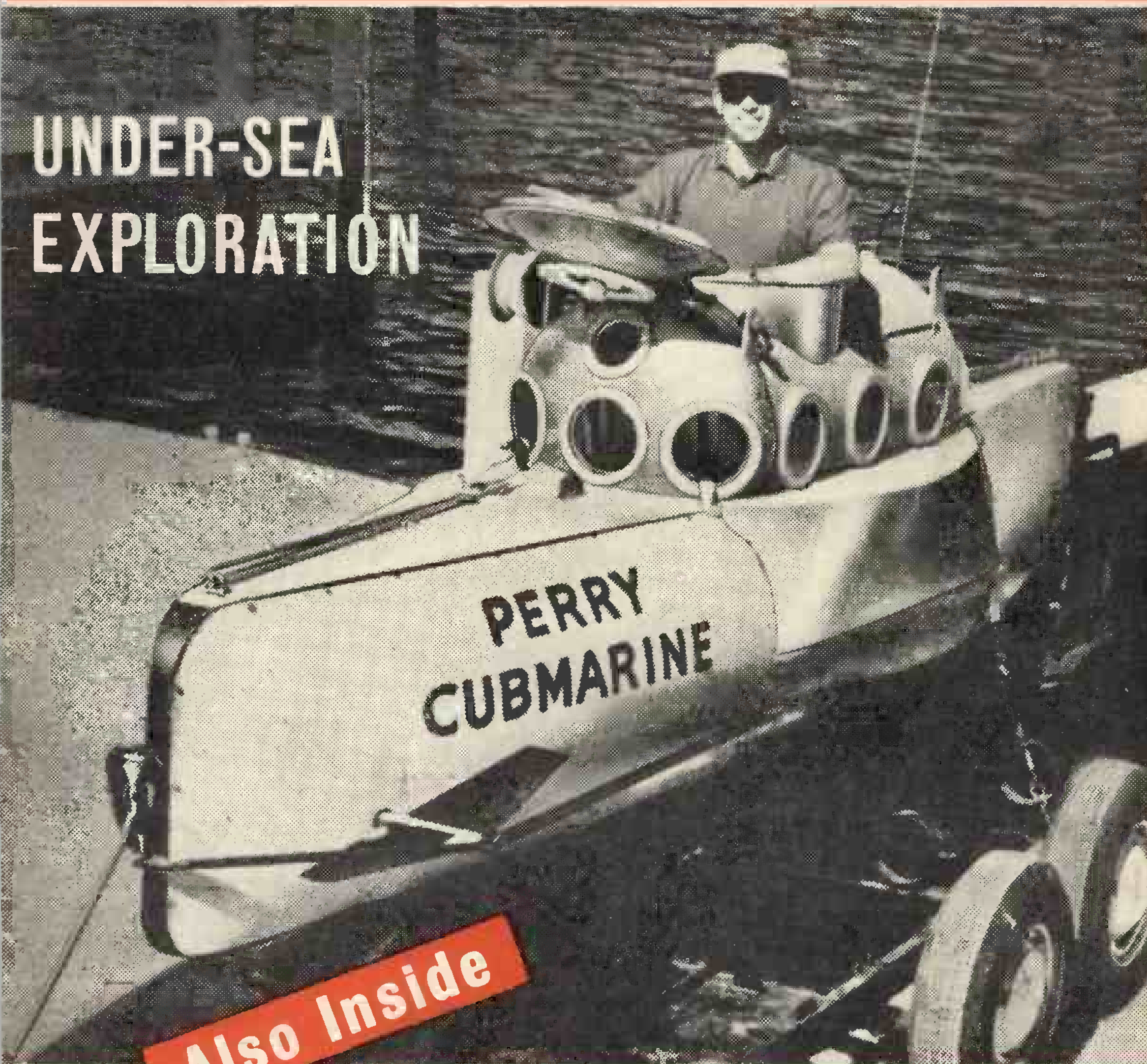

Also Inside

MAKING A MITRE CRAMP
AN ELECTRIC GAS LIGHTER
DEVELOPMENT OF SKYBOLT

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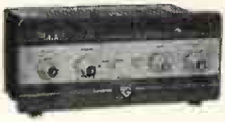

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0-12U

S-99

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PRACTICAL MECHANICS AND SCIENCE

Vol. XXX January, 1963 No. 345

Editorial and Advertisement Offices
"PRACTICAL MECHANICS AND SCIENCE"
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Phone: Temple Bar 4363
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CONTENTS

CONTRIBUTIONS

The Editor will be pleased to consider articles of a practical nature suitable for publication in "Practical Mechanics and Science". Such articles should be written on one side of the paper only, and should include the name and address of the sender. Whilst the Editor does not hold himself responsible for manuscripts, every effort will be made to return them if a stamped and addressed envelope is enclosed. All correspondence intended for the Editor, should be addressed: The Editor, "Practical Mechanics and Science", George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2.

TALKING POINT

Exploration of Tottan Mountains

MEMBERS of the British Antarctic Survey who are to take part in a concerted drive to open up the almost unknown Tottan Mountains area of Coats Land for further exploration, sailed from Southampton recently.

They are among a party of 19 scientists and technicians sailing from Southampton aboard the M.V. KISTA DAN on her fourth Antarctic voyage under charter to the Survey. Nearly all the party will be going to Britain's most isolated Antarctic station—the geophysical observatory at Halley Bay. This is the largest of the British Antarctic bases and stands on the coastal ice shelf of the Caird Coast.

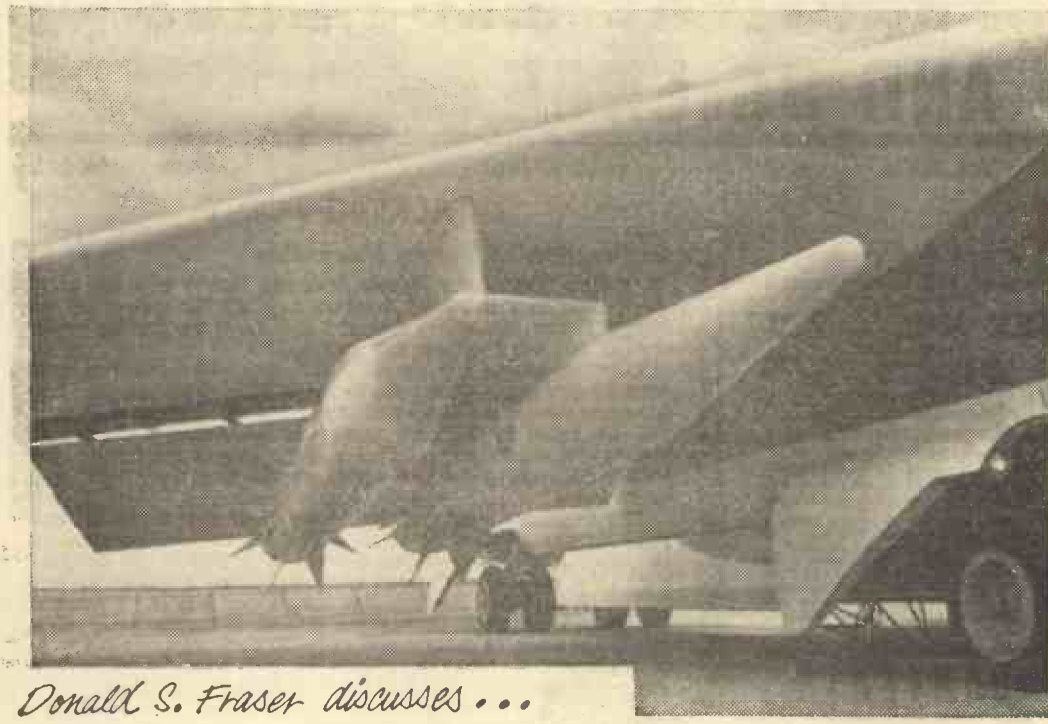
The enormous weight of the mantle of ice that covers the south polar continent—often up to 10,000ft thick—presses outwards continually so that there is a slow but relentless flow in the ice causing the coastal ice shelves to move seawards. Since it was set up at the end of 1955, Halley Bay base has moved over a mile. Members of the British Antarctic Survey are making a special study of this movement since, to make use of scientific observations taken as part of the base's geophysical programme, it is essential to know the exact location of the spot from which readings are taken.

Inland from Halley Bay there stretches a tremendous network of crevasses, separating the floating ice shelf from the mainland ice and, until the end of last year, the land away from the coast seemed to be impassable. But, after two years of intensive reconnaissance by men from Halley Bay, Colin Johnson and Dennis Ardus thrust inland with a dog-sledge across a vast expanse of towering ice cliffs and deep crevasses and reached the Tottan Mountains over 300 miles from the base—early in December, 1961.

Until then, the Tottans had never been approached from land; the mountains were discovered by Sir Vivian Fuchs during an aerial reconnaissance in preparation for his successful Commonwealth Trans-Antarctic Expedition. The success of the trek made by Johnson and Ardus, however, has encouraged the Survey to prepare for a larger-scale expedition into the Coats Land interior and already a supplies depot has been laid about 100 miles inland from Halley Bay by base members using dog-teams. During the coming months they hope to lay further depots in preparation for the beginning of the Antarctic summer, next October. Then, a large party of scientists and technicians are to set out for the Tottan Mountains, mapping the uncharted wastes and studying the geology of the area. This expedition will travel by dog-sledge, motor toboggan and track-laying vehicle. One of the tracked vehicles will be fitted with an ice-depth radio recorder, designed at the Scott Polar Research Institute and now under development in the field. This instrument, used for measuring the depth of ice below the feet of the expedition, down to the rock of the antarctic continent, eliminates point-to-point echo sounding observations and provides a continuous trace over the whole traverse undertaken by the vehicle.

Halley Bay base is reached by specially-strengthened ships that have to force their way through 700 miles of pack ice into the Weddell Sea. Aboard the KISTA DAN will be Michael Thurston, who will make a census of seals on route. He will also be making special zoological collections to augment those now being studied.

The Feb. 1963 issue will be published on Jan. 31st, 1963. Order it now!



Donald S. Fraser discusses . . .

The Development of

BAN the Bomb demonstrators are very much in the news these days. However much authority may sympathise with the public's reaction to nuclear-powered weapons, present policy demands that a sure-fire Western deterrent must be perfected for the future protection of civilisation.

Few people here in England realise to what extent these protection measures have gone. They are aware, of course, of the H-tipped Polaris rocket which is fired from an atomic-powered submarine. This weapon has been in the news as five of the nine existing Polaris-firing submarines are based at Holy Loch in the Firth of Clyde. Forty-one of these vessels are to be commissioned eventually, all of which it is expected will be committed to NATO command by the Americans.

Britain and America are closely allied in defensive emergency systems. Soviet missile bases, and other installations which might threaten the American and European continents at any time, are continuously covered. In view of which, a quick glimpse at some of the deterrent weapon systems at our disposal might be in order. One firm in the United States, for instance, recently produced its 40,000th missile, when a Thor space booster rolled off the assembly line. Thor is already deployed currently in the United Kingdom as a tactically ready deterrent IRBM weapon. Among the 40,000 were the Genie, Honest John, Nike Hercules, Nike Ajax, Nike Zeus, and Skybolt, in addition to the reliable Thor. The first missile produced by this firm, the Douglas Aircraft Company, was a Roc 1 (which flew along a guided beam somewhat crudely) some 22 years ago. The newest rocketry project is the development of the S-IV stage of the Saturn vehicle that will send men to the moon.

The missile in which Great Britain is currently interested is the Skybolt air-launched ballistic missile. This weapon will give both the Royal Air Force, and the United States Air Force, a system of major proportions through its ability to deliver a nuclear weapon from a highly mobile and nearly undetectable launching point. Launched from the R.A.F. Vulcan aircraft or the USAF B-52, Skybolt is designed to blast to a ballistic trajectory above the atmosphere, and race at hypersonic speeds to any predetermined target approximately 1,000 miles away. Among the many advantages of such a weapon system are its ability of remaining aloft on alert status within relatively close range of an aggressor; its invulnerability to destruction by surface-to-surface ballistic missiles. Its ability to remain "hidden" from an aggressor presents a formidable block to surprise attack plans.

It was the rapid growth of missile technologies, during the latter half of the last decade, that

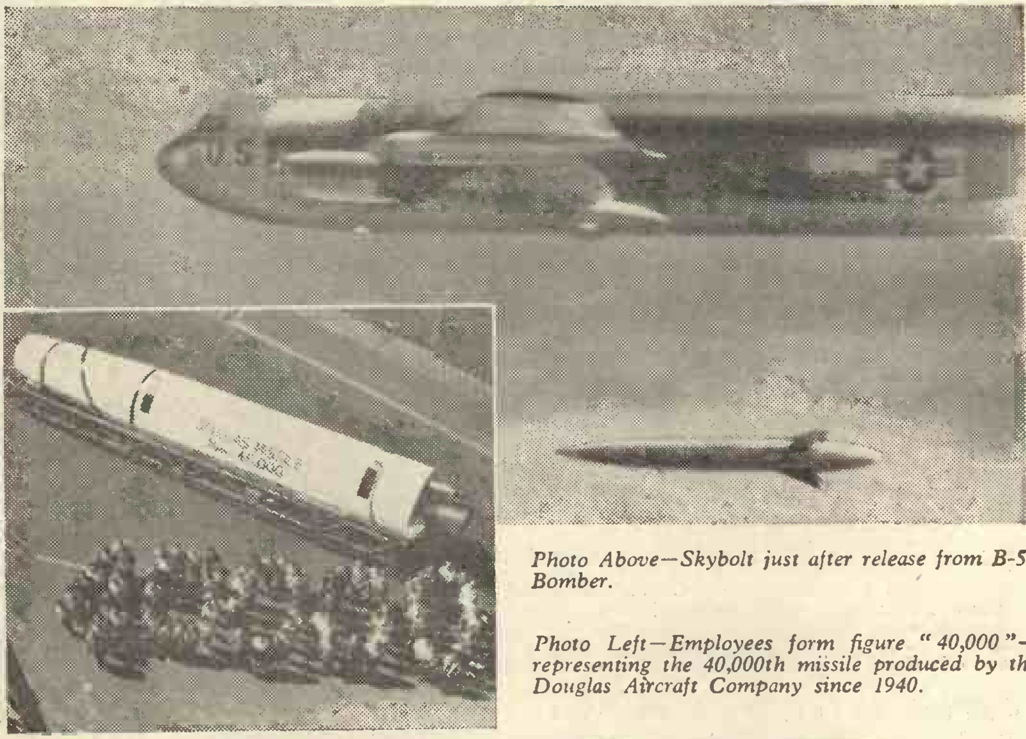


Photo Above—Skybolt just after release from B-52 Bomber.

Photo Left—Employees form figure "40,000"—representing the 40,000th missile produced by the Douglas Aircraft Company since 1940.

SKYBOLT

prompted the USAF to initiate a study programme aimed at the development of a long range, air-launched missile system. In May, 1959, the U.S. Air Development and Research Command, awarded a contract to Douglas Aircraft to develop an air-launched ballistic missile (ALBM) system. Douglas then awarded a sub-contract to Aerojet-General Corporation for the development of the Skybolt propulsion system; General Electric received a contract for the re-entry vehicle; Nortronics Division of Northrop was awarded the guidance system contract. During the early stages of the missile's evolution, Boeing Aircraft Co., and A.V. Roe Co., the firm which builds the Vulcan, assisted Douglas in developing the Skybolt system to be compatible with the B-52 and Vulcan bombers. Other major contractors and government agencies were called upon to participate in additional phases of the programme. Engineering and development activities on the Skybolt system, now in the advanced stage of development, have proceeded on schedule. Major test milestones already passed include first development engineering inspection, firings of the first and second stage engines, flights of inert test missiles aboard a B-52, separation tests from the Vulcan and B-52 bombers, and live launchings. Maximum range guided launches, to prove Skybolt's accuracy and range, are scheduled for later this year.

Getting a Skybolt air-launched ballistic missile tucked under the wing of a B-52, or Vulcan, for a test flight down the Atlantic Missile Range, involves assembly and checkout phases that extend across the United States. Behind-the-scenes activity in realising the successful live launch of the Skybolt starts in Southern California, where the missile airframe and component parts are fabricated. These are sent to Sacramento, California, for installation of the motor by Aerojet-General Corporation. Further processing is carried out at the Douglas Sacramento Field Station, from where the missile sections are shipped to Elgin Air Force Base, Florida. Here the last, and one of the most important, phases is carried out. This is the home of the Air Proving Ground Centre, where the Douglas Skybolt field station is located. The Douglas installation at Elgin consists of three large buildings, one housing the headquarters and the other two, the assembly facilities. Elgin is a sprawling base, and it is about five miles from the front office to the "hardstand", where the Skybolts are mounted on the bombers. It's a bustling place these days, with 205 engineers and technicians, and 50 associates, representing the Air Force and major contractors in the Skybolt programme, busy with the final

(Continued on page 165)

LATHE GADGETS

Part 13

D.T.I. Fixtures 2

by L. C. MASON

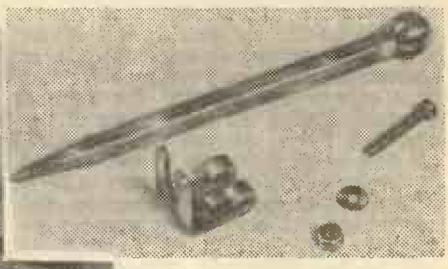
THE fixtures described last month for use with the Dial Test Indicator made it very simple to apply that useful workshop item in the accurate setting up of work in the lathe, either by reference to a turned surface, a flat face, or a bored hole.

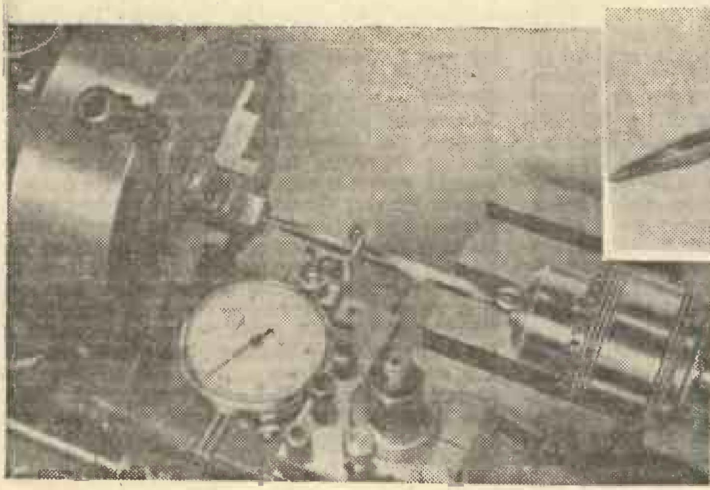
Quite often it is required to have a particular point on a surface central, and it may not perhaps be obvious at first sight how one can "clock" something like a centre-punch dot. Nevertheless this is equally simple—probably to a higher degree of accuracy than is possible in locating the centre pop itself on the job. The pop mark to be centred is used as one end bearing for a pointed bar, the other end of which is supported about a point fixed on the lathe centre line. Any eccentricity of the pop mark on rotation, produces a swing on that end of the bar lodged in it, and it is this movement of the end of the bar which can be shown up—and measured if necessary—by the indicator.

The components are extremely simple, the bar being merely a short length of $\frac{3}{16}$in. square silver steel. One end is pointed to engage the centre pop, while the other is supported by a tailstock drill chuck. This end is fitted with a ball, allowing it to pivot while the pointed end is following the circular path of the eccentrically mounted centre pop. A clip mounted on the bar loosely embraces the clock plunger and serves to prevent the bar from turning, so that it always presents a flat side to the tip of the plunger.

Very little work is required on the bar. Mount a suitable length to run truly in the four-jaw chuck and turn a gentle taper on one end. The angle is not at all critical; for the one shown, the taper of a scriber point was copied by eye. At the extreme point turn the tip very much more obtuse, matching as nearly as possible the angle of the centre punch point used for centre popping the job. Reverse the rod in the chuck and turn the other end to a diameter of $\frac{3}{16}$in. for a distance of $\frac{1}{4}$in. or so. Thread the round portion 2B.A. Remove from the chuck, harden the point dead hard and clean up.

The screwed end of the bar fits into a ball. A ball-bearing $\frac{1}{2}$in. or so in diameter can be used for this. The local garage can probably produce a scrap ball race from a car or lorry back-axle, providing several balls of a suitable size. The one shown was obtained that way, and is actually $\frac{7}{16}$in. in diameter. Anneal the ball by heating it to dull red and letting it cool very slowly. This can most easily be done by dropping it in a bright patch in the fire last thing at night and leaving it overnight. It will thus heat up and then "soak", cooling slowly till





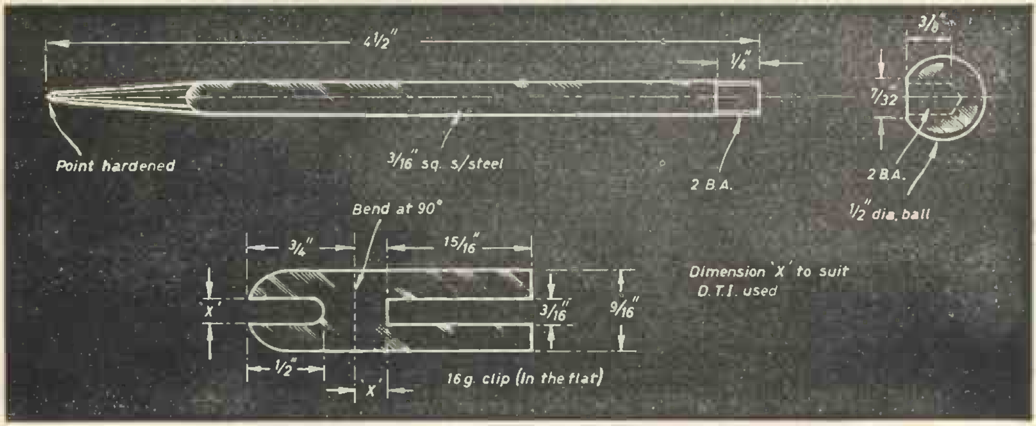
The D.T.I. fixture for centring pop marks, in component form and set up for a typical job.

