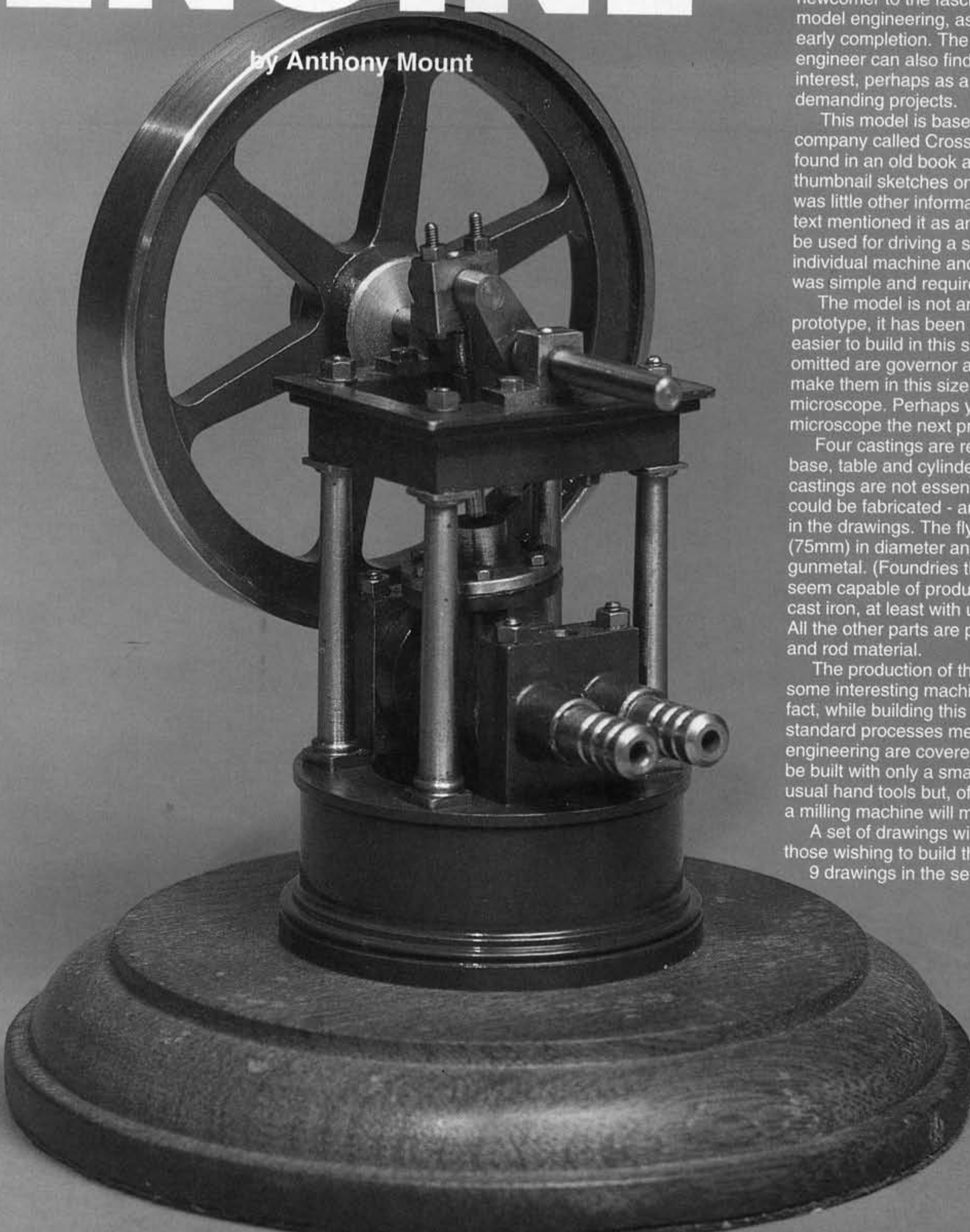
CROSSKILLS OSCILLATING ENGINE

by Anthony Mount



This pretty little engine would make an ideal starter for the beginner and looks much more interesting than the usual type of engine recommended as a first time project

Probably one of the most simple engines that can be built is an oscillating steam engine. It has only a few parts, all of which are easy to manufacture, and there are no valves to set. But it can still look an attractive engine, especially if modelled on one of the mid Victorian engines using a classic architectural style. It also fits the bill as an engine that can be aimed at the newcomer to the fascinating hobby of model engineering, as its simplicity allows early completion. The practised model engineer can also find such an engine of interest, perhaps as a break between more demanding projects.