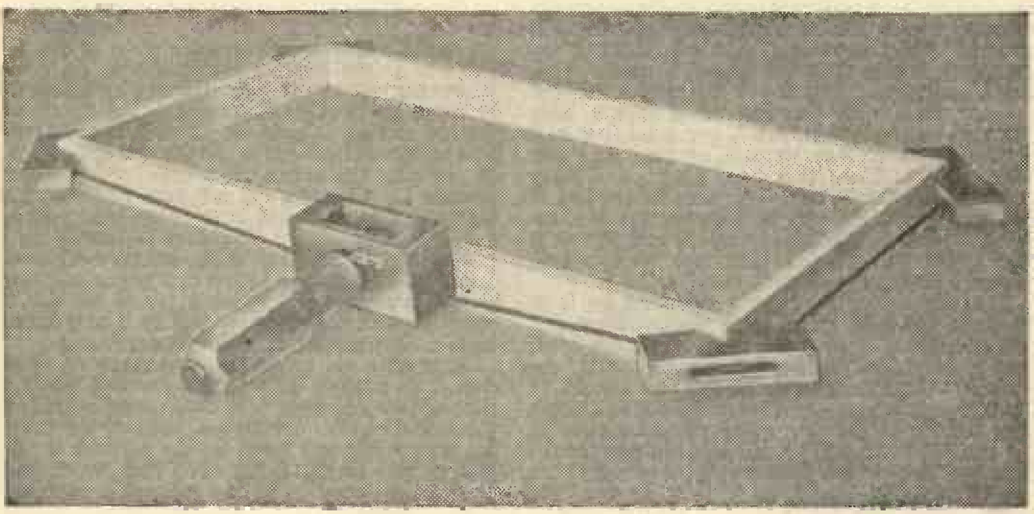
morning. Warn whoever does the fire in the morning that it will be amongst the ashes, and is wanted! After retrieving the ball, clean it up roughly and grip it in the three-jaw chuck. Face a flat on it about $\frac{7}{32}$in. across, and drill a hole for tapping 2B.A. As the ball is of pretty hard material, even when annealed, use a tapping drill somewhat larger than normal, or you may risk breaking the 2B.A. plug tap. Quite a shallow thread will suffice to hold it in place on the end of the bar. Screw the ball in place on the bar, re-chuck the bar in the four-jaw chuck, ball outwards, and polish up the ball with fine emery cloth. There is no need to attempt to re-harden it.

The clip should be cut out and filed up from 16 gauge (or $\frac{1}{16}$in. thick) steel plate. Anneal this too, to avoid a crack at the sharp 90 degree bend. The square-ended slot fits over the bar, whilst the ends of the clip each side of this slot should be curled round to fit a $\frac{1}{8}$in. Whit. (or 5B.A.) bolt which nips the clip to the bar. Make the slot a close fit for the bar, so that this small bolt can provide the light pressure needed. The round-ended slot in the tail of the clip should be a slack fit over the plunger of the indicator, as a slight movement in all directions takes place between the two.

When once a convenient spot has been found for the clip along the bar, the clip can be left there more or less permantly, moving it only at the requirements of some special set up. It will be obvious that the amount of movement shown by the clock will be less than the actual movement of the point, owing to the leverage effect of the bar. For this reason, the nearest reading to the actual movement will be shown on the dial by having the indicator set as close as possible to the chuck, and the bar as long as possible. Thus it is mainly the size of the indicator that determines the position of the clip, the length of the slot giving a little latitude for adjusting the indicator position. The indicator plunger should be at centre height, or the tail of the clip will be tilted over sufficiently for it to bind on the plunger. While accuracy is slightly improved by having a long bar, a reasonably short one as shown will be found to do all that is required, with the advantage that its light weight is more readily supported in a light centre dot.

In setting up, locate the pop mark as nearly central as possible by eye. Fit the drill chuck in the tailstock and open it to about three quarters of the ball diameter. Locate the point of the bar in the centre pop and bring up the tailstock for the ball to ride in the partly open drill chuck jaws. Only a light pressure by the tailstock is necessary; the bar should be quite free to turn, but with no end play. Mount the indicator in the toolpost at centre height, feed it forward with the cross slide till the needle begins to register on contacting the bar, then sideways with the saddle movement, guiding the tail of the clip over the plunger.





A Woodworker's MITRE CRAMP

This useful addition to your workshop equipment is described

by G. A. WARD

THIS mitre cramp is mainly for picture framing, but for holding any box-like structure together for glueing, checking etc., its help is invaluable. The tool is easy to make, has excellent pulling-up power and will cover a 3 foot square, yet when the cord is wound up it makes a compact and instantly adjustable device. By leaving extra cord tied up outside block B any size of rectangle can be accommodated.

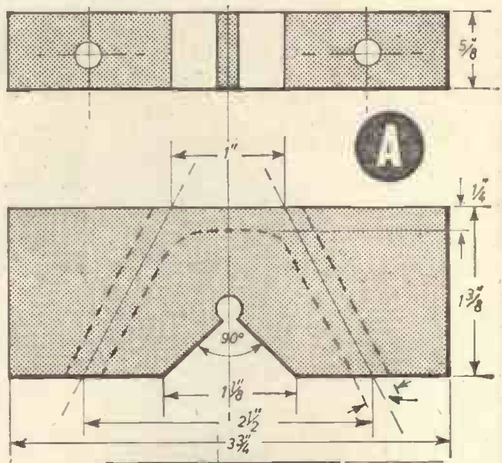
The cord is knotted into the counter-bore of block B then pulled through the ¼ in. diameter hole X. It now passes through all the corner pieces, back through the opposite ¼ in. hole in block B and into the handle, where it is knotted inside the counter-bore. By turning the handle the cord is wound on the bobbin and held there by the ratchet and pawl.

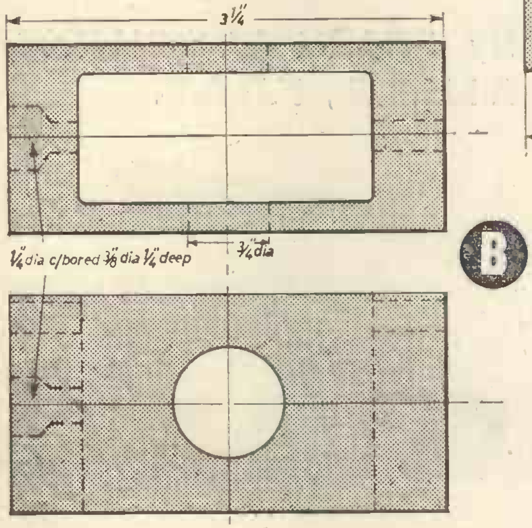
Any hard wood can be used but beech is preferred and is quite easy to work. Start by making the corner pieces. Mark out accurately and, starting from the V-side, drill the ¼ in. diameter cord holes. This is made easier if the centre-line of each hole is marked with pencil on the outside face and, with the work held in the vice, the drill is lined up to this line, also keeping it square through the thickness. The two holes are now joined on the back edge by a nicely rounded channel. This allows the cord to lie flush with the edge and to act quite freely without any sharp edge to fray it. The V's are cut after ⅛ in. diameter holes have been drilled in the corners. These holes allow the work to rest properly in the corners and must be kept clear of glue, etc.

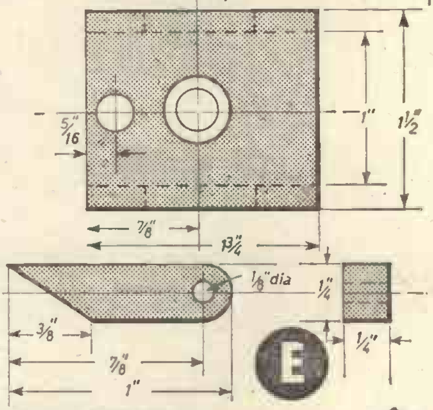
Block B can now be cut to size and the rectangular hole made. To do this, drill all round inside the dimension lines with a small size drill, keeping the holes as close together as possible. Then knock out the centre waste. Finish with a chisel, working flat from both sides. Drill the ¼ in. holes and counter-bore one for the cord knot. If a waste piece of timber can be wedged into the rectangle the two ¾ in. diameter holes can be drilled from both sides without fear of the bit splintering the wood on the inside.

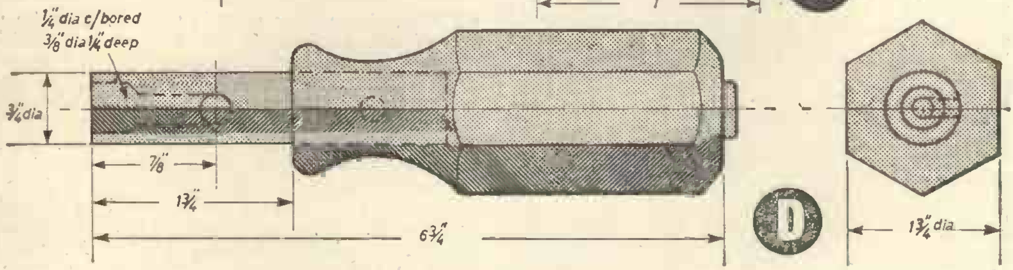
The handle could be made easily on a lathe but if this is not available a piece of ¾ in. dowel could be let in as shown by the dotted lines and glued and pegged to the hexagonal stock. Two ¼ in. diameter holes should be drilled in this dowel for the cord, one being counter-bored as shown, to take the knot. The ratchet C is of metal; a thick washer with a ¾ in. diameter hole and teeth cut and filed as shown would do. It must be a good fit on the handle however. Marking the teeth out on paper which is then glued to the washer helps in the cutting of the ratchet. A metal piece the same thickness as the ratchet should next be cut for the pawl E and drilled a loose fit for a No. 6 round head wood screw.

All the parts should now be cleaned up and, if of beech, soaked in linseed oil. To assemble, push the ratchet over the dowel down to the handle shoulder. Holding it hard down, drill a hole through the base of one of the teeth, but not into the dowel, and pin the ratchet securely in place



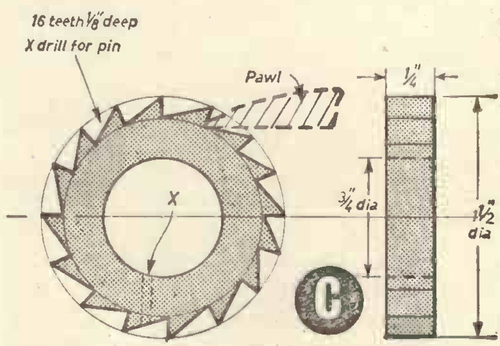


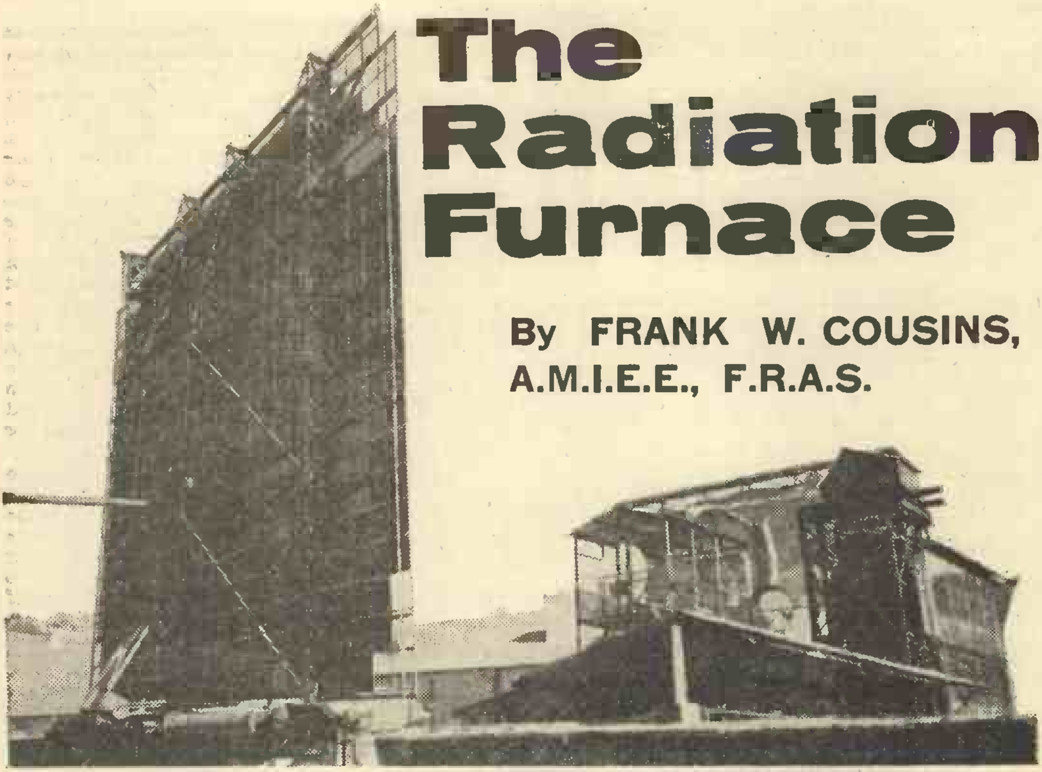




with a ¾ in. panel pin. Sink the head of the pin clear of the teeth. Insert the handle into block B and you are ready for the cord. This is ⅛ in. diameter glazed window cord available at any ironmongers. Four yards will fit nicely on the bobbin when the cramp is wound in, but if a bigger area is to be covered any amount can be purchased and left loose as described earlier.

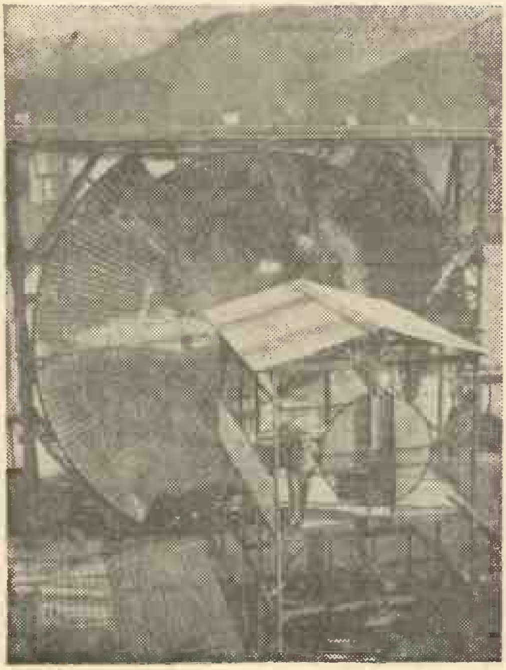
Make sure the corner pieces are in the right positions before knotting. A glance at the sketch will show you the position of the pawl which, being loosely held, falls by its own weight into the ratchet. But make sure its position is correct before finally fastening it in place. To loosen the cramp the tension is taken up and the pawl lifted.





The Radiation Furnace

By FRANK W. COUSINS, A.M.I.E.E., F.R.A.S.



THERE are clear records to show that the use of the sun's rays for heating and melting various substances has been known from very early times. Professor Forbes recorded in his great work on ancient technology that lenses and concave mirrors to focus the sun's rays were used for lighting fires and altar flames in antiquity. In the year 1540 a mirror of approximately 1ft in diameter was mentioned as having been built to melt gold coins. Towards the end of the 17th century E. W. von Tschirnhaus produced a number of elegant burning glasses for use by chemists and metallurgists. One fine example is still to be seen in the Deutsches Museum of Munich (Fig. 2). A glass similar to this was said to have been used by Humphrey Davy and Michael Faraday in Florence in 1814. They used it to heat a diamond placed in a platinum crucible in the middle of a glass sphere filled with oxygen. The diamond was held in the concentrated heat of the sun for a period of about three-quarters of an hour. One of the most spectacular burning glasses ever built was made by Lavoisier in about 1775. This had an alcohol-filled hollow glass lens 4ft in diameter with a second, smaller lens to shorten the focal length. The pair were mounted in a hinged frame which could be elevated as required. The whole affair was supported on a platform nearly 30ft long, with radial wheels so it could be turned to face the sun.

Nowadays it is more usual to concentrate the heat of the sun by means of paraboloidal mirrors. A paraboloid is obtained when a parabola is rotated about its axis to form a bowl of three-dimensional form. This bowl is, of course, a precise geometric form but is essentially the shape of a motor-car headlamp. The paraboloid may have a short or long focus—*i.e.*, the bowl may be sharply curved or gently curved. Its prime characteristic is its ability to concentrate parallel rays impinging on its surface to a single point or focus. In the case of the car headlamp the reverse process is used, light from the focus being directed outward in a parallel beam (Figs. 1a, 1b).

The largest solar furnace in the world is that at Mont Louis, in the Pyrenees, in the South of France. This furnace is constructed within the walls of the Fort of Mont Louis built by Vauban in 1676. The area of the paraboloidal mirror is 969 sq. ft and it consists of 3,500 individual mirrors. The rays of the sun are collected by a great heliostat mirror 1,500 sq. ft in area which moves on a track to compensate for the passage of the sun across the sky (Fig. 3). The heliostat directs the light of the sun on to the paraboloidal mirror, which is at a distance of 80ft from it. At the focus of the paraboloidal mirror a temperature in excess of 2,800° C can be generated. The furnace, which is placed at the focus, excels in the preparation of refractory oxides of high purity. It will be seen that Mont Louis is an ideal situation for this enterprise in that it receives over 2,500 hours of sunshine a year.

More recently a similar method of heating has been developed using a carbon arc as the primary source of heat. This furnace also has distinct advantages in the melting of crystals of refractory oxides such as nickel oxide, titanium dioxide, zirconium oxide and certain manganese ferrites. These have an inherently high electrical resistance and are therefore difficult to melt by radio frequency induction heating. The apparatus comprises two elliptical mirrors (Fig. 4) which produce an image of an intense carbon arc. The rod of oxide to be melted is placed within the image of the carbon arc. The furnace is descriptively called the carbon arc image furnace. A furnace of this type used by Kooy and Couwenberg for solid state research at Philip's Research Laboratories in Eindhoven makes use of a cinema projection arc lamp. The elliptical mirrors are each of 36cm ($7\frac{1}{4}$in.) diameter and have focal lengths of 14 and 68cm ($5\frac{1}{2}$ and $26\frac{3}{4}$in.). The carbons are rated for an arc current of 80 amps.

In closing this short account it is of interest to point out that the temperature at the surface of the sun is about 6,000° C and theoretically the image should be of the same temperature, but in practice this is not attainable. However, in both the solar and carbon arc furnaces the radiant energy used to melt the various substances placed at the focus is of the order of 1,500 watts per square centimetre.

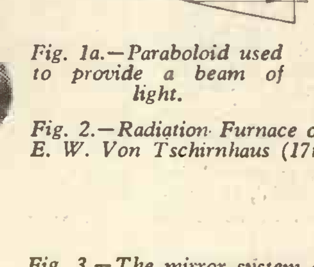


Fig. 1a.—Paraboloid used to provide a beam of light.

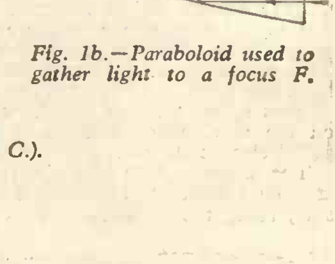


Fig. 1b.—Paraboloid used to gather light to a focus F.

Fig. 2.—Radiation Furnace of E. W. Von Tschirnhaus (17th C.).

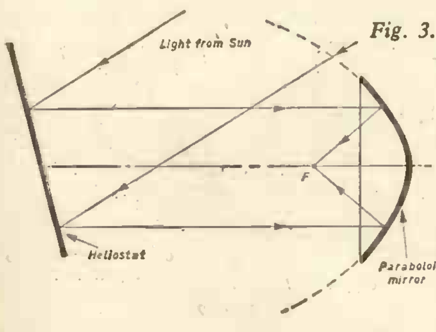


Fig. 3.—The mirror system of the Mont Louis furnace.

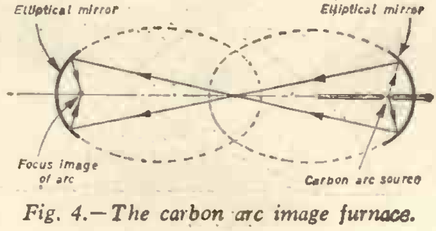


Fig. 4.—The carbon arc image furnace.

How CAPACITORS work

The nature of electricity

BY B. C. MACDONALD

ONE of the curiosities of electricity that puzzles many amateur electricians is how a capacitor works. (The term capacitor is the modern way of referring to the device that used to be called a condenser.) The two sets of plates of a capacitor are completely insulated from each other and yet an alternating current appears to get through. The reason for this apparent paradox is a simple one, but first we must understand something of the nature of electricity itself. It is known that everything is composed of atoms and that the atoms themselves are composed of a large number of various particles and electrical charges. The only ones that concern us here are the electron and the proton. The protons are fixed in the centre or nucleus of the atom together with the other "heavy" particles. The nucleus makes up the bulk of the weight of the atom. The electrons revolve around the nucleus in orbits of different sizes to form a kind of miniature solar system, in which the electrons represent the planets and the nucleus the sun. In a normal atom there are as many protons in the centre as there are electrons in orbit (Fig. 1). The proton carries a positive charge and the electron an equal negative charge, therefore when both are present in equal number

It is possible however for an electron to become the whole atom is electrically neutral and balanced. detached from an atom and when this happens the electrical balance is disturbed, the protons now predominate, and therefore the atom now has a positive charge. When an atom becomes positive due to the loss of one or more electrons in this way, it is called an ion. Now these electrons which have become detached from the atom can move from one atom or ion to another rather like grains of sand sifting through gravel. It is such electrons on the move that are believed to constitute the actual electric current.

The movement of the electrons is caused by creating a difference of electrical potential, or pressure, along the conductor. This can be achieved by connecting a battery or dynamo. Both these devices function as pumps, the one because of the chemical reactions going on inside it, the other because its rotation creates magnetic effects in the windings. In both cases this results in the free electrons being crowded up to the negative terminal, leaving the positive terminal starved of electrons. When a conductor is connected across the terminals, electrons flow from the negative terminal, through the conductor, and into the positive terminal. As long as the chemical reaction in the battery continues, or the rotation of the dynamo, the current will continue to flow.

A curious convention which has persisted from the early days of electrical knowledge is that the current is said to flow *from the positive terminal to the negative terminal,* although as we have just seen, the *electron* flow is in the opposite direction. Until understood, this convention often causes confusion. In many ways the flow of electricity through wires is very like the flow of water through pipes. The water will flow through a pipe if we create a pressure difference by means of a pump. In the early days of science, electricity was in fact believed to be a fluid of some kind as it behaves so much like one.

Although it is only the electrons in the outer orbits of the atoms that move when a pressure difference occurs, this movement takes place very much more easily in some substances than in others. In conductors the free electrons move quite freely from atom to atom but they can only move with great difficulty in insulators. Because of this insulators can become electrically charged. For instance, if we rub a glass rod with a piece of silk, some of the free electrons pass to the silk, and this gives the rod a positive charge because of the positive ions the loss of the electrons has created. If we rub an ebonite rob, instead of a glass one, with a piece of fur we obtain the opposite effect, the rod becomes negatively charged by having too many electrons and too few ions or positive atoms.

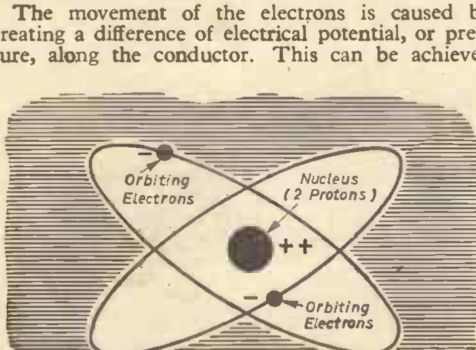


Fig. 1.

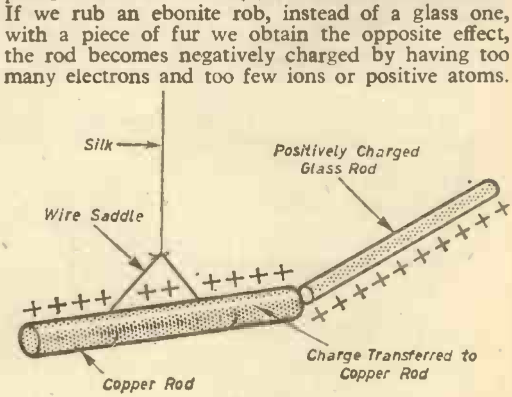


Fig. 2.

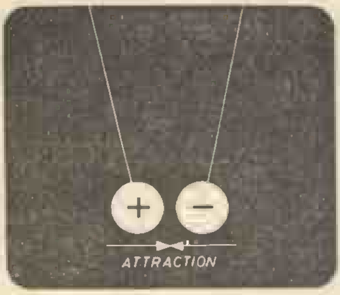


Fig. 3.

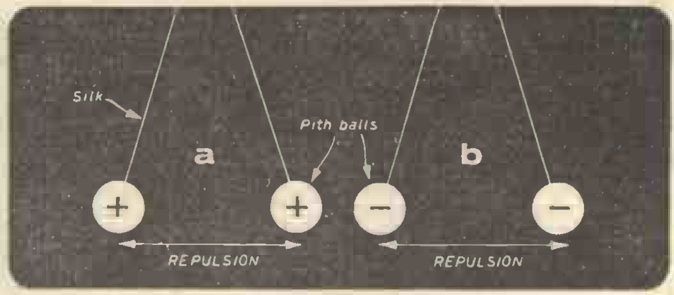


Fig. 4.

A conductor can be charged if we first insulate it, say by suspending it on a strand of silk, and then touch it with a charged rod (Fig. 2). The power lines we see on pylons can be dangerous even when not connected to the power station and also when they are being constructed. This is because the very high insulation from earth allows the accumulation of electric charge on the wires, which must be well earthed before it is safe to work on them.

These electrostatic effects can easily be demonstrated. If we take two pith balls suspended on a silk thread (pith because it is very light, and silk because it is a very good insulator), we can charge them by touching them with a charged glass or ebonite rod. If we try to bring the balls close together, after charging them positively with a rubbed glass rod, they will repel each other. If we charge them both with a fur-rubbed ebonite rod they will still push each other apart even though they are now charged negatively (Fig. 4). But if we give each ball an opposite charge, touching one ball with a charged ebonite rod and the other ball with a charged glass rod, then we find that the two balls attract each other (Fig. 3). This proves two important laws of static electricity; like charges repel each other, unlike charges attract each other. If we bring two opposite charges near enough, and the difference in charge is great enough (i.e. the voltage is high enough), the electrons will jump across the gap as a spark, to make up the electron deficiency.

Thunder and lightning are of course an electrostatic effect of this nature. The raindrops bring down to earth from the clouds an excess of electrons, so that the earth acquires a powerful negative charge with respect to the clouds. A pressure difference of several million volts is created, enabling the electrons to break their way back to the clouds through the air. The sound is caused by a very rapid expansion of the air due to the heat produced by the current. The initial discharge takes place from the earth to the clouds and not vice versa, as is often thought.

We can now understand how a capacitor works. We can charge a capacitor simply by connecting it to a battery as shown in Fig. 5a. The capacitor will become charged because the positive pole of the battery will withdraw electrons from the right-hand plate, leaving a positive charge there, at the same time forcing them into the left hand plate and giving it a negative charge. If we reverse the connections as in Fig. 5b, we reverse the charge. The capacitor will remain charged if we disconnect the battery because the two plates are insulated and the electrons cannot pass from one plate to the other to equalise the charges. The amount of charge that the capacitor absorbs depends upon the voltage of the battery and on its capacity. The capacity depends on the area of the plates, on how close they are together and on the nature of the insulator separating them. A 0·1 mfd radio condenser can be charged from any d.c. supply. If an H.T. battery

(Continued on page 190)

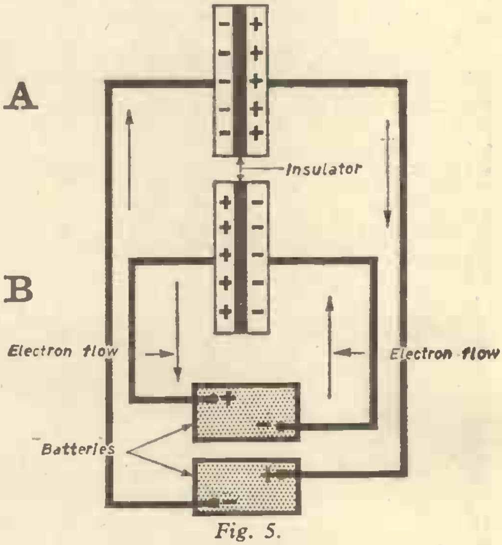


Fig. 5.

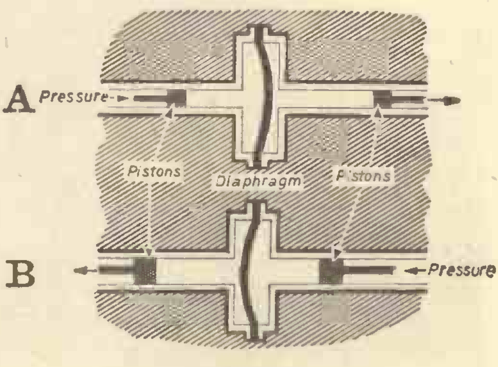


Fig. 6.

A SIMPLE DISTANCE GAUGE FOR MAP READING

BY G. A. W. PARTRIDGE

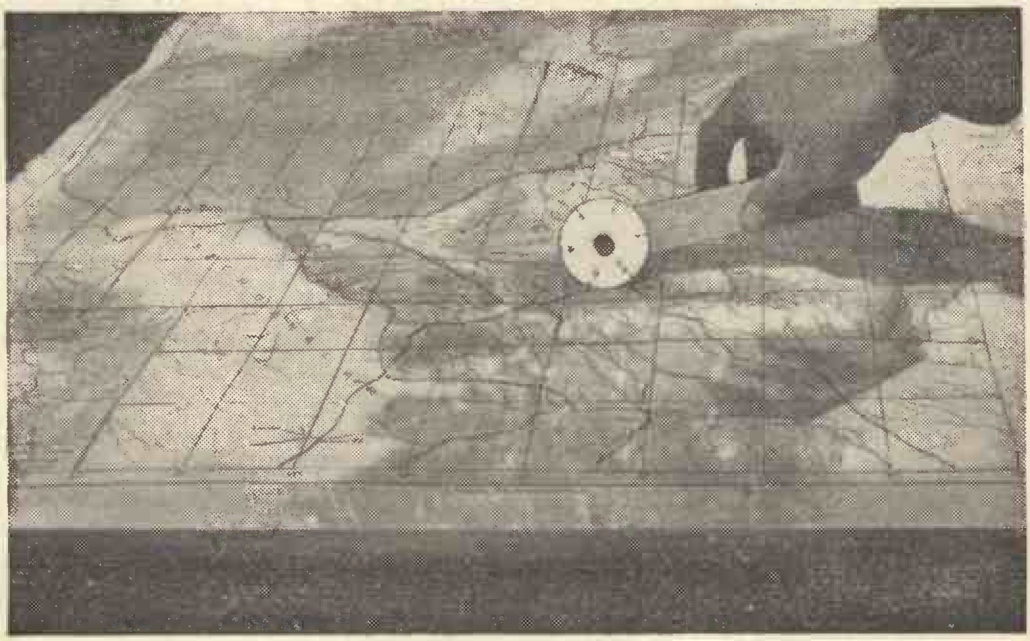
THERE are times when it is necessary to calculate distances between various places on a map, when the mileage between the towns is not marked. However, most maps are drawn to scale, which is either indicated in the margin as being a certain number of miles to the inch, or else a special scale is included giving the equivalent distances in miles. In the first place the distance from say, A to B is measured in inches and the mileage is then calculated by multiplying this measurement by the scale in miles per inch. Distance in miles=length in inches × miles per inch. For example, the distance from A to B (Fig. 1) may be five inches and the scale, eight miles to the inch. Thus distance in miles$=5\times8=$ 40 miles.

The problem is how to measure the distance by road from A to B. If a rule is used it will only give the distance " as the crow flies ". One method is to lay a piece of string along the line indicating the road and then measure its length with a rule or along the map distance scale. It is, however, harder to lay string along a map line than is at first realised, especially if the map is on a wall. The simple distance gauge described here helps to overcome these difficulties, and give greater accuracy.

Fig. 2 shows the device, which can be made up in less than an hour. The wooden handle should be made about 6 × ½ × ½ inches. The disc should be made out of stiff white cardboard, or could be cut out of thin sheet metal. Set a pair of compasses to exactly 0·95in. (19/20in.) and draw a circle on the cardboard or metal. Now mark six points on this with the compasses set to the same radius (Fig. 3). Mark these points carefully with ink and number them from 0 to 6 as illustrated in Fig. 2. These numbers represent inches measured along the map. Cut out the disc very carefully and attach it to the end of the handle with a drawing pin. See that it rotates freely, but at the same time is not so loose that it wobbles.

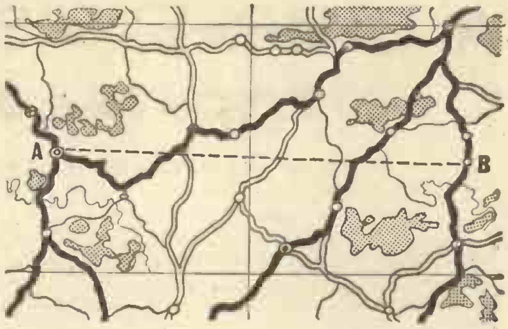
Distances between places are found by first positioning the zero mark on point A, then wheeling the disc along the road line to point B, always from left to right so that the wheel rotates clockwise. Note the distance on the disc, say five inches. As before, this multiplied by the map scale gives the distance in miles. Alternatively, if the map has a distance scale, place the disc zero on the scale zero and run the wheel along to the same number

Showing method of using distance gauge on a map.



that corresponded to point B. The distance can then be read directly off the map scale.

At first the gauge may appear to be rather clumsy, but after a little practice distances can be obtained quite accurately.



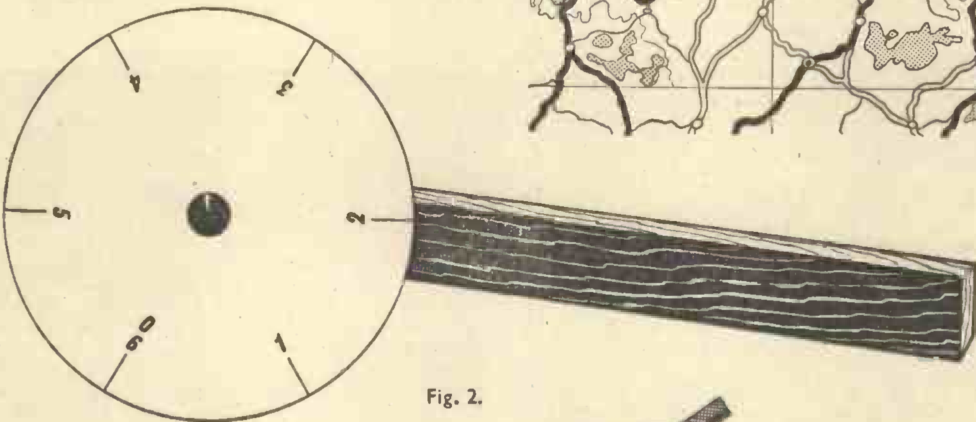


Fig. 2.

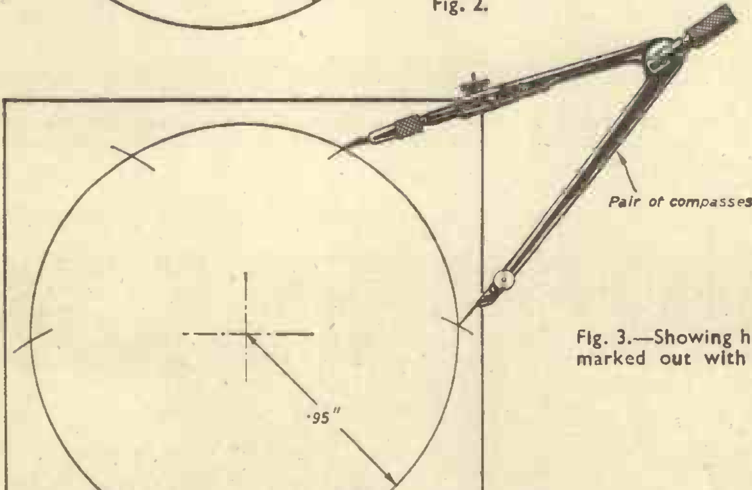


Fig. 3.—Showing how disc is marked out with compass.

L.B.S.C's 3½in. Gauge

EVENING STAR

We regret that it has been necessary to discontinue this series for a time, as the author, L.B.S.C., is unable to supply further drawings or instructions.

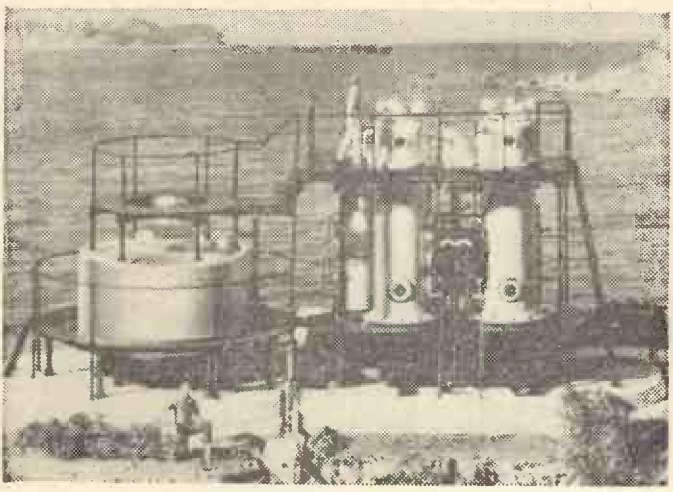
It is realised that some inconvenience will be caused to followers of this series, and we shall publish any further developments concerning this as soon as possible.

PICTURE NEWS

FROM THE WORLD OF SCIENCE

Home sweet home—in space

SPACE travellers of the future may have easy chairs and igloos such as pictured here, readily available when they wish to "stop for the night". The hut, which looks like a giant 7-foot diameter pumpkin, and the chair are made from a new foam plastic material intended for building light-weight forms in space. They are made to inflate and are covered with thin discs of the special plastic whilst deflated. When required during the journey in space they are inflated and the plastic discs "sudse" under the action of solar rays, to form a hardened rigid mass.



Sea water to fresh water

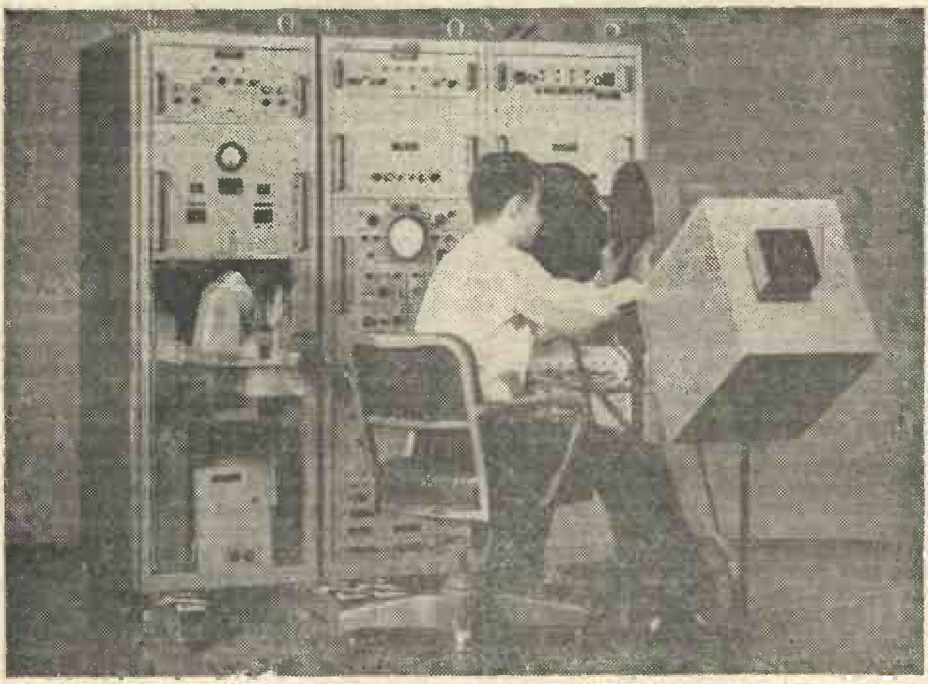
THIS model shows how a pilot salt water conversion plant to be built by U.S. General Electric for the U.S. Department of the Interior, will look when completed at the testing ground of the department's Office of Saline Water at Wrightsville Beach, North Carolina. The plant will be the first to employ a new thin-film distillation process and will permit further study of the use of the process for large-scale conversion of salt or brackish water. The plant's two stages, each consisting of 15 distilling units, will provide a total fresh water capacity of 37,000 gallons per day.

A pedipulator or walking vehicle

THE development of a manned robot able to stride on legs twelve feet long, at a speed of 35 miles per hour across rough terrain, is now being studied. The pedipulator's "body" would be large enough to contain a man whose arm and leg movements, with the aid of electronics, would induce like movements in the powered limbs of the robot, which of course would be power operated and much stronger. The pedipulator would therefore belong to the new class of devices called "CAMS" (cybernetic anthropomorphous machines), in which the human operator is part of the machine itself. One such machine, called "Handyman", has already been developed for the U.S. Atomic Energy Commission.

Such devices eliminate much of the training necessary with conventionally-controlled machines as the machine merely follows the operator's natural actions. He can thus concentrate on the task rather than the machine as he does not have to think about operating various knobs, levers, etc.

In this vehicle, agility and power over rough terrain, not just speed, are the main design goals. The pedipulator could pick itself up if it fell down, and could be used with others to transport loads, much as men carry a load between them. The initial specification only requires it to be able to walk slowly on a level plane or slight incline, to side-step and turn about, and to step up or down stair-like obstacles.

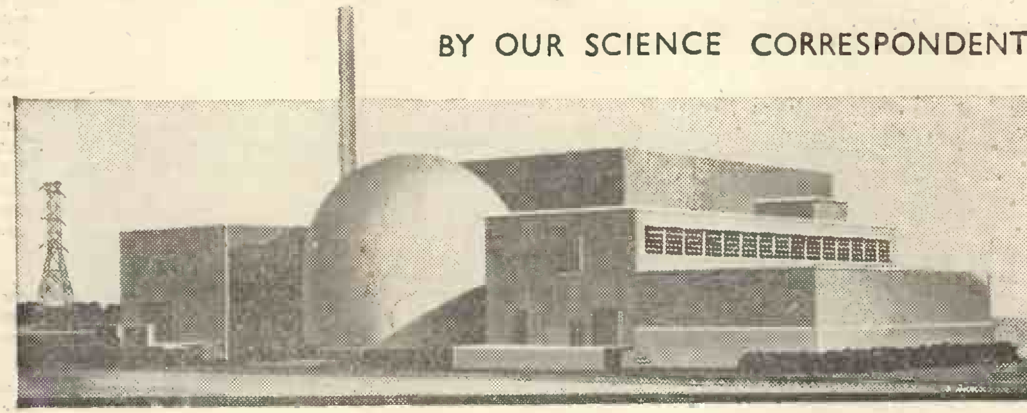


TARE, a new pulse recorder

HIGH speed transient phenomena studies are now being facilitated by a new pulse recorder, TARE (Transient Analysis Recording Equipment). TARE records complex video signals on photographic film by combining a special dual-beam oscilloscope with a high speed shutterless 16mm camera. The special cathode ray tube used permits pulses having widths as small as 0·1 microsecond, with rise times as fast as 19 millimicroseconds, to be recorded. TARE eliminates the need for supplementary log sheets, as the time of day, sweep rate, vertical sensitivity, and video input selector position, are automatically recorded on tracks along the edges of the film. In addition, accurate time markers, and standard amplitude reference markers can be shown on the horizontal sweeps. The camera is controlled from the operator's position, and can be loaded and unloaded from this position. An optional automatic film processor can make the film available for detailed analsis in about six minutes after a recording has been completed.

How Atomic Engines Work

BY OUR SCIENCE CORRESPONDENT



HEAT is produced in an atomic reactor by breaking down the complex and heavy atoms of uranium into simpler and lighter atoms. The quantity of heat produced in relation to the material used is very great. For instance, the heat content of one ton of uranium 235 is equal to that of 3,000,000 tons of coal. All the reactor provides is heat. To convert this heat into mechanical energy the obvious thing to do is to use a steam engine and this is just what all atomic power plants do. Instead of using coal or oil to produce the steam, atomic heat is used.