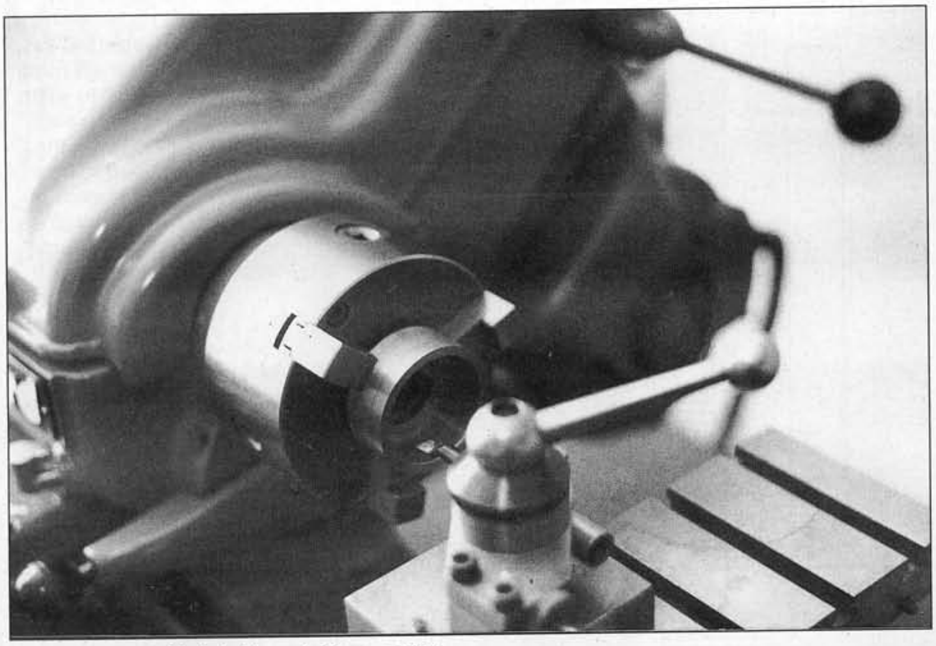
This model is based on a design by a company called Crosskill. The design was found in an old book amongst about six thumbnail sketches on one page. There was little other information to go on. The text mentioned it as an engine that could be used for driving a small workshop or an individual machine and also that the design was simple and required little maintenance.

The model is not an exact copy of the prototype, it has been simplified to make it easier to build in this small size. Two things omitted are governor and slide valve, to make them in this size would require a microscope. Perhaps you could make the microscope the next project.

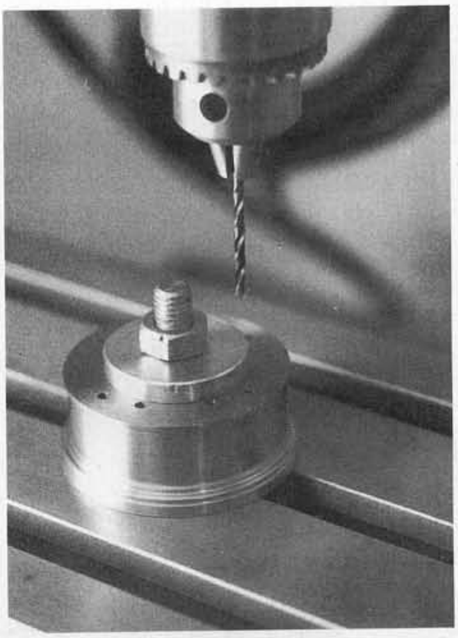
Four castings are required, flywheel, base, table and cylinder - even the castings are not essential as all the parts could be fabricated - and details are given in the drawings. The flywheel is 3 inches (75mm) in diameter and is cast in gunmetal. (Foundries these days do not seem capable of producing such an item in cast iron, at least with unchilled spokes). All the other parts are produced from bar and rod material.

The production of the model calls for some interesting machining set-ups. In fact, while building this model, many of the standard processes met with in model engineering are covered. The engine can be built with only a small lathe and the usual hand tools but, of course, a drill and a milling machine will make life easier.

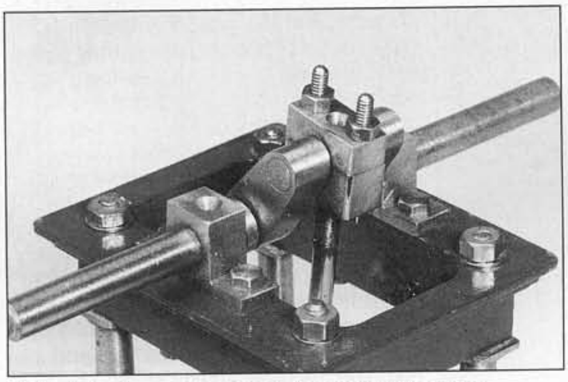
A set of drawings will be available for those wishing to build the model. There are 9 drawings in the set, all A4 size. As we



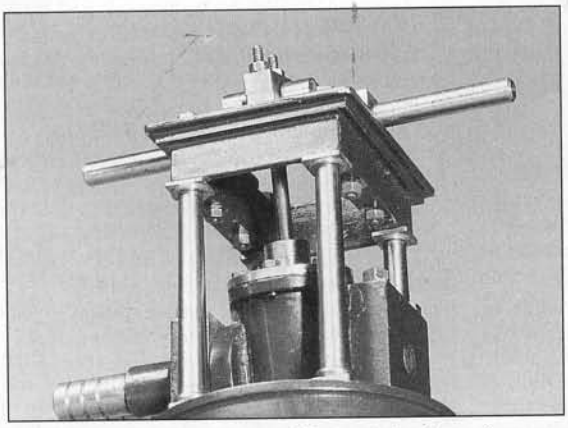
Boring the central hole in the metal base casting.



Drilling the holes for the main pivot bearings in the metal base.



This photo shows the crankshaft and split crosshead. Note oil holes in main bearings.



This underside view shows the fixing nuts for the main bearing bolts.

seem to still be in a dual measurement society the drawings are dimensioned in both metric and Imperial sizes. It will be noticed that the dimensions are not exact conversions, where possible standard stock sizes of materials have been used. The imperial dimension is given first with the metric measurement underneath. Drill sizes are in metric only as these are now the preferred size. It is hoped to produce a book giving step by step instructions on building the model. Drawings, book and castings will be available from Bruce Engineering, please see their advertisement elsewhere in this issue.

The engine will run on steam or compressed air. A small vertical boiler such as the "Pipet" from Cheddar Models, usual disclaimer, would be ideal and is representative of the type of boiler that would have powered many a full size oscillating engine. Compressed air could come from one of the small diaphragm type paint compressors now readily available. The engine should run quite happily on 5 psi. Though not as efficient as more sophisticated engines, they were simple, rugged, cheap engines which were easy to maintain and with little to go wrong. Even so they could look quite elegant, as I feel this design does, see Fig 1. I hope you feel the same and gain much pleasure from building and running the engine.

It would be wrong of me to give you the impression that oscillating engines were only built in small sizes. In marine practice, particularly with paddle ship engines, some were built to very large sizes indeed, cylinders were in the region of 100 inches (2.5 metres) diameter.

Construction

I do not intend in this article to give a blow-by-blow account of building the engine, but rather to discuss the main machining operations that are met with in building this model. If we start at ground level and build upwards, the first item met with is the *Wooden Base*.

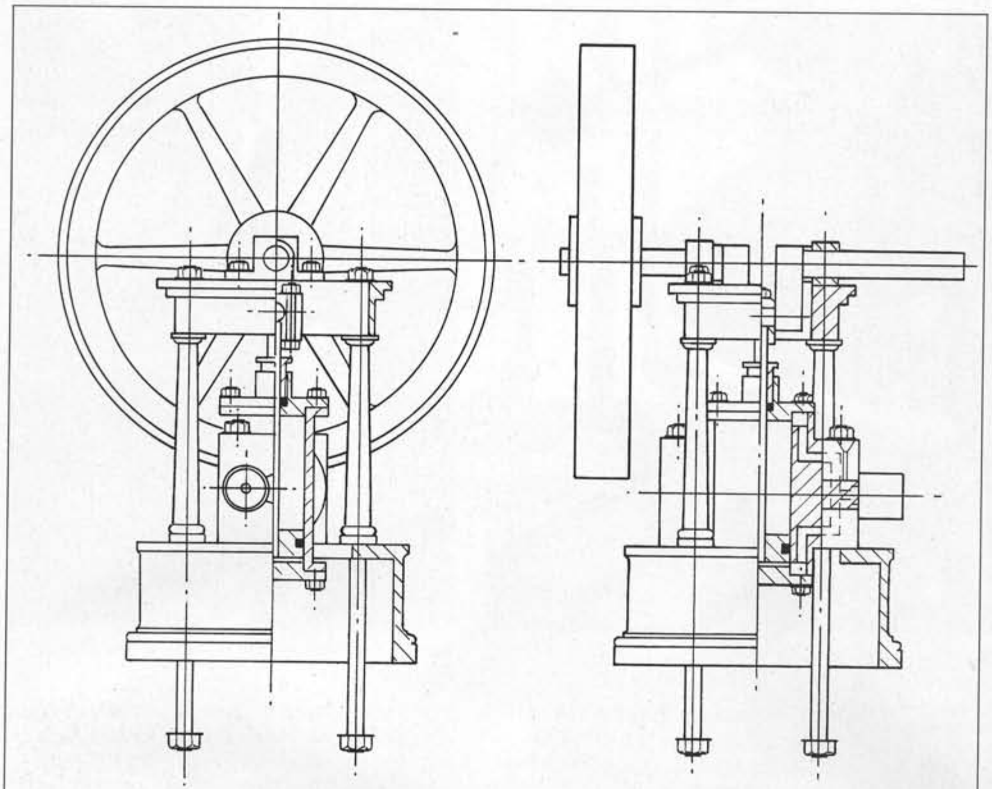
A large diameter base is needed as, without it, the weight of the flywheel would unbalance the engine. I will leave the choice of material to you as it will probably be whatever wood is easily available. Mahogany is the traditional wood but this is a rainforest timber and with conservation in mind why not try a locally grown timber. In the UK this could be chestnut, it looks similar to oak but is much easier to work and takes a very good finish. Maple is close grained and easy to machine, as is walnut. Though I have shown a circular base it could just as well be square. An advantage of making it by hand rather than turning is that you do not cover the lathe and fill the workshop with dust and shavings. If you do turn the base on a metalworking lathe you do not need to use wood turning chisels and a hand rest. The tools you use for turning steel will work well and you have complete control by the use of the cross- and top-slides.