How does the atomic furnace work? Well, first you must obtain a quantity of radioactive material like uranium 235. The atoms of this material are complex and unstable—a very small number of them are breaking up all the time. When one of the atoms breaks up it gives off high-speed particles and emits gamma rays. Fig. 1 shows what happens when a uranium 235 atom splits. The atom breaks down into two smaller and lighter atoms and gamma rays are generated. From the centre or nucleus of the broken atom come two or three particles called neutrons, travelling at speeds of up to 18,000 miles per second. If one of these high-speed neutrons strikes the nucleus of another uranium atom that atom also splits. Since the atomic structure is a very open one, most of the neutrons pass right out of the uranium without meeting another nucleus. If, however, we bring together a large quantity of uranium the path of the neutrons in it will be so long that they are bound to hit the centre of another atom. We may read that a reactor under construction has become "critical", which means that the amount of the uranium added has brought the volume up to the "critical" size where more neutrons are being produced in the pile than are escaping. In other words a chain reaction has started.

Even if each exploding atom gives off only two neutrons there is a tremendously rapid build-up of the number of atoms involved, as shown in Fig. 2, and the reaction is said to be divergent, each split atom producing more than one new split one. Once such a chain reaction has been started it must be controlled, otherwise so much heat would be produced as to destroy the reactor, though no atomic explosion would take place, only a severe fire. Fortunately some other elements, boron and cadmium for instance, absorb neutrons in much the same way as a sponge absorbs water, so if rods of these materials are lowered into the reactor they mop up most of the high-speed neutrons and the number of splitting atoms is maintained in check. Thus by lifting or lowering the rods the heat produced can be increased or decreased at will. The effect of the rods is shown in Fig. 3, where half the neutrons produced are being absorbed and the chain reaction is stable. This is the state in which reactors are always run.

When it is desired to increase the power level of the pile the control rods are withdrawn slightly. This allows the reaction to become divergent again and the number of neutrons thus increases. This means that an increasing number of atoms are splitting and producing more heat. When the required level has been reached the rods are put back to their original positions, where they again absorb half the neutrons. The reaction thus becomes stable again though at a higher level of activity.

Having got a reactor producing heat the problem is how to use the heat. It was originally thought to be impossible to put an atomic furnace under a boiler as we could a coal fire; partly because of the high-speed neutrons and highly penetrating gamma rays already mentioned. Both are intensely dangerous to life. Therefore the reactor, though comparatively small in itself, must be surrounded by a thick steel and concrete shield which is necessarily large and heavy. British atomic power stations extract heat from the reactor by passing gas through it under pressure, the high temperature gas then being used to boil water in a boiler. The method is a good one but the plant is very large. The system used in the American submarine Nautilus and in other submarines of this type uses water under high pressure, 2,000lb/sq. in. in fact, circulating through the reactor, which it leaves at a temperature of about 250°C. The high pressure prevents the water boiling and allows this high temperature to be obtained. From the reactor the water passes to the heat exchanger, where the heat is transferred to a second circulatory system containing more water, but this time free to boil. The boiling water produces steam under pressure and this is passed to the steam turbines which drive the submarine. The low-pressure steam leaving the turbines is passed through a condenser to reduce it once more to water and it is then pumped back into the heat exchanger. The general arrangement is shown in Fig. 4. The second steam/water circulatory system is, of course, quite normal in ships using orthodox fuel.

The metal sodium in molten condition has been used in place of pressurised water in the reactor circuit. No matter how high the pressure, water boils at a little over 300°C. so there's a limit to the temperatures that can be used usefully. Sodium melts at about 880°C. and therefore can carry heat from the reactor at a much greater rate. Since it does not need to be under pressure, constructional problems are somewhat simplified. Such a system was used in the second atomic powered submarine to be made, the Seawolf. Unfortunately however, when sodium is subjected to irradiation in the reactor it becomes radio-active so that much more shielding is required than with the pressurised water type. This means more weight and an increase in size. Also liquid sodium is a dangerous substance and difficult to pump. After propelling Seawolf for 70,000 miles the sodium cooled motor was removed from the submarine, encased in concrete and dropped into the Atlantic. The pres-

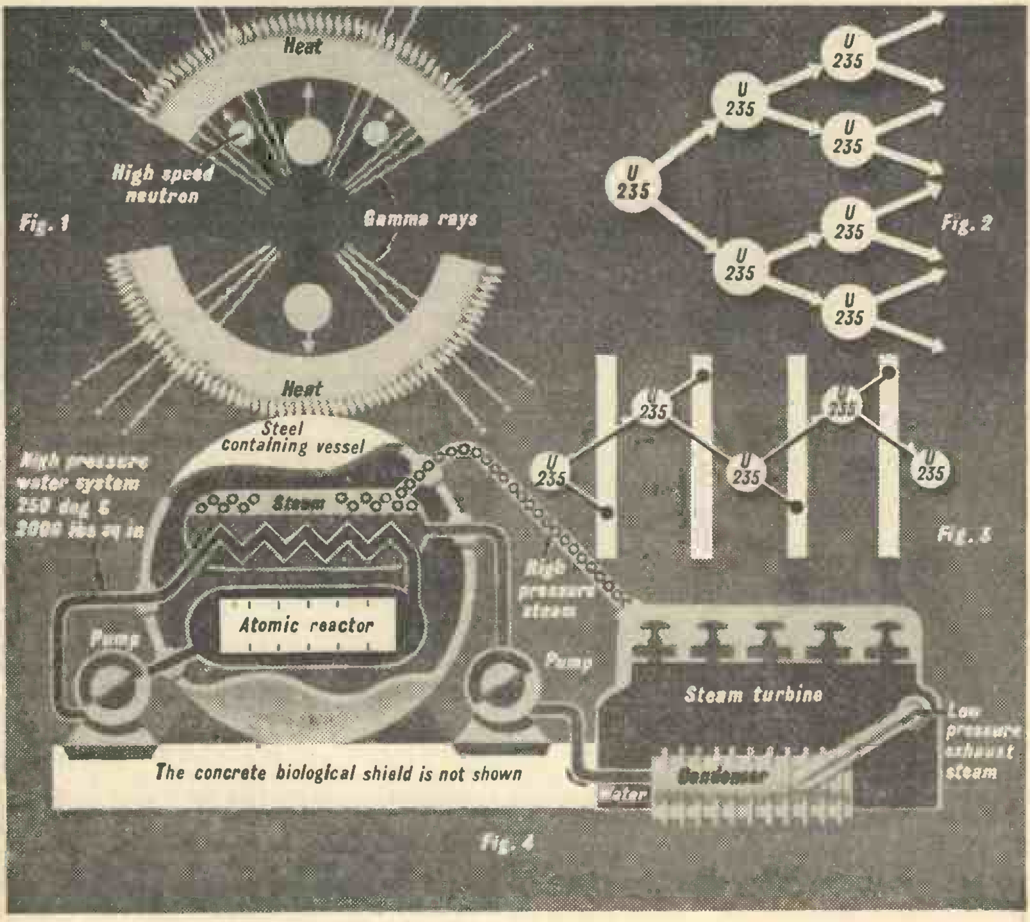
(Continued on page 190)

Fig. 1.—What happens when a neutron enters a uranium atom. Division into two simpler atoms takes place. Neutrons and gamma rays are emitted and enormous energy is released as heat.

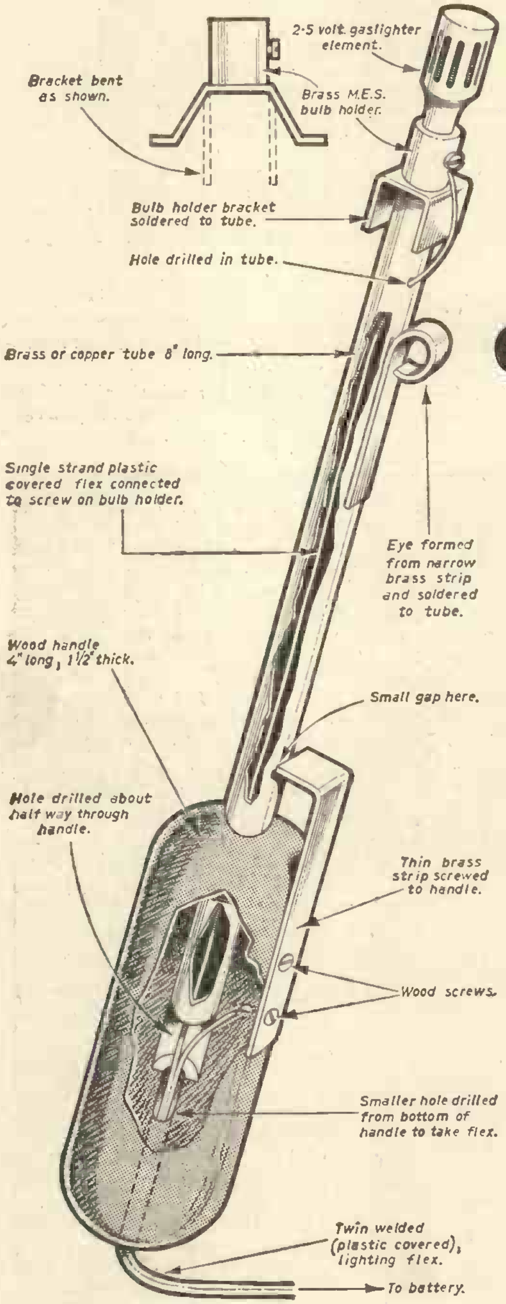
Fig. 2.—Showing how an exploding uranium atom, giving off two neutrons, can start a chain reaction involving millions of atoms.

Fig. 3.—By introducing rods into the reactor composed of materials that can absorb neutrons, the number of atoms breaking up can be reduced or the chain reaction can be broken.

Fig. 4.—Diagram showing in a much simplified form the arrangement of the engines in the atomic powered submarine Nautilus.



An easily made Electric Gaslighter



THIS gaslighter is very easy to make and the cost is only a few shillings. The twin-cell cycle lamp battery lasts a long time and the nuisance and cost of having to use matches are avoided. To use the lighter the gas is turned on and the lighter is held so that the element on the end is close to the escaping gas. At the same time the thumb is pressed on the brass strip on the handle, causing it to touch the tube. The gas then lights instantly as the element glows. The element should be withdrawn immediately the gas lights and the thumb pressure released from the brass strip.

The metal tube

Most amateur mechanics will have a suitable piece of tube in their possession. It should be about 8in. long with an outside diameter of $\frac{3}{8}$in. to $\frac{7}{16}$in. Any metal will do except aluminium, which cannot easily be soldered. Cut the tube to length with a hacksaw and smooth off the burrs with a file. Obtain a brass M.E.S. bulb holder of the type shown in Fig. 1. These bulb holders are made to take a torch bulb. Straighten the ends of the bracket by means of a pair of pliers, then bend them downwards so as to fit snugly over the end of the metal tube. The brackets can be cut shorter to make a neater job. Drill a hole large enough to take the plastic flex, about a $\frac{1}{4}$in. down from the top of the tube. To hang the lighter up an "eye" should be made as shown or it can be shaped as a hook to fit some convenient part of the cooker. In either case make the attachment from a strip of brass and solder it to the metal tube.

The handle

The handle can be made from any type of wood or it may be possible to use a tool handle. If the handle is to be made, the hole to take the tube should be drilled first. The brass strip which acts as the switch should be about $\frac{3}{8}$in. wide. To make a neat job the strip should be recessed into the wood of the handle and the screw holes in the strip should be countersunk so that the screw heads come flush with the surface of the handle. One of the screw holes should be drilled right through into the larger hole. It is also necessary to drill a $\frac{3}{16}$in. hole upwards from the bottom of the handle until it breaks into the larger diameter hole.

Assembling the lighter

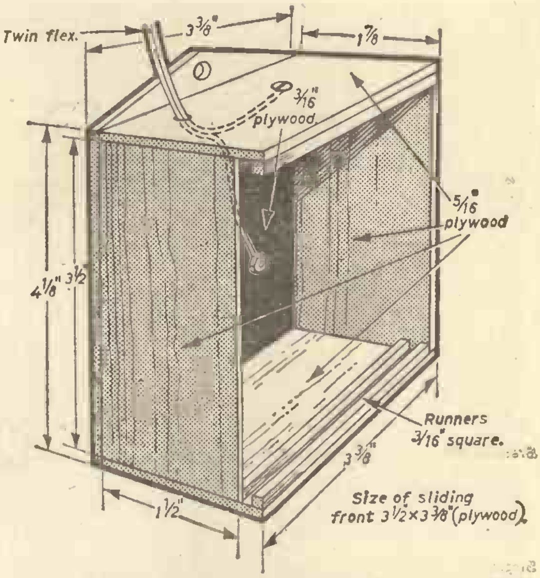
It is recommended that twin, side-by-side, plastic-covered flex should be used. Of course twisted flex may be used, but it is more difficult to keep clean. Side-by-side flex may be cleaned easily by drawing it through a piece of damp folded cloth. The two strands of flex should be separated for about 10in. Thread the flex upwards through the small hole in the handle. One of the strands has to pass through the side hole and it is not easy to make it do this. It can be done with patience and a small screwdriver or a piece of thread can be passed through the hole from the outside, fastened to the wire of the flex and then pulled to draw the flex through the hole. When this has been done the other strand of the flex should be passed up the metal tube, which can now be pressed into position in the handle. The top end of the flex should be passed through the hole already drilled for it near the top of the tube.

The next thing to do is to solder the M.E.S. bulb holder in position on the end of the tube as shown in the illustration. The bared end of the strand of flex should be wound under the screw on the side of the bulb holder and the latter tightened down. Cut the piece of flex protruding from the side of the handle to a convenient length, bare the end and fix it under the brass strip by tightening the two screws. The brass strip must be bent outwards so that it is about $\frac{1}{16}$in. away from the metal tube. It is very important that the strip should be stiff enough to maintain this gap unless firm pressure is applied to it. If for any reason the strip is allowed to remain in contact with the metal tube the battery will run down.

The battery

The twin-cell cycle lamp battery has a long life in normal use. It may be housed in a small box, placed close to where the lighter it to be used, perhaps on the wall behind or near the cooker. Alternatively it may simply be placed in a plastic bag and the bag hung on the wall. In this case it is preferable to solder the wires to the battery contact strips, although the lighter will work if the bared ends of the wires are simply wound round the strips. Whether the battery is placed in a box or a bag the flex to the lighter should not be longer than necessary. The gaslighter element, which is screwed into the M.E.S. bulb holder, is a 2·5-volt one.

The battery box shown is easily made using plywood, resin glue and panel pins. A sliding front is provided. The battery contacts inside the box, one on the top and one in the centre of the back, are 4B.A. or 6B.A. brass countersunk head screws with nuts and washers. The bared ends of the flex should be wound under the washers before the nuts are tightened. The battery should be placed in the case so that the brass strip on the face of the battery touches the screw in the back of the case. The brass strip on the top of the battery should touch the upper screw in the box. Some packing



may be required to hold the battery firmly in the box when the lid is slid into position.

Most of the gaslighters that can be bought have the battery as part of the handle. If the battery is a large one this means that the lighter is heavy and clumsy and sooner or later is usually damaged by a fall. If the battery is a small one it has too short a life. The lighter described is not too heavy and the battery capacity is good. Because of the connecting flex the lighter cannot be taken away and is therefore always in place when required.

THE DEVELOPMENT OF SKYBOLT

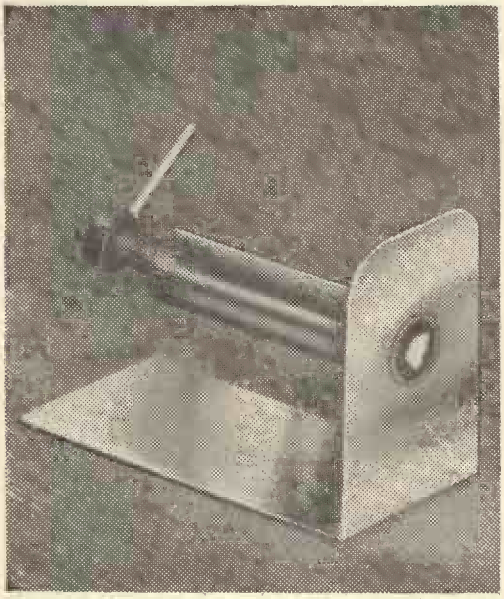
(Continued from page 149)

assembly of the weapon and in mating it to the airplane. Elgin is the centre of Skybolt testing activity, with Patrick Air Force Base, adjacent to Cape Canaveral, providing assistance in tracking the missile down the Atlantic Missile Range. Field engineers and technicians at Elgin test the system, and feed the results back to the designer at the drawing board. These can then be incorporated into the design of the missile during the continuation of its development.

Skybolt, will be the Free World's only air-to-surface ballistic missile, and is scheduled to become operational on Vulcan bombers in 1964.

SKYBOLT SPECIFICATIONS

Name:	SKYBOLT.
Type:	Air-to-surface ballistic missile.
Prime Contractor:	Douglas Aircraft Company.
Power Plant:	Two-stage solid propellant (Aerojet-General).
Guidance:	Inertial (Nortronics Division of Northrop Corporation).
Re-Entry Vehicle:	(General Electric).
Speed:	Hypersonic.
Range:	Approx. 1,000 miles (nautical).
Armament:	Nuclear warhead.



CONSTRUCTING A MICROTOME

BY W. R. SPENCE
M.A., B.Sc.

ALTHOUGH the microtome is such an indispensable microscope accessory it is also a most expensive instrument. However, the version described here will satisfy the needs of any amateur for an outlay of only a few shillings. It possesses a reasonably professional appearance and can be made to operate with truly scientific precision.

As most objects in their natural state do not occur in thicknesses which render them suitable for viewing by the normal method of transmitted light, some means of producing thin slices is required by the microscopist who wishes to prepare his own specimens rather than purchase commercial slides. The microtome described enables sections of any desired thickness to be removed cleanly and accurately from most soft materials. Yet it is so simple and robust that it is entirely free from subsequent variation and thus eliminates those tedious adjustments which appear to be inseparable from factory made models.

Materials required

Only three basic items are necessary, viz, a piece of heavy gauge metal about 7in. by 2in. which forms both the base and the face-plate; a 2in. length of 1in. diameter tubing to act as the barrel of the instrument; and a suitable bolt about 3in. long. Although thin steel would be best for the face-plate almost any metal may be employed providing that extra care is taken not to damage a softer material such as aluminium, either during construction or in subsequent use. For the neatest appearance it is advisable to purchase a section of aluminium or chrome tubing, but the model in the photograph embodies a length of sawn-off towel rail! The bolt should be one with the finest thread available although even a ¼in. Whitworth bolt will give satisfactory results.

Construction

As shown in Diagram 1, the barrel of the microtome should be fitted into the face-plate portion of the metal sheet after bending this to a convenient L-shape. The other end of the barrel should then be plugged by pushing a disc of metal tightly into it. By using a metal-cutting fret-saw, or similar blade, both pieces marked "A" and "B" in Diagram 2 may be cut from the one metal strip. If the cut is made in the shaded area, which is waste material, a half round file can be used to bring the work to the correct dimensions.

It is essential that the internal and external diameters of the tube be obtained precisely. Calipers, or a suitable gauge, must be made use of to ascertain these measurements before transferring them to the face-plate for cutting operations. All other dimensions are a matter of convenience only and the sizes suggested in the drawings should be taken as approximate indications.

During assembly the respective components should fit together so snugly that a mallet has to be used to drive them home. No other form of jointing should be necessary although a smear of a modern epoxy resin such as Araldite will ensure permanent union. It has been found in practice that much improved cutting results from allowing the barrel to project initially a very short distance beyond the face, the whole surface then being worked flush by draw filing and polishing.

The sketches show the disc "A" tapped to accommodate the bolt but an alternative, and equally effective, mode of construction will find favour with those who have limited resources at their disposal. A hole slightly larger than the overall diameter of the bolt should be drilled and an appropriate nut should then be fixed internally, by means of an adhesive as suggested above. By this means it is comparatively simple to centre the nut, the finished instrument appearing as illustrated.

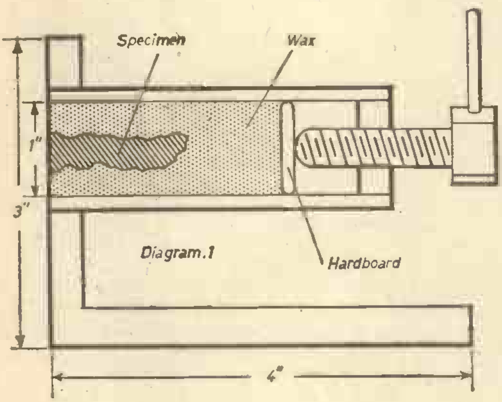
The microtome in operation

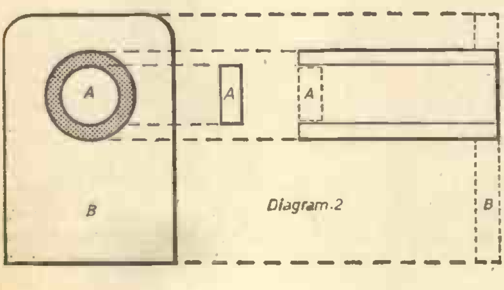
Most microscopists use paraffin wax to hold specimens in place for cutting. A disc of hardboard should be dropped into the barrel before any wax is poured in. The wax melts readily at a low temperature and sets very quickly holding even the most fragile object immovable without damaging it in any way. The solid cylinder of wax may then be advanced any desired amount by rotating the bolt head, and the extruded material is sliced off against the smooth surface of the face-plate with a scalpel or cut-throat razor.

The pitch of the screw naturally determines just how far the cylinder is pushed out for each turn of the bolt. It is desirable to know the number of threads per inch so that, whatever thickness of specimen is required, the machine can be pre-set to give the correct cut. To choose a convenient example: if a $\frac{1}{4}$in. Whitworth screw were used it would have 20 threads per inch and a complete revolution of the head would therefore advance the material by 1/20th of an inch. One fifth of a turn would result in a movement of only 1/100th of an inch, and so on.