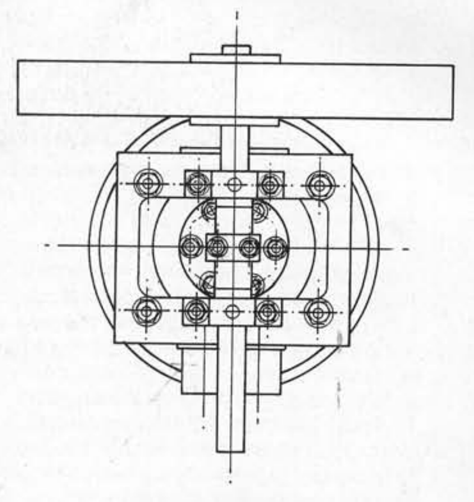
The base can be screwed to a plywood backing piece and the backing piece bolted to the lathe faceplate. The plywood can be ½" (12mm) thick, and its use is to make it easy to hold the wooden base and to avoid marking the faceplate with tool marks. The fixing bolts should be of the countersunk type which should be flush with the face of the plywood, and with the nuts behind the faceplate. There will then be no danger of catching tool or hand on protruding bolts.

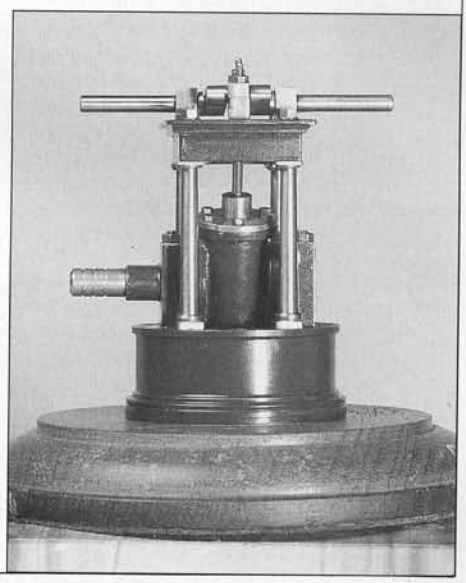
There are many types of polish with which to finish the base. One of the easiest to apply is a wax polish, and some include a stain that will darken the timber. Try different polishes on a scrap of waste wood until you obtain the finish you require.

The next item is the Metal Base of the engine. This is circular and comes as a gunmetal casting, though it could be machined up from a small billet of steel. The casting only requires the central hole to be opened up to size, and the column and bearing bolt holes to be drilled. These can be quite difficult to position on a round object. Centre-lines can be marked on by traversing a tool across the face while the base is held in the chuck. If a co-ordinate table is available, for example a milling machine table or vertical slide, once the centre has been found the holes can be positioned by using co-ordinates.

The columns are machined up from ¼" (6mm) square bright mild steel bar. This is where a four jaw self-centring chuck comes in very handy - failing one of these, set up in the four jaw independent chuck. Set the bar running true and, when pulling more bar from the chuck, use only the same two jaws for releasing the work, then the bar should stay running true. A slender bar like this will need tailstock support during turning. It might be an idea to leave the columns bright







rather than painting them as this will form a contrast with the rest of the engine.

On the prototype the *Main Bearings* would have consisted of a pedestal with separate split bearings, but on the model they are machined from the solid in brass.

The table is a little casting and only needs facing off top and bottom and the holes drilled for the columns and studs.

There are two *Main Pivot Bearings* that carry the cylinder. One is plain and has holes for the pivot, studs and oil reservoir. The other pivot bearing is also the port face and is honeycombed with holes to take the steam and exhaust in the right directions. Study the drawings carefully and mark out the hole positions. After drilling, some of the holes are plugged with little threaded rods. The ports are just drilled holes and, again, can be positioned using co-ordinates. The valve face needs to be steam tight and, though it could be machined, it is just as easy to rub it in a circular motion on a piece of fine emery laid on a flat surface. The emery paper can be held down to the flat surface with masking tape *(Or double-sided adhesive tape - Ed.)*

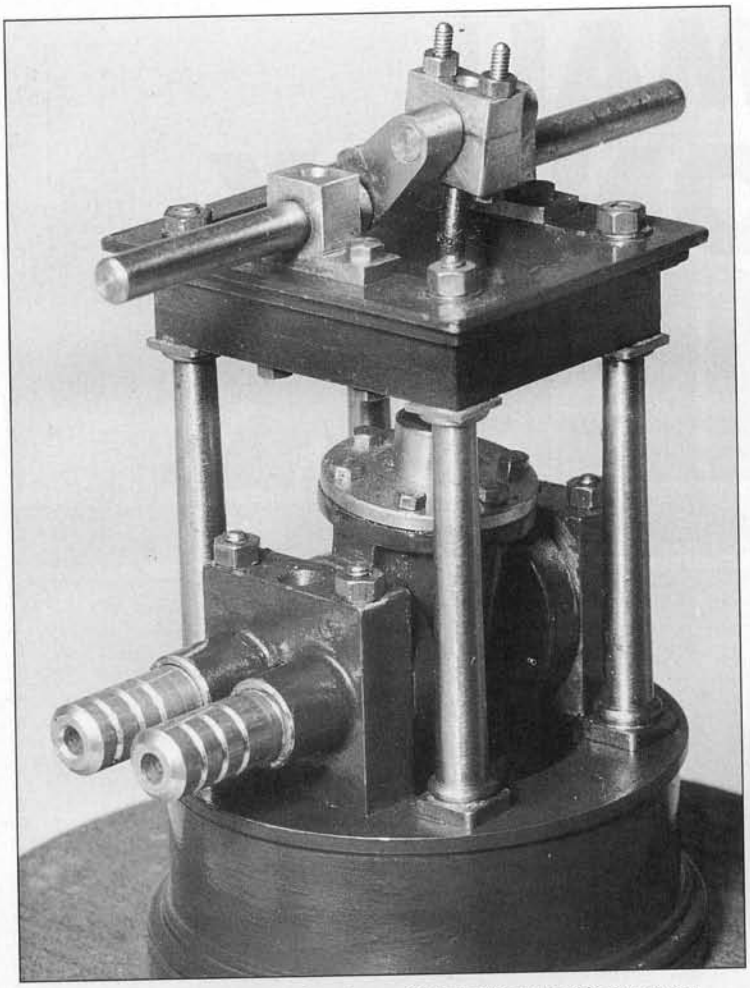
The Flywheel is another gunmetal casting and the first thing to do, as with all castings, is to go over it with files to remove any roughness or flash. Hold it in a suitable chuck by gripping on the inside of the rim and machine the rim face and edge. Do not machine right up to the chuck jaws because you can turn away the last few thou. on the rim when you turn the wheel round. Face off the boss and drill through. Ideally the hole should be bored to size to a good fit on the crankshaft but you would need a very small boring tool to do this. Before machining the flywheel, test drill a scrap of gunmetal to find the right size drill for your crankshaft. Change to outside jaws in the chuck and, gripping the flywheel on the outside of the rim, machine the other side bringing down to overall thickness. Obviously you will need to take equal amounts off both sides of the flywheel. Drill and tap the boss for a 5BA grub screw to lock the wheel to the shaft.

The crankshaft is built up from mild steel sections and Loctite is used to hold it together. Starting off with a length of material sufficient for two webs, the $^1/_4$" (6mm) square section material will need to be milled down to $^3/_{16}$" (5mm) in width. Cross drill for the shafts - co-ordinates can again be used to get the holes the right distance apart - they need to be a sliding fit on the shafts. File the ends round and cut the taper. The crankpin is just a straight length of rod faced each end, as is the other shaft, though it needs to be long enough to pass right through both webs. Slip the webs into position and it will be seen that the long shaft holds all true. Slide the webs to one side, apply Loctite and reposition. When the adhesive has cured, cut away the section of long shaft between the webs and the crankshaft is complete.