When estimating partial turns it is of great assistance to have some clear indication of the amount of angular travel of the bolt head. This can, with practice, be gauged fairly well if a small tommy-bar is fixed to one flat of the bolt as shown in diagram Fig. 1. It can, of course, be converted into a pointer of real reliability by incorporating a 360° scale behind it. Better still, the scale could be marked to indicate, instead of angles, the amount of forward travel produced in fractions of an inch.

Alternative forms of construction based on the above outline will undoubtedly occur to the keen amateur and if they help to extend the scope of his hobby they will be equally effective in increasing the scientific enjoyment derived from microscopy.





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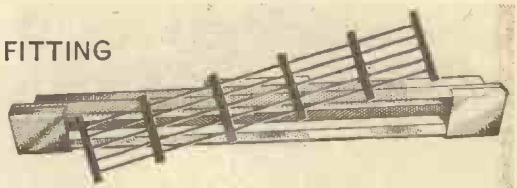


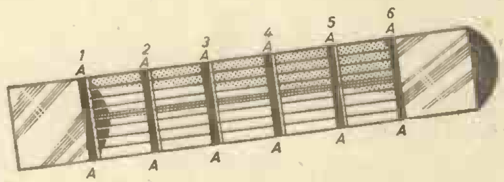
A GUARD TO YOUR

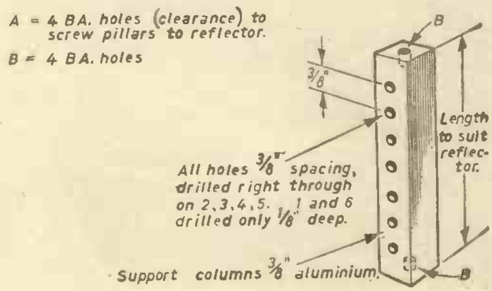
"INFRA RED HEATER"

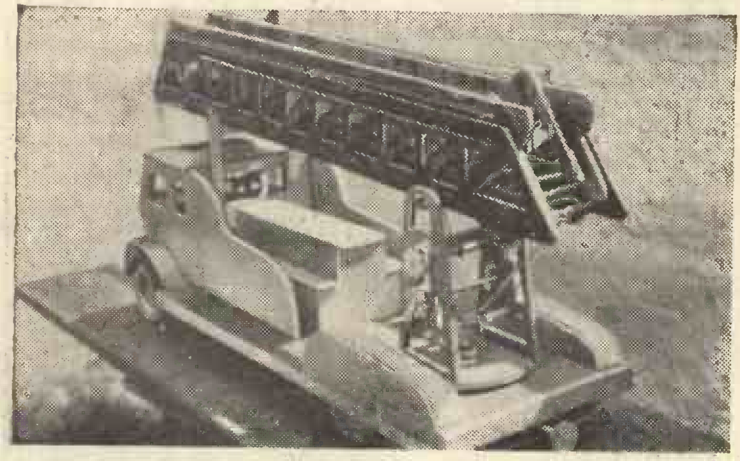
IN the July issue the construction of an infra-red heater was described but no details of a suitable guard were given. In the author's home the heater he made is permanently fixed 8ft above ground and a guard is therefore not essential. British Standard Specifications now require the fitting of guards to all forms of heating apparatus with exposed elements. There is also a legal obligation for manufacturers to fit suitable guards to their products, as is highly desirable for the safety of children and others.

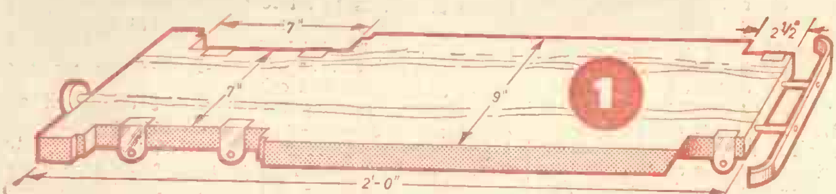
The accompanying diagrams give details of an efficient and cheaply-made guard for the infra-red heater. As can be seen from Fig. 1, six $\frac{3}{8}$in. square pillars are fixed at regular intervals. Holes are drilled at $\frac{3}{8}$in. centres in these, right through blocks number 2, 3, 4 and 5 but only $\frac{1}{8}$in. deep in blocks 1 and 6. Chromium-plated $\frac{1}{8}$in. diameter rods are inserted through the blocks, being kept in place by blocks 1 and 6. The blocks are secured to the reflector with $\frac{1}{4}$in. 4B.A. screws. The end blocks are concealed behind the end plates and should not be fitted till the rods have been inserted. A similar assembly could be brazed up from brass rod and bar, but the cost of having the assembly chromium plated might be rather high.

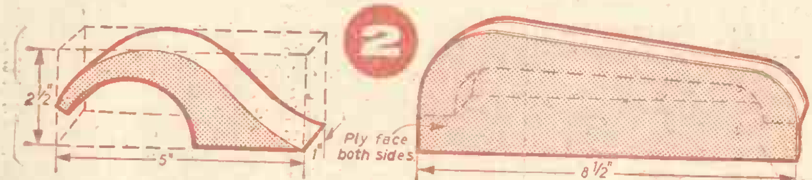
The guard shown, although permanently fixed to the heater, does not hinder the replacement of the element as all that is necessary is to remove the end plates before detaching the element.

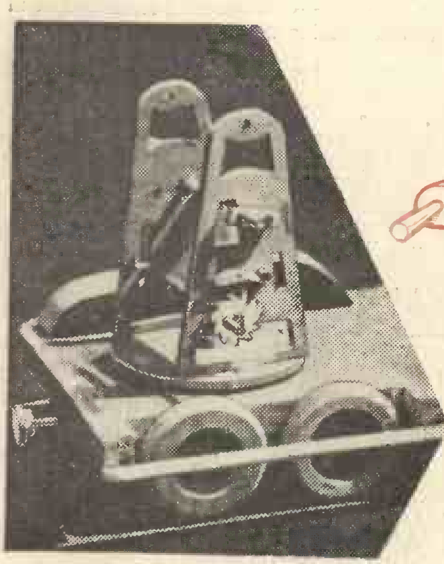


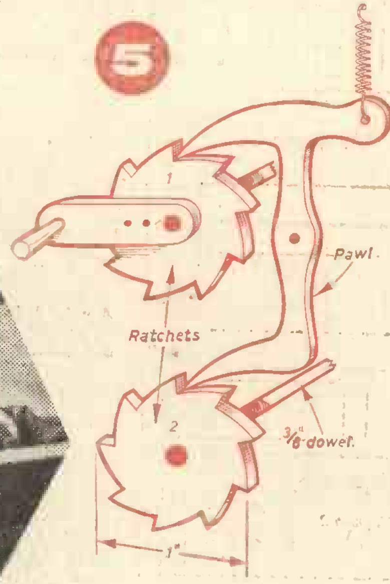





7"
7"
9"
2½"
2'-0"
1


2½"
5"
1"
Ply face both sides
8½"
2




5
1
Pawl
Ratchets
2
⅜" dowel
1"

TU

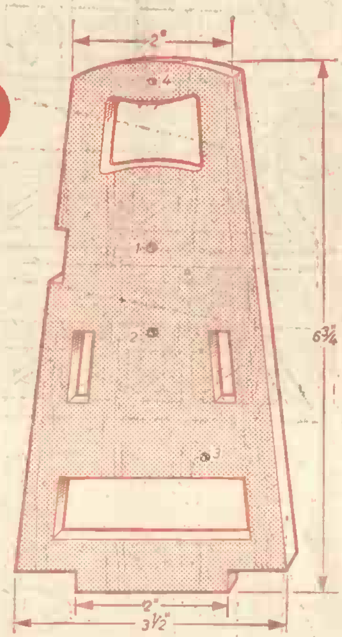

Steeri
block

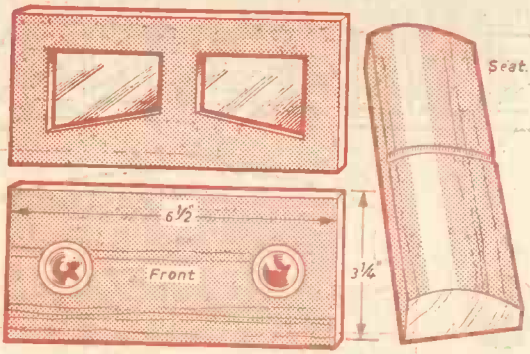
RNTABLE

FIRE ENGINE

By C. Cook

5





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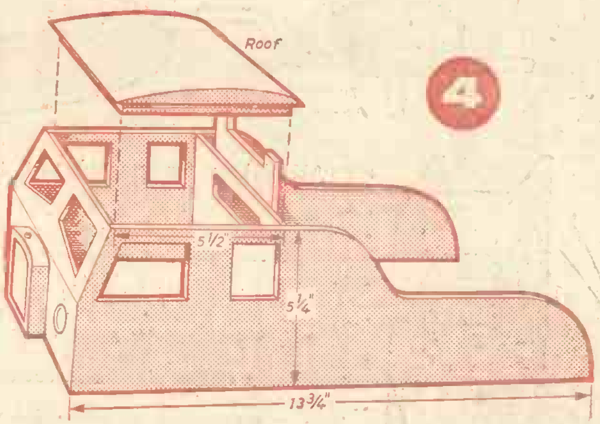

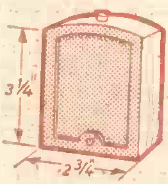

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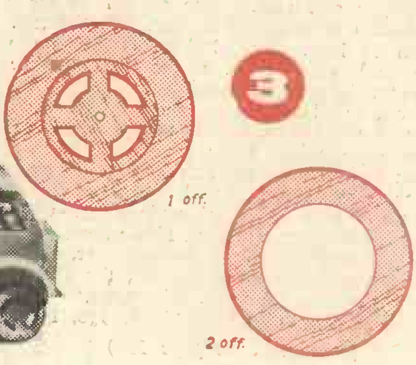
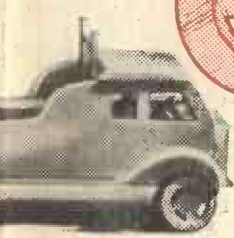
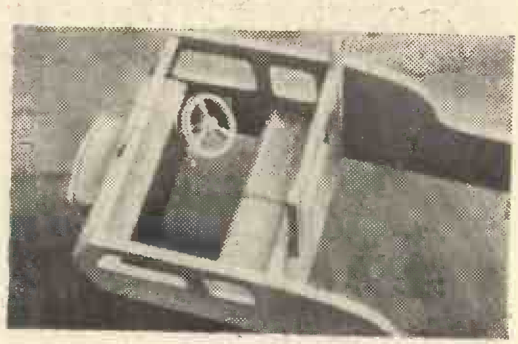
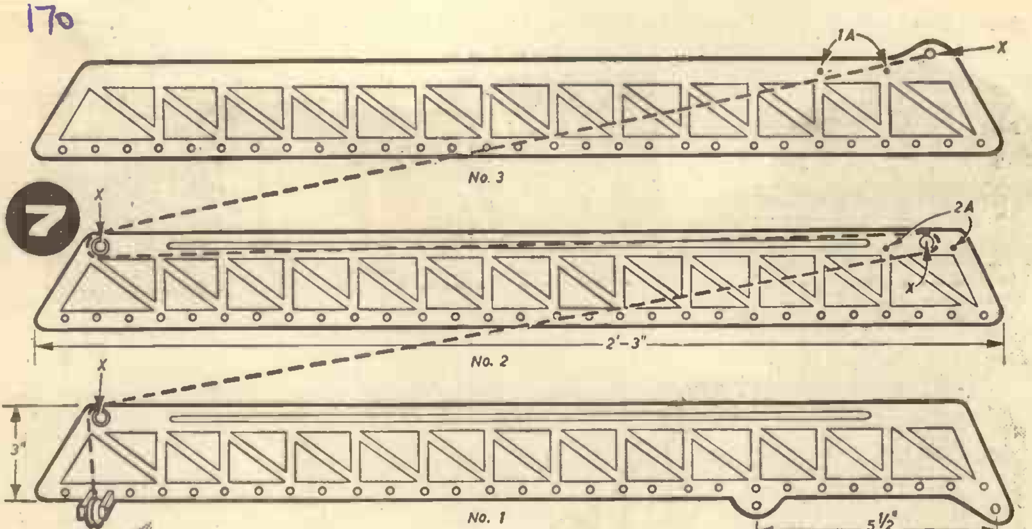
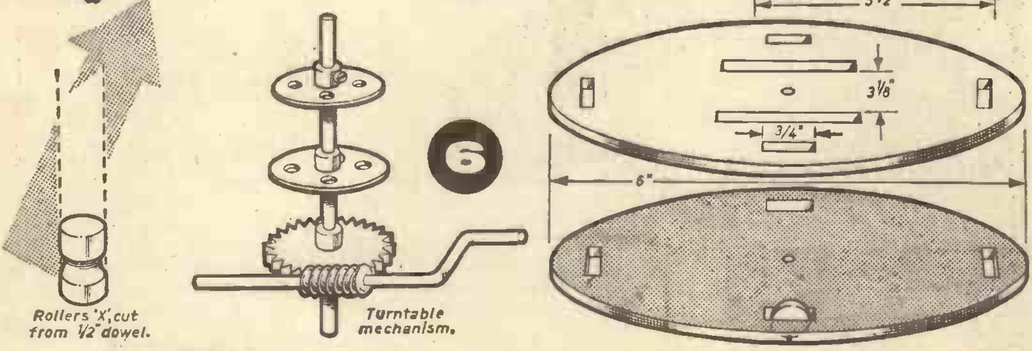
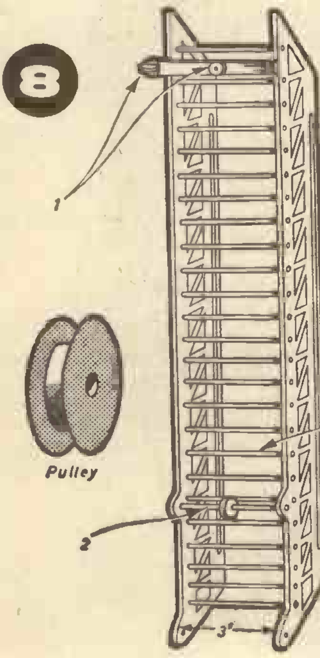












TAKING it for granted that the reader has an elementary knowledge of woodwork, only the essential measurements and details have been shown in the drawings. The rest follow quite simply in the marking out. The model shown is a fairly simple one but more technically minded constructors can add as much detail as desired.

The chassis should be made up from $\frac{7}{8}$in. thick wood, cut out as shown in Fig. 1. The wings for the wheels should be shaped as in Fig. 2. They should be roughly cut out first and then shaped with a rasp and glasspaper. The wheels should be 3in. in diameter and can be bought if preferred. If not, cut three discs as in Fig. 3, glue them together and sand to shape.

The cabin should be made from $\frac{1}{4}$in. ply, except for the seat, radiator, steering block and roof, which should be made from 1in. wood. The roof should be rabbeted to drop into the cab. The slope of the windscreen is $1\frac{1}{4}$in. The locker should be made $8\frac{1}{2}$in. long, $3\frac{1}{2}$in. high and $4\frac{1}{2}$in. wide. It should be made in the shape of seats for the crew, from solid wood or 3-ply, as preferred.

Cut out two ladder support columns as in Fig. 5. The cut-out in the left side is to take a bracing piece. Holes 1, 2, 3 and 4 all take $\frac{3}{8}$in. axles. The turntable is 6in. in diameter and slots should be cut in it to take the four rollers (only one is actually shown) and the columns. These should be spaced $3\frac{1}{8}$in. apart. The turntable mechanism (Fig. 6) should be made up from Meccano parts, which can be purchased quite cheaply. Those required are, two $1\frac{1}{2}$in. faceplate wheels, one worm gear, one toothed gear, one 6in. winding handle, one 3in. axle and 3yd of twine. All the other controls are simple ratchets and pawls cut from ply. The axles should have a small hole drilled at their centres to take the twine. No. 1 ratchet extends

(Continued on page 189)

a simple teaching MACHINE...

by Schoolmaster

Fig. 1.

THE mechanical teaching machine described in this article (Fig. 1) is efficient, cheatproof and easily constructed. Fig. 6 shows the top layout. Q=question, A=correct answer, SA=student's answer. The Q and A are on one roll (Fig. 2) and the student's answer on another. Both rolls move upwards when a knob on the side of the machine is turned.

Q1, A1 and SA1 show the first question and answers, which are all under a Perspex sheet and thus cannot be tampered with. Q2 shows the next question in position and SA2 the student's answer written through an open window on to the answer tape. The dotted lines show A2, the correct answer, hidden under the cover sheet. When the knob is turned Q1, A1 and SA1 disappear on to the take-up roller, while Q2, A2 and SA2 take their place and answers can then be compared. Meanwhile Q3 takes the place of Q2 and the process starts all over again.

Construction of case

The machine is 10in. square and about $1\frac{3}{4}$in. deep (Fig. 1). The windows in the top cover decide the area of the question and answer paper. If, however, the constructor feels that, for example, an 8in. question roll meets his requirements better than the 4in. roll described here, 4in. can simply be added to the breadth of the machine without requiring the other dimensions to be altered. In this way the machine can be constructed to suit individual requirements with the minimum of effort.

Fig. 7 shows the case, which should be constructed from stripwood of a cross-section of $1\frac{1}{2}$in. x $\frac{1}{2}$in. and should have a hardboard base. The $\frac{5}{8}$in. square stripwood supports the $\frac{1}{8}$in. x 6in. x 9in. hardboard panel which is used for carrying the writing area of the paper rolls. The stripwood also acts as stops for the paper

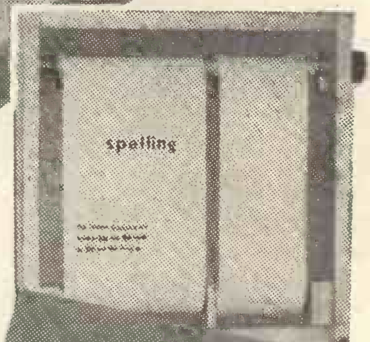


Fig. 2

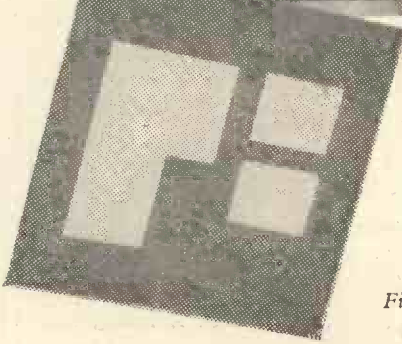


Fig. 3.

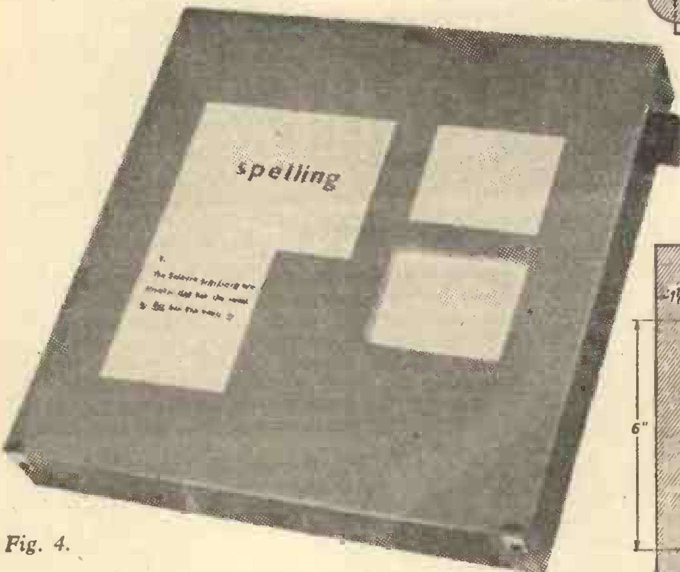


Fig. 4.

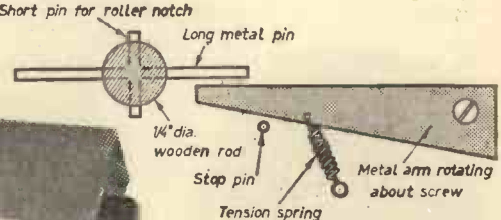


Fig. 5.

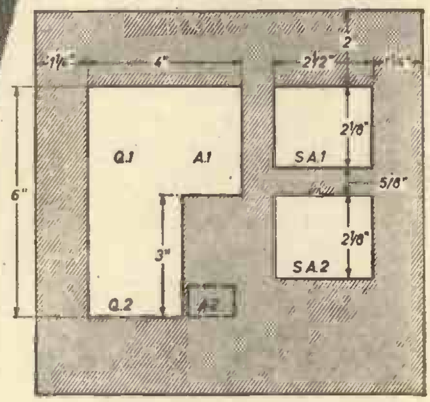


Fig. 6.

rolls (Fig. 2) and prevents too much lateral movement. The panel should be $\frac{1}{32}$in. to $\frac{1}{16}$in. below the top of the case edge. This allows enough depth for paper movement.

The case should be tilted by placing two $\frac{1}{2}$in. rubber feet at the back of the machine. This also prevents skidding of the machine on the desk top.

Case top

The $\frac{1}{8}$in. thick plastic top (Fig. 6) should be made opaque in the shaded areas only, by lacquering in any pastel shade. The student's answer window is the only one which should be cut out. The others should be left as transparent plastic. The top should be held in position on the case with two mirror clips nearest the operator and a screw through the centre of the top edge.

Roller mechanism

The question and answer rolls are held in compartments at the near end of the machine. The top end of the machine holds the take-up roller and mechanism (Fig. 8). The paper rolls can either be pinned to the take-up roller or held on with cellulose tape. The latter is preferable. With the method of construction shown, if by any chance the roller should stick when the knob is turned the pin will skid on the notched roller and there will be no damage to the paper rolls. These can be purchased from companies who supply such material for cash registers or adding machines.

Anti-cheat device

The simple device to prevent anti-clockwise rotation of the roller when the knob is turned is shown in Fig. 5. This device prevents the student turning his answer paper back if having second thoughts.

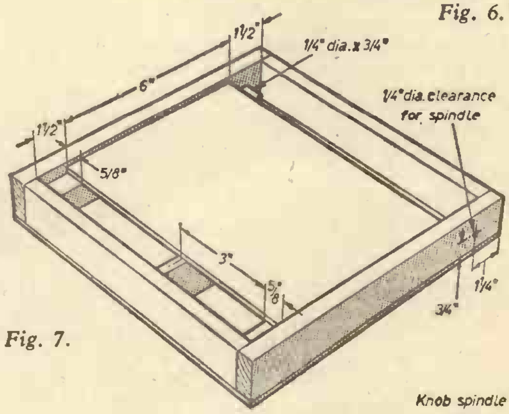


Fig. 7.