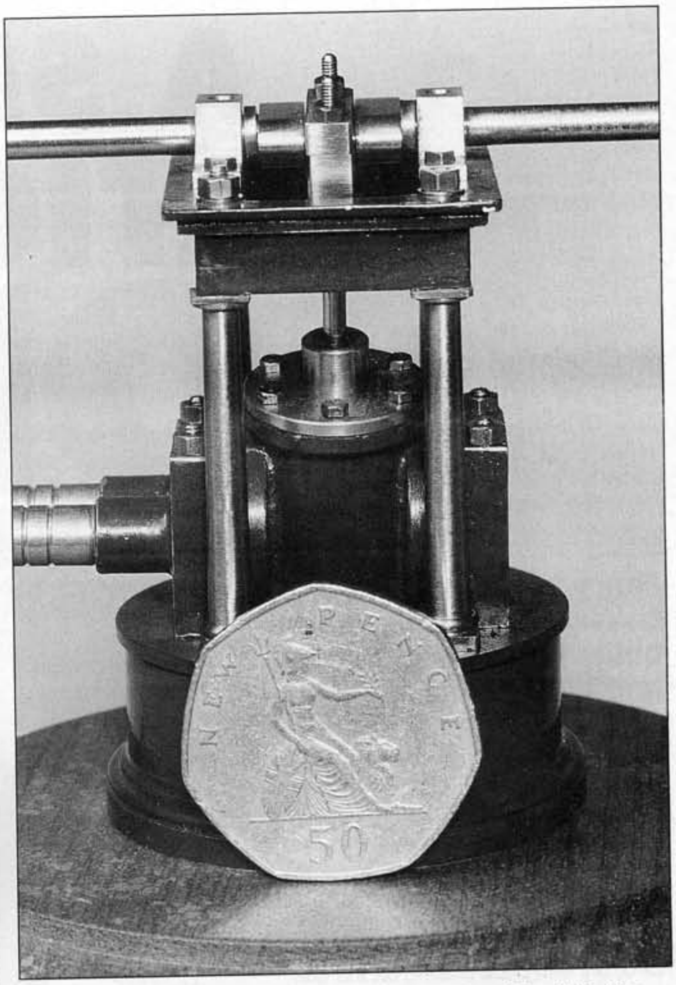
The Cylinder is another gunmetal casting and is an interesting component to machine. Hold it in the four jaw independent chuck, using packing where required to obtain a firm grip. Face off the end, and turn the edge of the flange to diameter. Centre, drill through and open out in stages to $^3/_8$" diameter. Then, using a boring tool, open out to finished diameter and to a good internal finish. Make up an expanding mandrel to fit the bore, and with the cylinder on the mandrel and held in a self-centring chuck, face off the other end of the cylinder and the flange edge. Change back to the four jaw independent chuck again and chuck the cylinder with the jaws across the ends of the cylinder and use packing to bridge the sides. Dummy steel cylinder covers can be made up to give a firm grip for the chuck jaws and to avoid marking the soft gunmetal of the cylinder. Set a pivot running true and machine the pivot and its seating and form the recess for the spring. For the time being, leave the pivot as long as you can. This will help when we turn the cylinder end for end and, holding by the pivot in the three jaw self-centring chuck, centre the other pivot. Use tailstock support and turn the other pivot and port face. Remove from the chuck and drill the steam passageways. The cylinder covers can be used as templates to spot through for the stud holes which are tapped 10BA.

The cylinder covers are turned up from brass bar, and the top cover has a little gland. Full size engines used a gasket between covers and cylinder flanges but on a little engine like this it is hardly practical, a liquid gasket is much more useful. Liquid gasket usually comes in a tube and can be squeezed on and spread around the mating faces in a thin layer. It never sets hard and the parts can always be taken apart. One thing to check for is that the gasket material used will withstand the high temperature of steam.

The *Piston and Rod* come next. The piston is turned up from brass rod and is grooved for packing. There are three types of packing available, the traditional material is graphited yarn. This is a woven yarn impregnated with graphite and it comes in various sections, usually square, and starts at $^1/_{16}$" (1.5mm) across the flats. It can be picked apart and the individual strands can be used for gland packing and the like. Similar, but of more modern materials, is a woven yarn impregnated with PTFE. This can be used the same as graphited yarn



A close-up shot of engine showing the oscillating cylinder and its top cover. Note oil holes in main pivot bearings.



The 50p piece in this photograph gives an indication of the diminutive size of the engine.

and should prove to be more slippery than graphite, though I have not used the material yet myself. Not really a packing but fulfilling the same purpose are silicone rubber 'O' rings. These make an excellent seal but need their seatings machined to close tolerances.

The piston rod is a length of stainless steel threaded at both ends. It is very simple to produce, but its selection needs care as the surface finish of stainless steel rod varies considerably. Choose one that has a fine ground and smooth finish. A rough finish will soon wear away the gland packing.

The *Crosshead* is a tiny item and is best machined on the end of a length of brass bar. Drill for the bolt holes, followed by the piston rod hole which is tapped 7BA. Then, with a slitting saw, saw off two slices. Remove any burrs and temporarily bolt the two pieces together, clamp them in a machine vice and drill and ream the bearing hole.

The spring washer is used to keep the port faces together and is machined from phosphor bronze rod. It only needs to be about 0.025" (1mm) thick and is bent in the middle. When the washer is in its housing it should stand proud by about $\frac{1}{64}$" (0.4mm). This should apply enough force to keep the port faces sealed. Too much pressure and the engine will become too stiff to run smoothly.

The form of pipe connectors used will depend on whether you intend the engine to run on steam or air. If running on compressed air they can be straight lengths of rod with a few recesses turned in with a vee tool to give extra grip on whatever tube you are using, the connector being a tight fit inside the tube. The engine should run quite happily on only a few pounds of air pressure, say 5 to 10 psi. If you are using steam then proper steam tight connectors need to be used. These are formed from coned olives, the olives being silver soldered to the steam pipes, secured with pipe nuts.

Assembly of the engine is quite straightforward. Just follow a logical process, checking as you go that the clearances are adequate and that all turns smoothly. A little oil should be applied to all rubbing surfaces and an air line connected up. With an oscillating engine there are no valves to set - the engine will either go or not. Direction of rotation depends on which inlet you use, just change over the tube for forward or reverse. Turn on the air and see if anything happens. Rather than allow full pressure direct to the engine, which can result in violent action and very high rotation speeds, have a bypass valve open so that most of the air pressure is bled off. With only a little air for the engine, turn the flywheel over a few times, watching that your fingers are not in danger of being nipped, and see if the engine starts. If there seems to be life there, close the bypass a little and see if the engine picks up. Once it is ticking over smoothly leave it well alone for a while and let things bed in. When you are happy that all is well you can up the speed a bit, but these little engines will run at very high speeds and, to be honest, this looks ridiculous. In full size the engines would have run quite slowly, so a speed of 50rpm is more than enough. It is a reflection on your workmanship if you can get the engine to run very slowly.

With the engine running satisfactorily, it is time to dismantle the engine and think in terms of what colour to paint it. The traditional colour was dark green but there is no reason why you should not paint the engine any colour you fancy. Some parts such as the columns can be left bright. Though it is not following full size practice, you could polish all the parts and avoid any painting at all.

With a little engine such as this you might find it easier to apply the paint by brush. I will not go through all the processes of painting an engine, but thin coats are better than thick and if the engine is carefully prepared a good finish should result. With the engine finally assembled sit back and enjoy the running of the engine. Think also of the full size engines, they worked hard for many years and helped lay the foundations of our modern industrialized society.