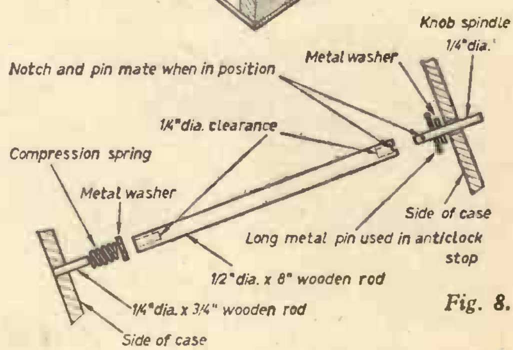
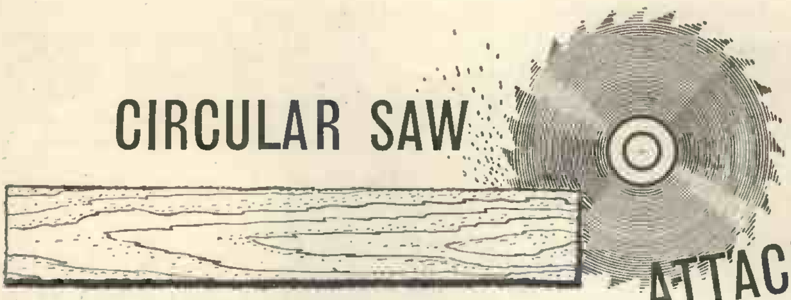


Fig. 8.

(Continued on page 190).



CIRCULAR SAW ATTACHMENT

by John H. S. Young

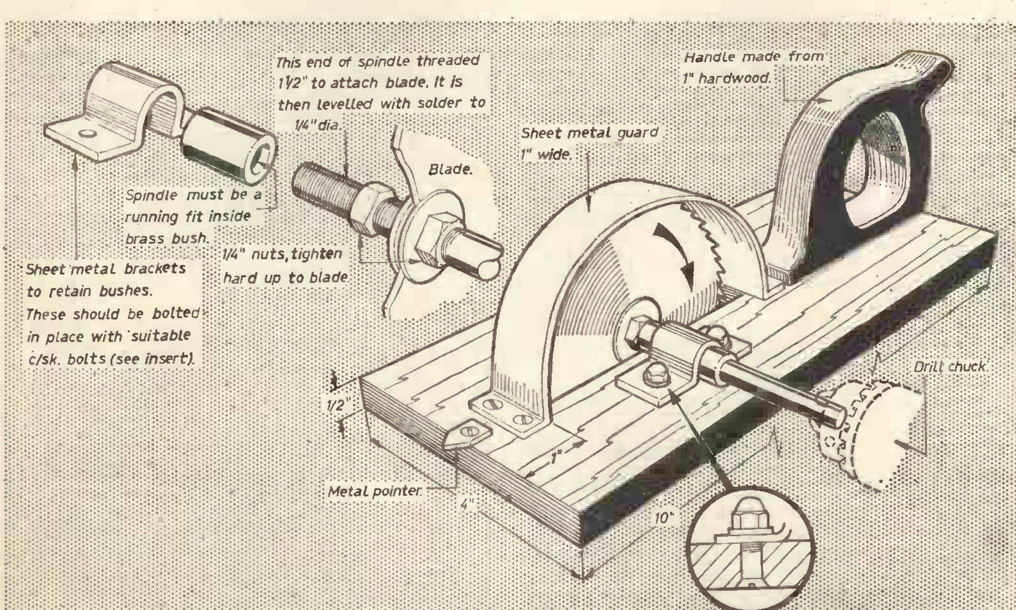
TO anyone having an electric drill the addition of a saw attachment is a useful project. The one described in the following notes was made by the writer a few years ago, and has stood up to many hours of hard work. It is easily made from odd pieces of wood; a 6in. length of $\frac{1}{4}$in. diameter steel rod; and two pieces of $\frac{1}{4}$in. bore brass tube.

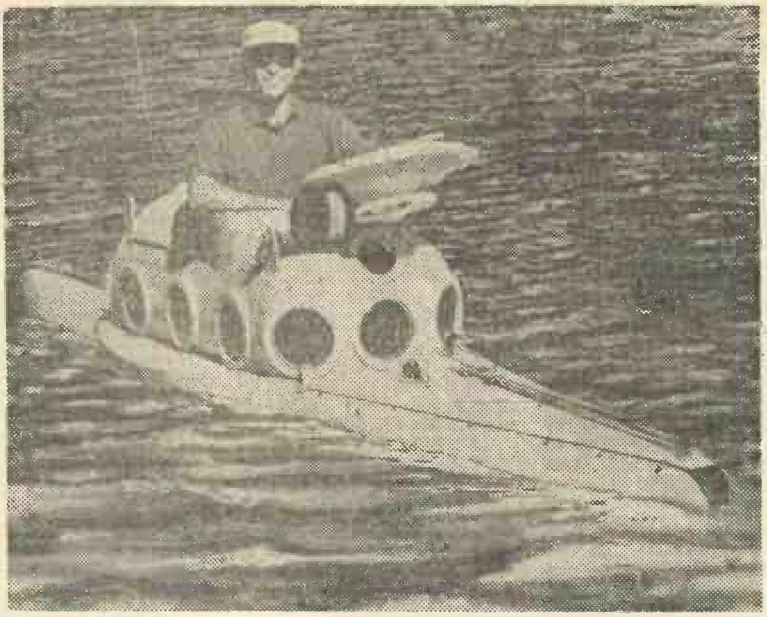
The base should be made from a piece of $\frac{1}{2}$in. thick ply about 10in. long and 4in. wide. In this a slot $\frac{5}{16}$in. wide and $\frac{3}{8}$in. longer than the diameter of the saw blade, should be cut. The slot should start about 1in. from one end. The handle shown in the sketch can be easily made from hard wood about 1in. thick by using a scroll saw and rasp.

The saw blade should be attached to the spindle by two $\frac{1}{4}$in. nuts tightened hard up on the blade. It is necessary to thread one end of the spindle for a distance of $1\frac{1}{2}$in. to accomplish this. Once the mounting is completed the threaded end of the spindle should be covered with solder and dressed down to $\frac{1}{4}$in. This is advisable as this end runs in one of the brass bushes. A sheet metal guard 1in. wide should be screwed to the base over the saw blade. A small metal pointer fitted to the front will serve as a guide to the cutting line.

The bushes should be held in position by small metal brackets and should be fitted closely to the saw holding nuts, though with sufficient clearance for free running. The handle, mounted in line with the blade, should be securely held in a shallow slot with screws from underneath. The blade used by the writer is of Wolf make and suitable for a $\frac{1}{4}$in. arbor.

A saw attachment of the size described will cut to a depth of $1\frac{1}{4}$in. and, barring accidents with hidden nails and screws, the blade will give months of good service before resharpening is required. Only light pressure should be applied, particularly when rip-sawing, as it is easy to stall the drill or possibly burn it out. This applies to all circular saw attachments used with drills other than those of industrial rating.





The Cubmarine, which is light enough to be hauled on a trailer, is rugged enough to withstand any seas.

UNDERSEA

THE NEW TWO-MAN "CUBMARINE"

SCIENTISTS are considering the use of a "dry" type, two-man submarine for hydro-biological research. The programme for which it is intended is being sponsored by the United States Office of Naval Research. The boat, which is 18ft long and only 5ft 7½in. high hatch to keel, might be useful for a wide range of undersea investigations, it is claimed.

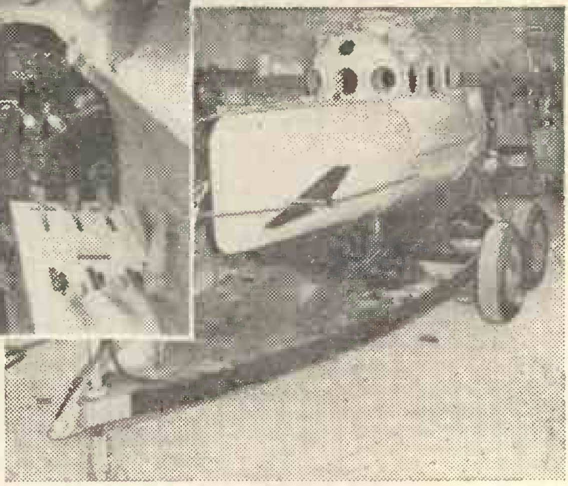
Through the use of such a vehicle, bottom communities at medium depth might be examined in the undisturbed state to obtain a true picture of the distribution of the various biological populations and their behavioral interactions. Sharks, for instance, rank high among fish which could be studied by means of a small submarine, particularly to ascertain how they are affected by various repellents and to observe at close range their reactions to various stimuli. The effects of seasonal changes or storms on the bottom sediments might also be investigated.

The Cubmarine appears to be well suited for these tasks because of its small size, manoeuvrability, hovering capacity, relatively long range (20 miles) and its diving capability (230ft maximum). Also, being a two-seater, a trained operator can pilot the machine, leaving the scientist-passenger entirely free to make observations. Another important feature from the hydro-biologist's point of view is the good visibility afforded by the craft's 12 portholes, all but one of which are 7in. in diameter. The Cubmarine is also potentially useful in many ways because of its eight-hour underwater endurance which permits continuous scientific observations to be made for long periods. Furthermore, lights and cameras can be attached to the Cubmarine and other adaptations made which will allow the installation of various collecting devices. Other features of the little boat are its strength—it is capable of withstanding 100 lb/sq. in. pressure—and its speed of five knots submerged and six knots on the surface.

The current model of the Cubmarine is the outcome of five years of research and development and the little craft has been undergoing actual sea trials and demonstrations since last December. It is the third small submarine developed during the last five years by John H. Perry, Jr., president of the *Palm Beach Post and Times*, other Perry newspapers in Florida and also TV station WESH, Orland-Daytona Beach.

Mr. Perry has just returned from making observations of the submarine in action and has expressed extreme satisfaction in the craft's manoeuvrability and visibility experienced while submerged and the numerous safety features incorporated in the Cubmarine. The builders are Perry Submarine Builders Inc., of West Palm Beach, Florida.

Interior view of the Cubmarine showing the operator's position and controls. The scientist-observer is seated behind the pilot.



Mounted on its trailer

EXPLORATION

SPECIFICATION

Dimensions: 18ft L.O.A., 3ft beam, 3ft 9in. draft surfaced, 5ft 9in. hatch to keel.

Weight: 4,000lb.

Propulsion: 4 h.p., 115 Volt, 32 Amp d.c. motor; 10 12 Volt Excel, 90 Amp hr marine batteries, 20hr rate; forward, reverse, series, parallel and rheostat groupings.
Maximum sustained speed six knots surface, five knots submerged.
Maximum range 20 miles.

Depth: Test depth 225ft; recommended operating depth up to 150ft.

Capacity: Two adults seated in comfortable sitting position on cushioned seats with back rest. Space for up to 50lb of special equipment. Arrangements can be made for more if desired. Batteries and motor are in special separate air and water tight compartments.

Controls: Aeroplane-type controls for rudder and bow diving planes. Simple blow and flood system for main ballast tanks. Simple trim system with forward and aft trim tanks. Water may be pumped or blown from tank to tank or to sea. Pilot in front seat handles all controls.

Instruments: Magnesyn remote reading compass, fathometer, two depth gauges, pressure gauges, inclinometer, voltmeter, ammeter, clock.

High-pressure air: four 2,00lb/sq. in. air bottles on two separate systems providing 270 cu. ft of air at atmospheric pressure.

Ventilation system: Air recirculating system, removes CO_2 and adds oxygen. Eight hours' capacity.

Hull: All areas subject to sea pressure are of aluminium, structural or stainless steel. Portholes are 1in. Plexiglass. Contoured outer hull is fibreglass. Lead keel shrouded in stainless steel.

Safety features: Life jackets. Ship's air mouthpieces handy to each occupant. Cockpit can be pressurised and flooded for emergency escape. Outside fitting to receive air from escort vessel or skin diver with air bottle. Cockpit, battery and motor in three separate watertight compartments.

Optional features: Two-way radio, submerged communications system, 5 h.p. main motor, 600ft test depth, 300ft operating depth, battery charger, air charger.

A LOW VOLTAGE SOLDERING AND BRAZING SET by J. L. Watts

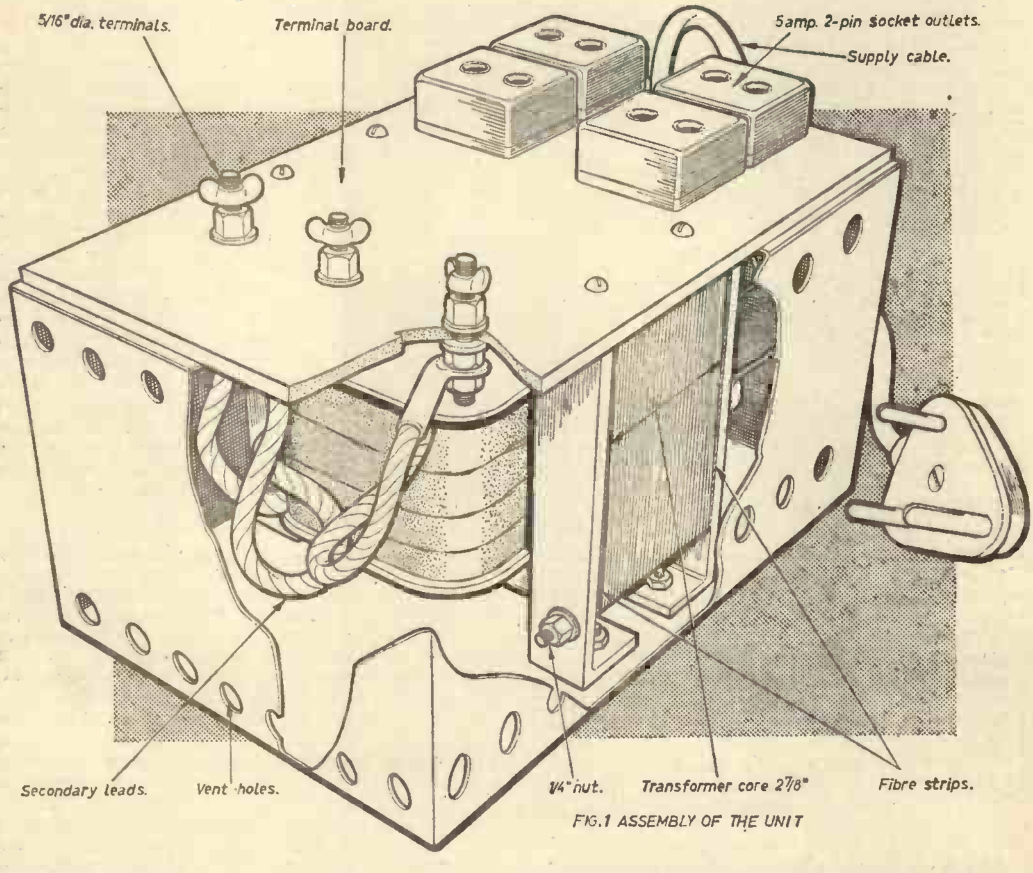


FIG.1 ASSEMBLY OF THE UNIT

ELECTRICITY is in common use for the various welding processes. It is also suitable for creating the heat necessary for soft soldering and brazing, one method being to pass current between a suitable carbon electrode and the metal. The resultant heating is proportional to the square of the current passed and to the resistance of the contact. The amount of heat applied to a contact of given resistance can thus be controlled by varying the current, in practice by varying the voltage applied between the electrode and the metal workpiece. Since the resistance between the electrode and work is quite low, only a low voltage is needed for carbon contact heating, which may be obtained from the a.c. supply through a step-down transformer. The equipment described can be constructed by most amateurs and is suitable for use on a 200-240 volt supply, taking a current of little more than 3 amps at its maximum setting.

Winding the primary coil

The most important component is the transformer, the core being built of stalloy stampings approximately 0·014in. thick to the dimensions given in Fig. 2, the stampings being lightly insulated on one side. About 200 T and 200 U stampings will be needed. The primary and secondary coils should be wound on a bobbin the dimensions of which are given in Fig. 3. The bobbin may be of Pirtoid (laminated bakelite) or may be built up from Presspahn or even plywood.

Whilst winding it is advisable to support the bobbin by mounting it on a wooden mandrel. The mandrel should preferably be mounted on a rod secured in the chuck of a lathe or in a wheelbrace held in a vice. The primary coil should be wound on first, for which 7lb of 17s.w.g. D.S.C. copper wire will be needed. About 12in. of this wire should be covered with systoflex sleeving. Roughly 1in. of this should extend into the winding space, the wire then being temporarily secured with a piece of thin string passed through one of the slots in the cheek of the bobbin. This starting end of the primary winding should be labelled A.

The coil turns should then be wound fairly tightly on the bobbin, the turns being kept close together. If there is any tendency for the wire to bulge out this should be avoided by giving the wire a contrary set as it is laid on turn by turn. It should be possible to wind approximately 52 turns in the first layer, after which the second layer should be wound back over the first. Continue thus until nine layers (468 turns) have been wound on, when the wire should be cut off, leaving a lead-out about 14in. long which should be passed through the coil cheek. Slip a piece of systoflex sleeving over the end of the lead and pass it through the coil cheek. Label the lead B as in Fig. 6. Now wind on one more layer, starting from B, insulating the lead-outs with systoflex as before and labelling start and finish C and D. In the same way wind on two more single layers EF and GH to complete the primary winding of approximately 624 turns. In order to avoid difficulty when assembling the transformer all the leads should be brought out through the two cheeks, using a pair of slots on the same narrow side of the bobbin.

The secondary winding

Over the primary winding three layers of 0·010in. thick leatheroid must now be wound, followed by three layers of 0·010in. empire cloth before winding on the secondary. It is most important that the primary winding be completely covered in order to avoid any risk of leakage between the two windings and consequent shock to the operator.

The secondary winding is more difficult than the primary since large conductors are necessary to carry the high current. For this winding 3lb of 12s.w.g. (0·104in.) D.S.C. copper wire is required. It is preferable that conductors of square section be used, though circular wire will serve if there is difficulty in obtaining square wire. The coil of wire should first be cut into four equal lengths, the four wires being lightly taped together with cotton tape for a distance of about 2ft from one end. The conductors should be secured in a square formation as at J in Fig. 6.

Some assistance will be required whilst winding the secondary, which is commenced by tying down the taped end of the conductor, leaving about 8in. projecting from the side of the coil as at J in Fig. 6. Note that all the secondary leads must be brought out from the same narrow side of the bobbin on the opposite side of the bobbin to the primary leads. The square formation of the wires should be maintained as the conductors are wound on the coil, the assistant taping the wires in this formation as the winding proceeds. The conductors should be tightly packed and may need tapping lightly into position. After winding on seven turns of the conductor (28 wires) the turns should be tied in position and the conductors cut off with a lead-out about 8in. long outside the coil, this lead being labelled K as in Fig. 6. The end L of another length of the four-section conductor is then taped and tied to K with about 8in. outside the coil as before. Wind on four more turns (16 wires), taping up as before. With care it should be possible to accommodate the 11 turns of the four-section conductor in the width of the bobbin, after which the end of the conductor should be tied in position and the lead M brought out from the coil.

Finishing off the windings

The windings should now be dried out. This may be done by standing the bobbin on a piece of wood in an oven or suspending it over an electric fire for about two hours. It is necessary that the air temperature round the coil should not be above 180-200 degrees F during this period, otherwise the coils may be damaged. Consequently the temperature should be checked periodically by means of a thermometer whilst drying out proceeds. While the coils are drying, an insulating varnish, such as the stoving type of Ohmaline or Armacell, should be placed in a suitable container of a size such that the windings can be completely immersed in the varnish. The windings should be lowered into the varnish as soon as they are removed from the oven and should be left immersed for five to six hours. They should then be allowed to drain for about an hour, during which period they should be turned round occasionally in order to avoid varnish building up at any point. The windings should then be suspended in an oven for baking at 180-200 degrees F for six to eight hours, after which the winding may be wrapped with empire tape.

Assembling the transformer

Four mild-steel mounting brackets and four clamping rods will be needed. Four pieces of $\frac{1}{16}$in. thick fibre $\frac{3}{4}$in. by $5\frac{1}{2}$in. should also be cut. When assembling the core round the bobbin the insulated sides of the stampings must all face the same way but with adjacent layers turned round so that a T stamping is always placed on a U stamping, and vice versa, with no joints coinciding.

Pass the centre limb of a T stamping through the core of the bobbin to line up with a U stamping around the bobbin. This loose U stamping will be held in place when the core is clamped up later. Place a U stamping on the T stamping, followed by a T stamping on the U stamping at the opposite end of the bobbin and so on. It is important that the T and U stampings be tightly butted together to avoid leaving any air gaps in the core, which would make the transformer inefficient and may cause the windings to heat up. Core assembly should be continued until the full $2\frac{7}{8}$in. hole in the bobbin is full, the stampings being tightly packed.

The clamping strips shown in Fig. 4 can now be assembled to the transformer core. As shown in Fig. 1 the transformer core will be mounted with its centre limb vertical, two clamps being placed over each vertical outer limb of the core with a strip of fibre between the clamp and core. The two clamps should be secured with the $\frac{1}{4}$in. screwed rods and nuts as in Fig. 1. Make sure that the rods do not touch the ends of the stampings. If the bobbin tends to become slack on the core while tightening up it should be wedged by driving a thin strip of insulating material between the bore of the bobbin and the core.

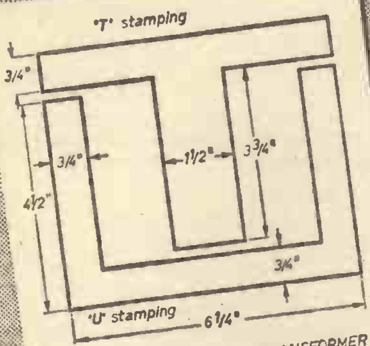


FIG. 2 DIMENSIONS OF TRANSFORMER CORE STAMPINGS

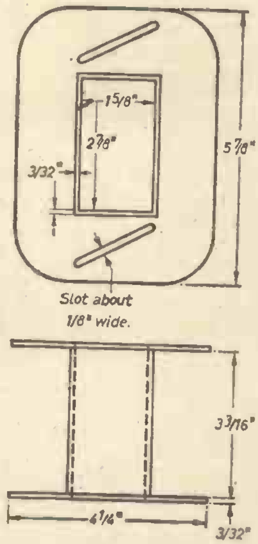


FIG. 3 A SUITABLE BOBBIN FOR THE COILS

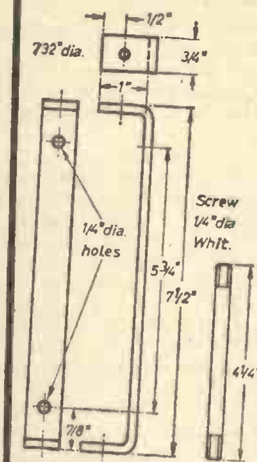


FIG. 4 TRANSFORMER MOUNTING BRACKETS AND CLAMPING RODS

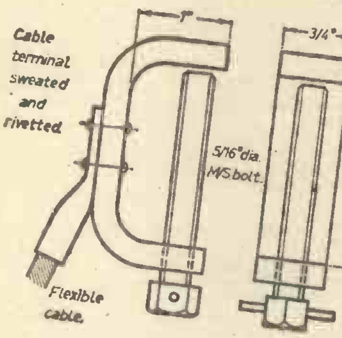


FIG. 5 WORKPIECE CLAMP

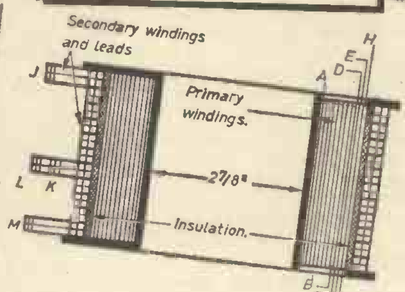
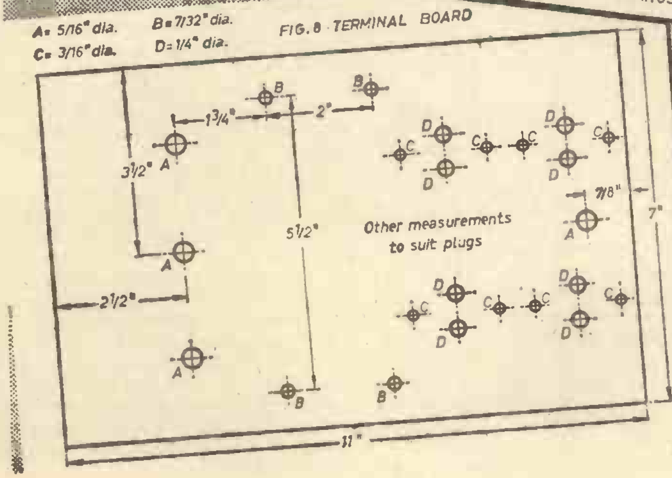


FIG. 6 ARRANGEMENT OF THE WINDINGS

FIG. 8 TERMINAL BOARD



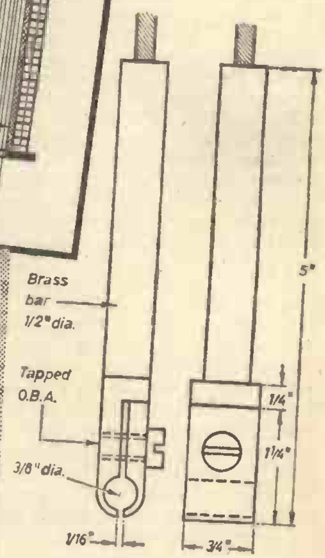


FIG. 7 ELECTRODE HOLDER

The terminal board

The terminal board should next be made from $\frac{1}{4}$in. bakelite as shown in Fig. 8. The holes C and D are for four 5-amp, 2-pin socket outlets, the holes D being $\frac{1}{4}$in. diameter for the connecting leads, while the $\frac{3}{16}$in. holes C are for the socket outlet fixing screws. The terminal board should be fixed to the clamping brackets with 2B.A. screws and nuts through the holes B. The four socket outlets should next be secured in position. Three $\frac{5}{16}$in. screwed brass rods with brass nuts and wing nuts form the secondary terminals, being fitted through the holes A at the left of the board. The hole A in the hight-hand side of the terminal board is for the three-core 23/0·0076 tough rubber flexible supply cable, which should be fitted with a suitable plug. Fit a 5-amp fuse if a 13-amp plug is used.

Connecting up

The transformer winding should be connected to the terminal board as shown in Fig. 9. Note that the red core of the flexible cable is connected to one terminal of No. 1 socket outlet, which should also be connected to one terminal of each of the other socket outlets with 3/0.029 cable or a similar conductor. The black core of the flexible cable should be connected with a porcelain-shrouded connector to the lead A from the primary winding. It is important to connect the green lead of the flexible cable to the transformer core at one of the core clamping nuts. The flexible cable should be secured so that the internal connections will not be disturbed if the cable should be pulled.

Four cable lugs are required for connecting the secondary windings to their terminals. These should be fitted as in Fig. 1 and the secondary leads bent round and cut off as necessary. Fig. 9 shows the connections, from which it will be seen that a four-strand secondary lead will enter each cable lug, two cable lugs being required on terminal Y. The ends of the conductors should be tinned and sweated into the lugs. In case of difficulty the terminal board may be removed during this operation after bending the leads into the required positions. The primary leads B and C should be connected together at the second terminal of No. 1 socket outlet, the leads D and E at the second terminal of No. 2 socket outlet, leads F and G at the second terminal of socket outlet No. 3, while the outer lead H of the primary winding should be connected to the second terminal of No. 4 socket.

The case could be made from one piece of thin sheet iron or aluminium 27in. by 24in., cut and bent to form an open-topped case 11$\frac{1}{2}$in. long by 7$\frac{1}{2}$in. wide by 7$\frac{1}{2}$in. deep with a ledge about $\frac{1}{2}$in. wide at the top as shown in Fig. 1. The edges of the terminal panel may then be drilled and the panel secured to the ledge with self-tapping screws. The case could also be built from five separate pieces of sheet metal. A row of $\frac{5}{8}$in. ventilation holes should be drilled round the case at the top and bottom on all four sides.

Workpiece connector and electrode holder

Fig. 5 shows the construction of a clamp by which to connect the set to the workpiece and Fig. 7 shows a suitable electrode holder. A cable lug should be riveted and sweated to the clamp and a hole drilled in the end of the electrode holder. The ends of a 5ft length of single-core 266/0·012 tough rubber sheathed flexible cable should be sweated into a cable lug and into the workpiece clamp. One end of a similar cable should be sweated into the electrode holder, after which a suitable wooden handle may be passed over the cable and pressed on to the end of the electrode holder before sweating the other end of the cable into a cable lug.

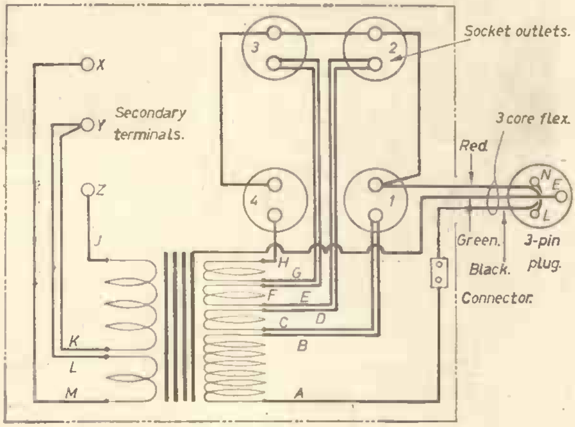
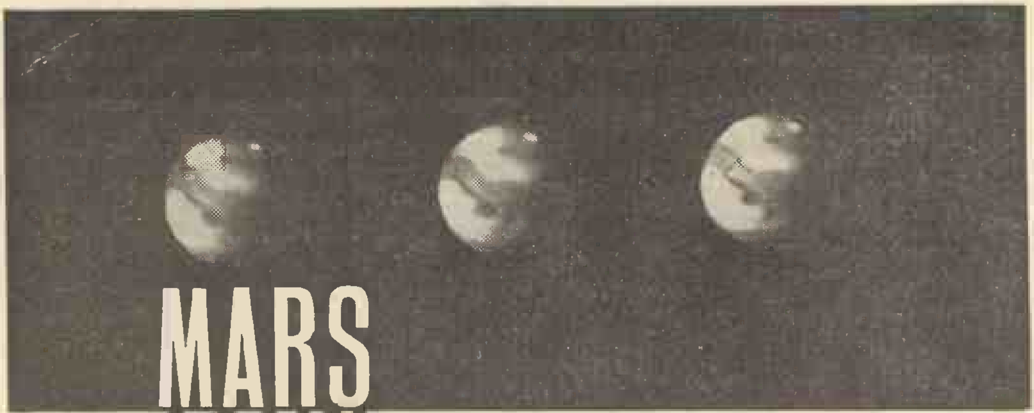


FIG. 9 DIAGRAM OF CONNECTIONS

Control and use

The heat can be controlled in two ways: by using various secondary terminals and by inserting a 5-amp, 2-pin shorting plug in any one of the socket outlets. The terminals of the 2-pin plug should be connected together inside the plug with a piece of stout copper wire. It is important not to use this plug on any other circuit, so it should be tied to the set. For maximum heat the leads to the workpiece clamp and electrode holder should be connected to secondary terminals X and Z. For medium heat they should be connected to terminals Y and Z and for low heat they should be connected to terminals X and Y. Fine control between these ranges is provided by inserting the shorting plug in one or other of the socket outlets, maximum current being provided with the plug in socket outlet No. 1 and minimum current with the plug in socket outlet No. 4. The plug should not be moved without switching off the main supply.

The electrode used is a $\frac{3}{8}$in. diameter carbon rod. This should be clamped in the end A of the electrode holder with about $\frac{1}{2}$in. of the carbon rod projecting from the holder. This end of the rod should be pointed. After securing the workpiece clamp to the work and applying a suitable flux the set may be switched on. The electrode should then be applied to the work to warm it up and the filler rod should then be applied to the work and/or electrode in the usual way. Provided the unit has been properly constructed and the transformer core earthed the unit is perfectly safe and there is no risk of shock as the maximum voltage between the secondary terminals is no more than six volts.



MARS AGAIN

The Russian rocket to Mars revives the controversies about the nature of the planet. V. A. Firsoff, M.A., F.R.A.S., discusses what we know about it at present.

17th August **A** *1955.*

17th February **B** *1948.*

11th September **C** *1956*

ON November 1st the Russians lobbed a rocketful of 1,970 lb of scientific instruments into space towards Mars, and apparently this 'automatic interplanetary station' is on course and going strong. It is expected to take and record various measurements, send information back to Earth, enter a close orbit about Mars, take photographs and return to the Earth's vicinity where these photographs will be televised to the scientists. An ambitious programme—too ambitious perhaps—but even if only partially successful it could add a good deal of our uncertain knowledge of this intriguing world.

Mars has figured so largely in fiction and speculation that an astronomer cannot help feeling a little awkward about it. There exist time-honoured ways of dodging some of the Martian issues. For instance, when the Italian Schiaparelli discovered the so-called 'canals' in 1877 he used the Italian word *canali*, which stands for channels, not canals, to describe the fine straight lines on the planet's surface. But the American enthusiast Percival Lowell believed them to be an artificial irrigation system on a desiccated globe. Controversy has been raging for years about the existence or non-existence of the Lowellian canals, and, truth to tell, the matter has not yet been settled. Some kind of rectilinear markings are there, but more probably could be tectonic fractures through which water vapour ascends from underground, thus giving rise to vegetation.

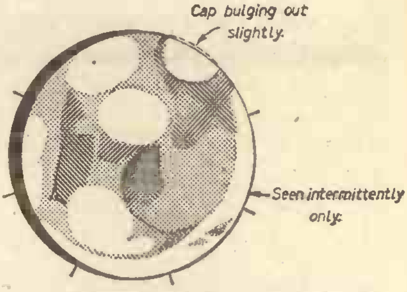
An equally involved controversy is centred on the nature of the dark *maria* or 'seas' of Mars. That they are not seas there is little doubt; but what are

The sizes of Mars as seen through the telescope at the same magnification but at different times. 1948 was an unfavourable opposition, 1956 a favourable one.

they? The balance of evidence is in favour of their being vast vegetated areas. Recently Dr. W. M. Sinton has found in the infra-red spectrum of Mars three absorption patterns, characteristic of the carbon-hydrogen bond in organic molecules, which are strongest in the maria. Two of these are found in the spectra of terrestrial land plants and the third in that of some species of algae. Is this sufficient evidence of life on Mars? Some think not.

Mars is the best known of the planets, but this is not saying much. It is a small, Earth-like world, 4,200 miles in diameter, fourth out from the Sun and 141 million miles away from it on the average. But the orbit of Mars is eccentric and this distance varies by 13 million miles either way, which, jointly with the fact that the Earth's own orbit is slightly elliptical, explains why the closest approaches of the two planets may vary from 35 million miles to as far as 63 million miles. The latter occurs about once every two years, at opposition, *i.e.* when Mars is exactly opposite the Sun in the sky and highest up, at midnight. This variation in distance makes a lot of difference to the telescopic appearance of so small a body as Mars (see drawing), and the coming opposition of February 3rd is about as unfavourable as can be, with Mars 61,800,000 miles away. At opposition, Mars is full; although, being outside the Earth's orbit, it never shows much phase. About the maximum phase effect can be seen in the photographs reproduced here. There is little cloud in the atmosphere of Mars and so we get a good view of its full face at opposition; this shows much firm detail, but even so, Mars at best does not appear any bigger in a large telescope than the Moon through a pair of binoculars.

We know that the Martian year is about twice as long as ours, the day is very nearly 24 hours, and the inclination of the polar axis is barely some 30′ more than the Earth's. Thus the two worlds have very similar climatic zones and seasons (the Martian ones being about twice as long as ours however). Here however the resemblance ends. The surface gravity of Mars is only two-fifths of ours and this has various far-reaching consequences. Also the heat of the Sun is two and a quarter times less at the distance of Mars. This is partly offset by the lack of clouds in the Martian air. Mars reflects back 15% of the radiation falling on it, whereas the cloudier Earth casts off 39% of the sunlight it receives. As a result it is quite warm in the equatorial regions of Mars, where temperatures of up to +30°C (86°F) have been recorded. But by the same token it gets very cold at night, though how cold exactly we do not know because the night hemisphere of Mars is not accessible to observation. The mean annual temperature of the surface, as estimated by myself on certain reasonable assumptions, would be −16°C (3·2°F) as against +14·2°C (57·6°F) for the Earth.



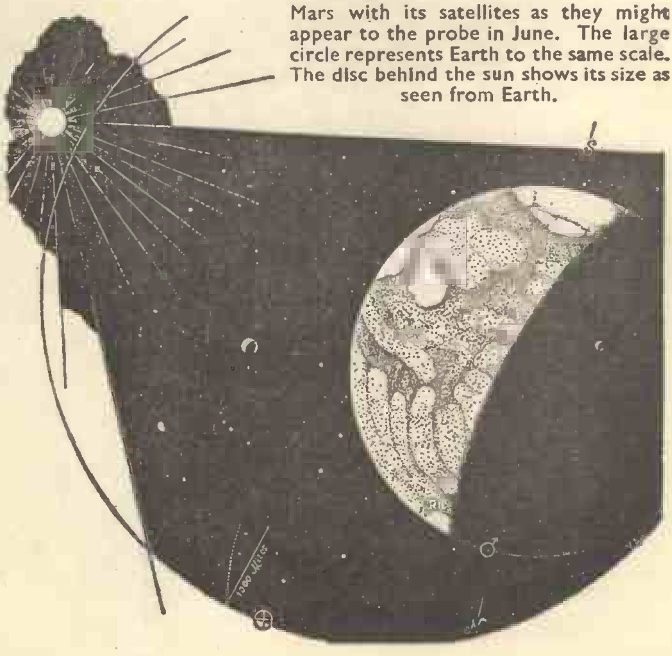
An observational drawing of Mars made by the author in 1956.

Yet all such estimates are highly speculative. We can measure only the heat that escapes through a planet's atmosphere and is further depleted in our air; the deficiencies have to be made good from theory. It is a salutary reflection that the Earth radiates to space as though its mean annual temperature were −24°C (−11·2°F) fully 38°C below the actual. This is due to the so-called greenhouse effect of the atmosphere, and the greenhouse effect of the Martian atmosphere is conjectural.

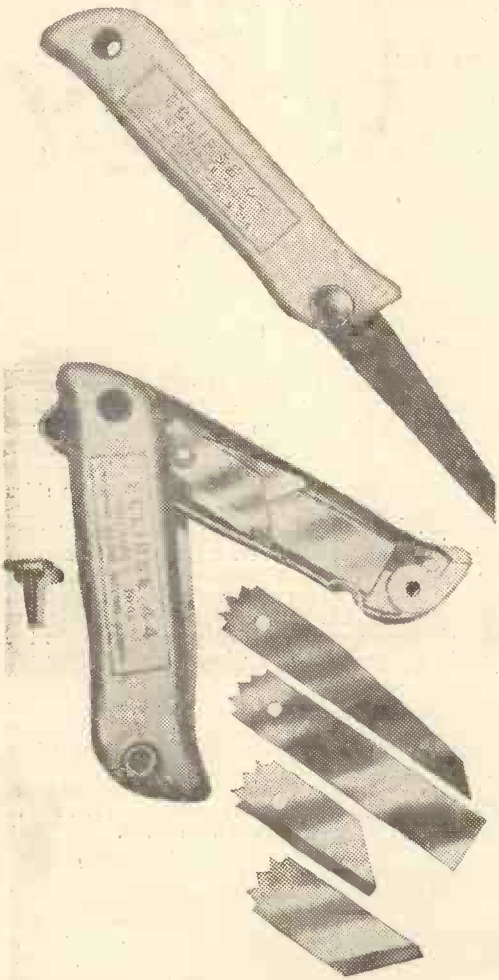
Although there is little cloud on Mars, its skies are often hazy at various levels. Some 80 miles above the ground spreads the so-called 'violet layer', believed to consist of fine ice crystals, which cuts off the radiation of short wavelengths. Also, large areas of the surface are often veiled by a yellow haze, most probably fine dust in suspension; while the Russian astronomer N. A. Kozyrev adds to the list a 'yellow-green' haze at a lower level. There are also more conventional white mists, especially near

(*Continued on page 190*)

Mars with its satellites as they might appear to the probe in June. The large circle represents Earth to the same scale. The disc behind the sun shows its size as seen from Earth.



TRADE NEWS



A new aid to spraying paint

THE Humbrol Jet Pak Spray Gun is the newest aid to household painting and spraying jobs. There are no wires, no complicated fitting to do. It is a complete spray outfit that can be used and carried easily in one hand anywhere. It will spray paint, insecticides, penetrating oil and a host of other liquids by a simple press-button action. It is always ready for use and quick switches of materials can be made—simply—by changing glass containers.

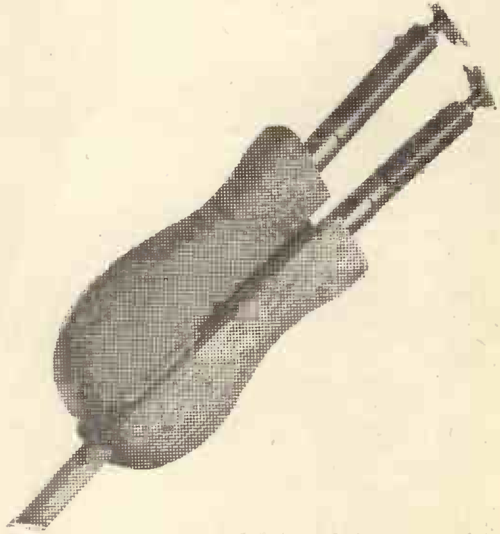
The Jet Pak costs 35s. complete. Replacement Power Units and extra glass containers are available at 10s. 6d. and 1s. 6d. each respectively.

Novel stripper for PVC covered wire

AN ingenious wire stripper with electrically heated elements for PVC covered wire is now available from Labgear Ltd., Cambridge. It is extremely simple to use, the wire being gripped by two V-shaped prongs which heat the PVC and allow it to be gently pulled off, leaving the conductor undamaged and ready for connection. This completely eliminates time-wasting faults arising from nicked or even cut wiring which could be caused when using old-fashioned mechanical-type strippers.

It is also completely safe to use as it operates from a low voltage supply (12 volts).

A suitable 12V transformer is also available.



New multiple tool

AN addition to the "Eclipse" range of tools is the No. 44 Multiple Tool. This is a handy and versatile tool which can be used for innumerable jobs in the home and garage and for engineering work.

It is a compact, self-contained outfit having four blades for sawing, slotting, slitting and scribing which, when not in use, can be housed in the handle.

Each blade can be positioned at any one of four different angles, a feature which adds greatly to the utility of the tool. The blades are made from specially heat-treated high-grade steel which will give good service and long life. Spare blades are available.

The complete tool retails at 8s. 6d.

TEA TROLLEY

by

LAWRENCE OLDFIELD

THIS trolley was designed in an attempt to break away from the conventional rectangular style, whilst still retaining relatively simple construction. This has resulted in curved sides, and "boomerang" shaped legs, angled inwards. The framework was cut from an old mahogany mantelpiece, but oak or some other hardwood would be equally satisfactory, provided that plywood of the same colour can be obtained for the trays. Wood of this nature is invariably hard to saw and plane, so after being marked out, it could be taken to the local woodyard. Here it can be sawn for a small fee, provided that no nails are present. A generous allowance should be made for the thickness of the saw cut (approximately $\frac{1}{8}$in.).

The legs should be cut from $\frac{7}{8}$in. wood, and should be shaped in accordance with the dimensions shown in Fig. 1. It will be helpful if the marking outlines are left on at this stage, as they will be required when the joints are made. The sides are strips $\frac{5}{8}$in. x $1\frac{1}{4}$in. cut to the lengths indicated in Fig. 2. Additional pieces will be required to enable the side pieces to be shaped to a curve. These can be obtained from the odd pieces cut off when making the sides.

When the sides and shaping pieces have been planed to the required widths, thicknesses and lengths, the shaping pieces should be glued to the sides, using a resin glue such as "Cascomite". While these are setting, it is a good plan to make two templates to facilitate the mark-out of the curves on the sides, one for the long sides and one for the short sides (Fig. 2). Before the marking and cutting out of the curves can be done, the ends must be squared off and the tenons cut, otherwise it will be difficult to obtain the 45° angle required (Fig. 2). It is best to make all the tenons at the same time, using the same gauge setting throughout so that all will be the same size, and thus interchangeable on the legs.

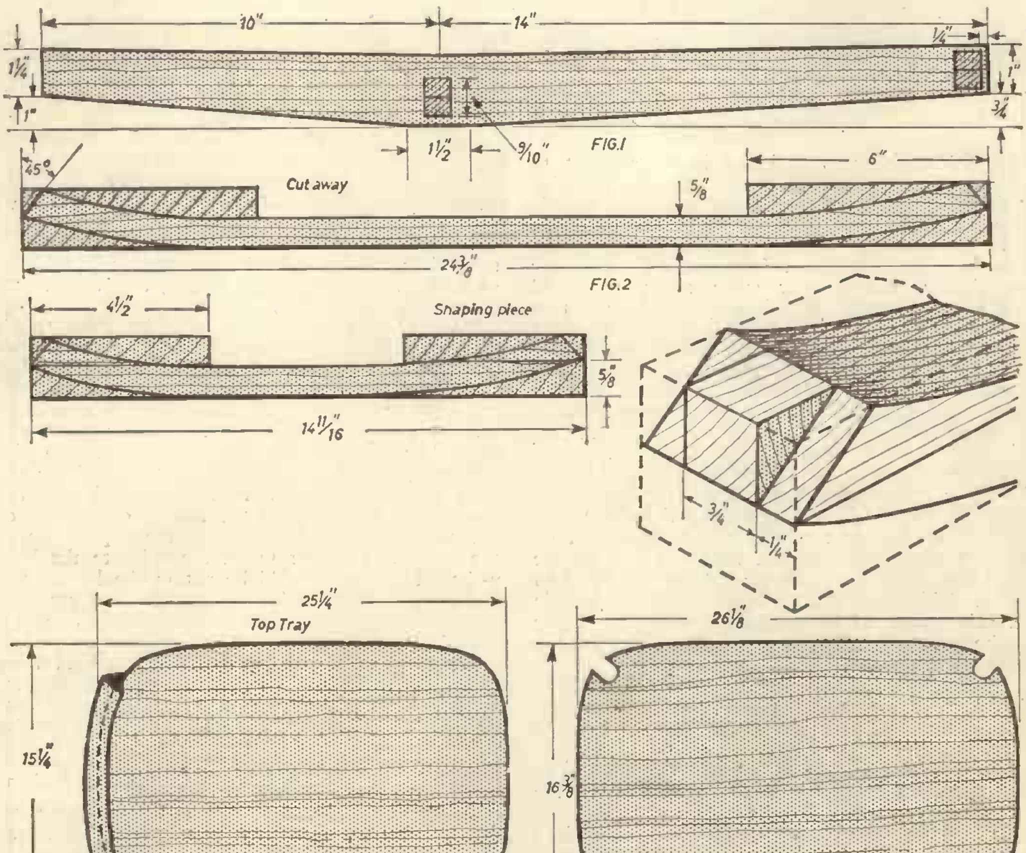
Shaping of the sides can now be commenced, this being effected by sawing down to the line at frequent intervals and finishing off with chisel and spokeshave. It is important not to encroach over the lines at the ends as this may result in gaps appearing when the trolley is assembled; excess can always be trimmed off after completion. An $\frac{1}{8}$in. chamfer should be applied to the inside of the top edge of all eight pieces. This considerably aids the constructor in obtaining the correct orientation of the sides, as well as enhancing the appearance of the trolley. In order to fix the sides to the legs, v-shaped grooves should be cut in the legs at top and bottom (Fig. 1). These must be very carefully marked out, remembering to have a gap of about $\frac{1}{16}$in. between the ends of the sides and the edges of the legs, so that the legs may be rounded after completion. The top grooves especially require great care in cutting or the grain will split out; although this difficulty could be overcome by making the tops of the legs project above the sides. A sharp $\frac{1}{2}$in. chisel should be used, the 90° edge being used to determine the correct depth.

When all the joints have been cut and are good fits, it is a good plan to have a mock assembly so that measurements can be taken for the trays. It is also a good idea to draw a pencil line along the bottom of each side so that the grooves for the trays will be made along the right edges. Two double loops of picture cord and eight short twisting pegs is the best means of cramping the trolley together; one double loop round each set of joints.

The trays, which should be prepared from ¼in. plywood, veneered or ordinary, should be slotted into the sides by means of ¼in. grooves. A plough plane will make quick work of this, but the job can be done with a sharp knife and a ¼in. chisel, if used with great care. If the knife and chisel method is adopted, the same gauge setting must be used on each side to ensure correct alignment when the trolley is assembled. When the trays have been cut to a rectangular size, ½in. longer and wider than the inside dimensions of the tray frame, the actual outline should be marked out, using the sides themselves as templates. It will be seen from Fig. 3 that the trays differ slightly in shape, this is due to the fact that the legs need to be stronger lower down and cannot be grooved too deeply without seriously impairing the strength of the trolley. The fitting of the upper tray requires shallow grooves to be made in the legs, the depth of which should be adjusted until all joints close when the assembly is cramped up. The lower tray requires similar treatment, except that pieces should be cut from the tray, and the sides of the legs should be grooved as well as the edges. At this stage the inside edges of the legs should be chamfered, ¼in. at the bend, tapering to ⅛in. at each end.

When all joints fit to satisfaction the assembly should be glued, taking care not to spill it where it is not wanted, otherwise complications may arise when cleaning up operations commence. It is a good plan to stand the trolley on a flat surface and weight it whilst the glue is setting so as to obviate any potential wobble.

When the glue is thoroughly set any excess should be removed from the joints, and the legs rounded to follow the curves of the sides. Sandpaper should then be used to smooth off and prepare the surfaces for polishing. The castors fitted should be of the "ball" type for best results; these can be purchased with push-in fittings and provided the holes in the legs are drilled straight and true should present no problems in fixing. For the final finish it is recommended that white polish be used on the bare wood, each coat being rubbed smooth with flour-paper before applying the next. After the final coat, steel wool dipped in wax polish should be rubbed on the whole assembly. A rub with a soft rag will then produce the final finish.



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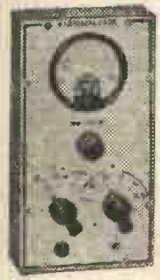

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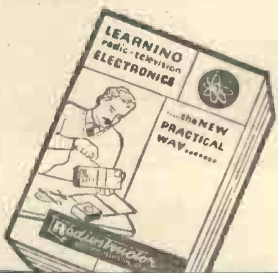

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EMERGENCY LIGHTING for slot-meter users

By K. V. R. BOWERMAN

IF you have a pre-payment electricity meter (*e.g.*, 1s. in the slot) you must have been plunged unexpectedly into darkness at some time or other. This is embarrassing if you have guests and can be dangerous for older folk who may trip or fall while trying to find the meter. One cannot always be sure of having a torch or candle to hand. This simple emergency lighting system eliminates inconvenience and danger from sudden blackouts. As soon as the main electricity supply fails for any reason, a number of 2 volt torch bulbs light up at strategic points around the house. It is suggested that one of these over each doorway and one near the slot-meter should be adequate. The system relies on a relay which holds a pair of contacts open until the supply fails, whereupon the contacts close and bring into circuit the 2-volt bulbs, which are fed from an accumulator.

The circuit

See Fig. 1. RY1 is a G.P.O.-type relay with a 10,000 ohm coil. It has one pair of contacts which open in the "energised" position and close when no voltage is applied. The relay is fed directly from the mains via a wire-wound 100k pre-set potentiometer and a rectifier, MR1. The relay takes only about 3mA at most in this circuit, so almost any metal rectifier will do provided it is suitable for up to 50 volts working. This part of the circuit has a torch bulb included as a fuse. While the mains are "live" the relay is energised and the contacts are open. When the mains fail the contacts close and connect the accumulator to the emergency bulbs, which light up and remain alight until the mains supply is restored by the insertion of a coin.

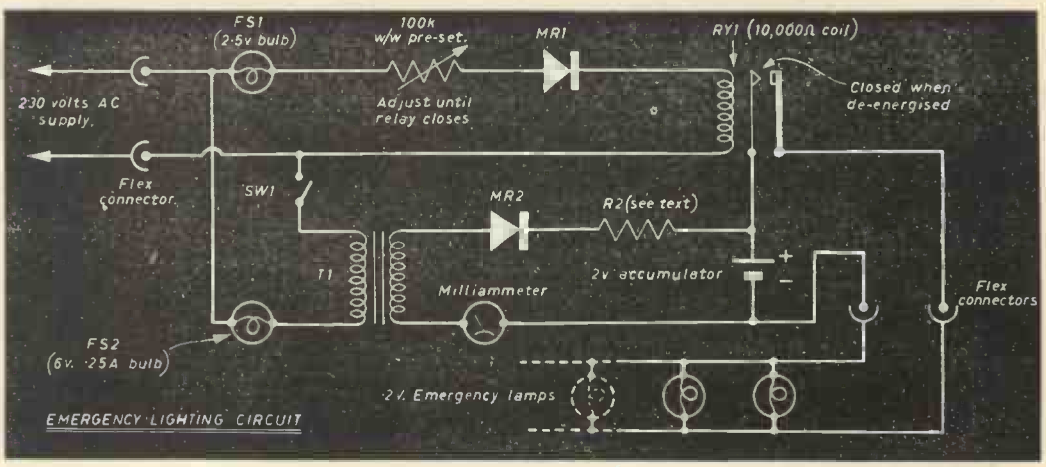
The second half of the circuit is a simple trickle charging scheme for keeping the accumulator charged. T1 is a radio component, a filament transformer delivering 6 volts at 2 amps. The current from this is rectified by MR2, which should be capable of passing 6 volts at 2 amps. The charging current is adjusted to the right value by resistance R2. This should be a wire-wound component rated at 2 watts and having a value of about 5 ohms. Such a value may be difficult to obtain but can easily be made up by joining two 10 ohm or four 20 ohm resistors in parallel. The charging rate with this resistance in circuit is approximately ½ amp. A milliammeter inserted at "X" will show the exact rate, although this is not critical as long as it is not greatly in excess of ½ amp.

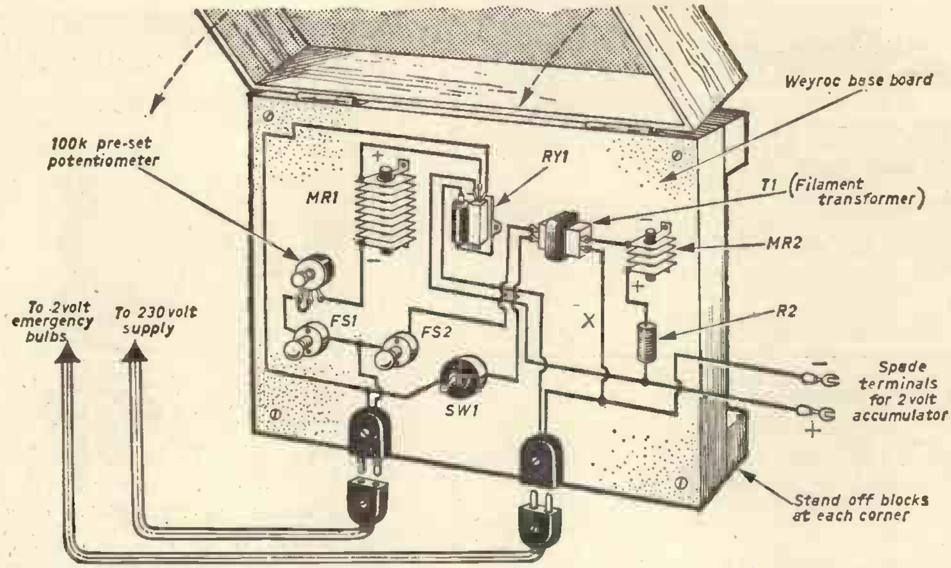
Construction

This equipment lends itself well to the "bread-board" type of layout. A piece of five-ply wood (or "Weyroc") about 8in. x 6in. should take all the components comfortably (see sketch). The relay can be mounted by passing a thin strip of tin or aluminium over the coil and securing each end of the strip with a wood screw. Mount the relay, transformer and rectifiers first. Follow by mounting the two lamp-holders. The two resistors may be suspended in the wiring without further support. Use a fairly heavy gauge of tinned copper wire for wiring up and insulate it with sleeving. Connections to the relay, transformer, rectifiers and resistors will have to be soldered; other components will probably have screw terminals.

You will notice that the incoming leads from the mains and the outgoing leads to the emergency

(*Continued on page 188*)





lamps are terminated by flat two-pin connectors. When the main wiring on the panel is complete join the socket (female) half of one pair of connectors to a flexible cable long enough to reach a wall socket or, alternatively, the fuse box of the mains supply (see under "Installation"). Do not connect this cable to the supply yet. The plug, or male half, of the connector should be wired to one side of SW1 and to one side of the fuse FS1. The screw and nut of the plug should be discarded and a wood screw of suitable size may then be passed right through the assembly to secure it to the baseboard. The same treatment can be given to the emergency lamp connector except that this time the socket should be mounted on the baseboard and the plug should be connected to the outgoing lead.

As a safety measure the completed panel should have a wooden lid fitted over it to prevent accidental contact with live parts. A lid can easily be devised from three-ply wood and battens as shown above. Don't forget to cut three slots in the lid for the entry of mains and lamp leads and for the accumulator lead. This last should be of heavy gauge flex terminated by spade terminals clearly marked "positive" and "negative" (+ or −) or colour-coded red and black. The accumulator should stand on a piece of glass or other insulating material which is unaffected by acid.

Installation

Remove the lid. Drill four holes, one at each corner of the panel, to take No. 6 wood screws. Make four wooden blocks from five-ply offcuts about 1in. square. Drill holes through the centre of each, using the same drill. Now secure the panel to the wall near the meter, using the four pieces of plywood as stand-off blocks. This procedure helps to minimise any possible effects of damp. Connect the accumulator. Plug in the emergency lamps, which should light. If all goes well disconnect the accumulator. It is now necessary to connect the mains supply cable to the mains. You can either terminate this cable with an ordinary two or three pin plug and plug it into the nearest wall socket or you can connect the cable directly to the supply at the fuse box. To do this proceed as follows: Switch off the main switch of the electricity supply. Open the cover of the fuse box. Withdraw a pair of fuses known to control one of the lighting circuits. On the house side (*not* the supply side) of each fuse-holder loosen the grub screws securing the outgoing cables to the house lighting circuit and withdraw them from the connector. Strip the insulation from about ¼in. of each lead in the mains supply cable coming from your emergency lighting panel and make a twist joint with each of the outgoing cables to the house lighting circuit. Insert each twisted joint into the appropriate connector on the fuse-holder and secure the twisted leads with the grub screws.

You may now test the relay circuit. Reconnect the accumulator. The emergency lights should come on again. Now switch on the electricity supply. The relay should operate and the emergency lamps go out. Switch on and off at the mains a few times to make sure the relay works correctly. If it does so the emergency lamps should light whenever the mains are switched off. This is, of course, what we set out to achieve.

Charging

It is recommended that SW1, the charging switch, is switched on for a period of two or three hours every week to keep the accumulator up to scratch. If the emergency circuit comes into operation at any time for a longish period—more than half an hour, say—give an additional charge to the accumulator, equal to twice the time for which the emergency lasted. Occasionally top up the accumulator with *distilled* water before charging. Keep the terminals clean and thinly coated with "Vaseline".

BOOKS Received

" The Amateur's Lathe " by L. H. Sparey. 224 pages. Price 20s. Published by George Newnes Ltd., Tower House, Southampton Street, W.C.2.

HERE is a book that every amateur, every small garage proprietor and every light engineer will find of unending interest. The author has succeeded in giving a complete course of instruction embracing almost every process that can be accomplished on the highly adaptable small lathe.

A refreshingly new approach to the amateur's problems, combined with an extensive knowledge of professional practice, enables the author to provide information and guidance on a range of subjects never before offered to the small lathe user. Here is no " scaling down " of professional usage, but a truly practical work of a man with full appreciation of the difficulties besetting the average owner, with his small workshop and small lathe, who nevertheless has a wide range of objects to be machined on it.

It is suitable not only for the amateur mechanic, but for the professional also. For the apprentice, the young engineer and the garage engineer with limited equipment, no better book could be possible, if only because it reveals in a carefully selected series of examples, the resourcefulness and ingenuity for which the amateur engineer is famous.

TURNTABLE FIRE ENGINE

(Concluded from page 170)

the ladder and No. 2 lowers it. No. 3 raises the escape to the working position. Hole 4 is for the ladder pivot. No. 2 handle is fitted to the other side of the column to allow more freedom of operation.

The $\frac{1}{4}$in. ply used for the ladder sides must be quite straight and flat, to enable them to slide freely inside each other. Cut them out as in Fig. 7, making them all the same length. Dowels 1A and 2A project and fit in the slots of the lower ladder. Those marked with an X are rollers fixed to the outside of the ladders as guides for the twine. Fig. 8 shows the underside of the completed first ladder. Pulley 2 should only be allowed a restricted sideways movement on its axle, to stop the twine from binding on the columns. The pulleys should have deeper grooves than the rollers to prevent the twine coming adrift.

To connect the controls, start by threading the twine through the hole in axle 1 (Fig. 5) then on to pulleys 2 and 1 (Fig. 8). Finally follow the dotted lines in Fig. 7 and tie the twine to roller X on the top ladder. Thread another length of twine through axle 3 and then on to the end of the lowest ladder.

HOW CAPACITORS WORK

(Concluded from page 157)

of about 100 volts is used it will then give a spark if the two wires are brought together. If a 50 mfd condenser is charged from a 30 volt deaf-aid battery it will flash a 6 volt, 0·04 amp cycle bulb. We know then that direct current will not pass through a condenser but how is it that a.c. will? It does it this way. In Fig. 6 we have two pipes, connected together by a chamber which is completely divided into two compartments by a flexible diaphragm. The pipes and chamber are filled with water, but the water on one side is separated from the water on the other side by the diaphragm. Water cannot pass continuously through the chamber, but if we push the left-hand piston inwards it will cause the water to bend the diaphragm and so force the water out of the other side of the chamber (Fig. 6a). In this way we can communicate the movement of the left-hand piston to the right-hand piston. If one piston moves back and forward the other piston does too, but no water passes through. In the same way, when we apply an alternating, or "back and forward" voltage to a capacitor, this is communicated through it. Of course the insulator between the plates of the capacitor does not bend, but it is subjected to electric strain in separating the opposite charges of electricity.

SIMPLE TEACHING MACHINE

(Concluded from page 172)

These are not essential but can be added if desired. A metal strip across the rolls in the compartment will tension the paper rolls and cut down any longitudinal movement. A thin sheet of rubber under the writing window—a large motor inner tube patch will do—will prevent paper movement while writing. A line drawn on the Perspex between Q1 and Q2 will help to keep the question material separate and is less likely to confuse the younger users.

MARS AGAIN

(Concluded from page 181)

the poles and at sunrise. Most of these 'hazes' thicken at nightfall and will shield the surface from too rapid a loss of heat to space. The Soviet probe might shed some light on these features. We know very little about these 'hazes', or about the composition of the Martian air. It appears to contain about twice as much carbon dioxide as ours and traces of water vapour have been found at the poles, but nothing else. Yet the atmosphere of Mars amounts to about a quarter of ours. The ground-level barometric pressure is estimated at 80-90 millibars. Such pressures are found in our atmosphere at an altitude of about 10 miles, but with a gravity only two-fifths of Earth's, two and a half times as much gas is needed to produce this pressure on Mars.

Our spectroscopic investigation is substantially limited to the narrow, so-called 'optical window' outside which, radiations from space are absorbed by our own atmosphere. Many common gases, such as nitrogen, hydrogen and argon, show their absorption patterns in the wavelength outside the optical window and thus cannot be detected by them. Moreover, it is not easy to disentangle the weak planetary absorptions from those produced in our air. For these reasons it is highly desirable to obtain air-free spectrograms of planets, and it is hoped that the Martian probe will be able to obtain some. Alas, its chances of success do not appear too bright. In particular the return of the vehicle to the neighbourhood of the Earth requires some very delicate control. The American stratospheric balloon telescope may yet be first with substantially air-free spectrograms of Mars. We can but wait and see.

HOW ATOMIC ENGINES WORK

(Concluded from page 163)

surised water principle was reverted to for all new submarines of this type, because servicing and refuelling was easier. In fact refuelling is seldom required. The Nautilus covered over 65,000 miles before she required to be refuelled, and the amount of fuel actually "burned" in this distance was just under three pounds of uranium. In bulk this would be about the same as a medium size apple (uranium weights about one pound per cubic inch).

There was actually much more fuel than this in the reactor but it only contains a small percentage of U_{235} which cannot in fact be used up completely as the reactor would cease to function long before this point.

Finally there is the boiling water reactor, in which the water is actually boiled in the reactor core. This might seem to have been the most sensible thing to do in the first place since it does away with the intermediate cooling system and therefore greatly increases efficiency. This system is now being actively developed, but it was thought at first that the presence of steam bubbles in the water might lead to local overheating in the reactor with unforeseeable consequences. Cost and safety dictated that development should first proceed along lines known to be sound and practicable but this type of reactor now has a bright future and more than one has been built in America. Our heading illustration is in fact of the Pathfinder plant just completed in Minnesota. This plant is unique in being the first in the world to include a nuclear superheater in which the steam passes directly through the reactor core.

SALES AND WANTS

The prepaid charge for small advertisements is 9d. per word, with box number 1/6 extra (minimum order 9/-). Advertisements, together with remittance, should be sent to the Advertisement Director, PRACTICAL MECHANICS AND SCIENCE, Tower House, Southampton Street, London, W.C.2.

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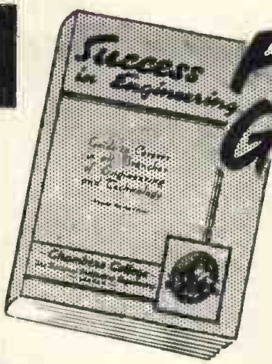

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