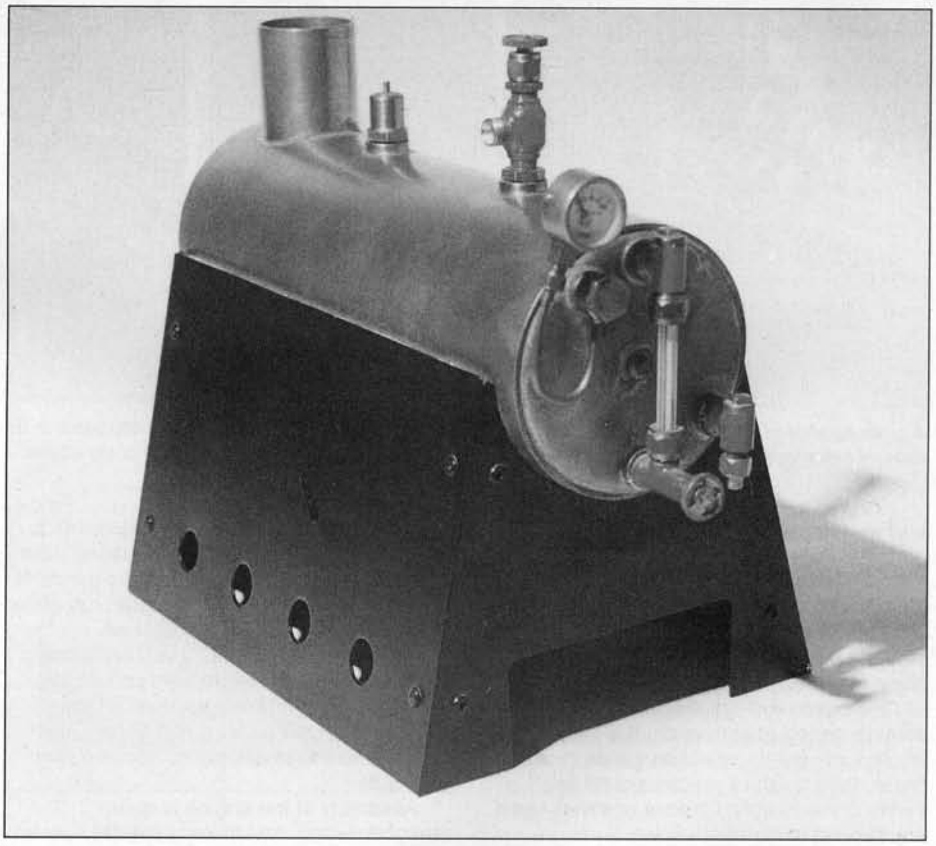
The complete set of drawings and castings for this model are available from Bruce Engineering, "Hollow Tree", Penny Lane, Walton Bridge Road, Shepperton, Middx. TW17 8NF
Tel: 0932 245529 or Fax 0923 226738.

The "Pipit" boiler referred to in the text is available from Cheddar Models Ltd., Sharpham Road, Cheddar, Somerset BS27 3DR
Tel: 0934 744634 or Fax: 0934 744733. ■

A SMALL STATIONARY BOILER

by Geoff Sheppard

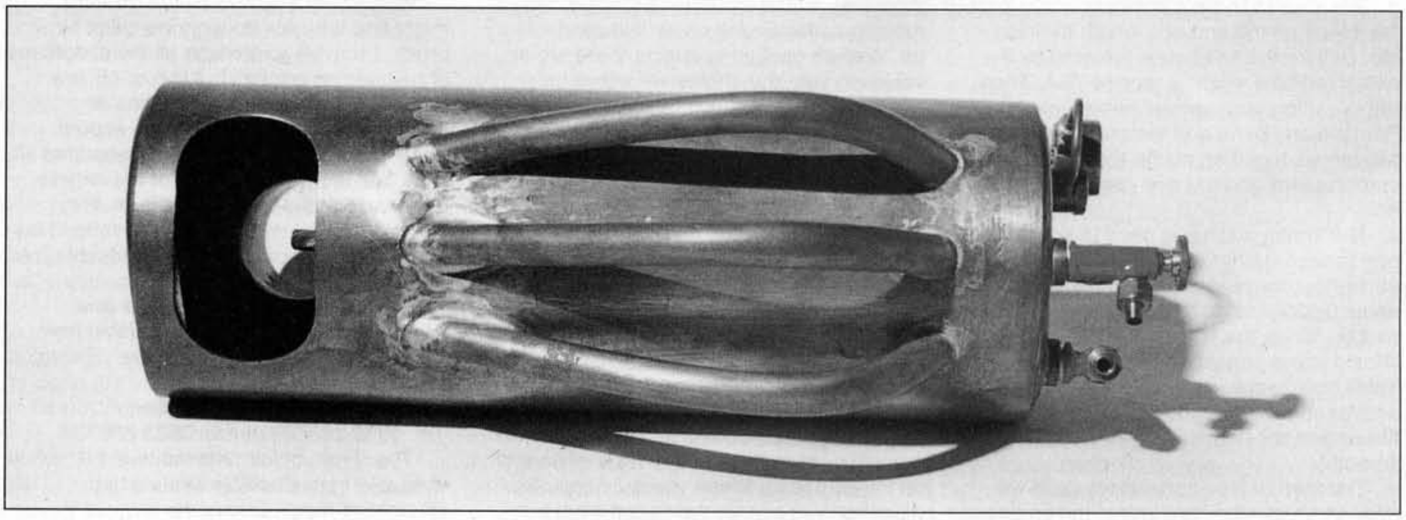
Fancy having a go at boilermaking? This easy boiler for the beginner to tackle could make a useful power source for the Crosskills engine described earlier ...



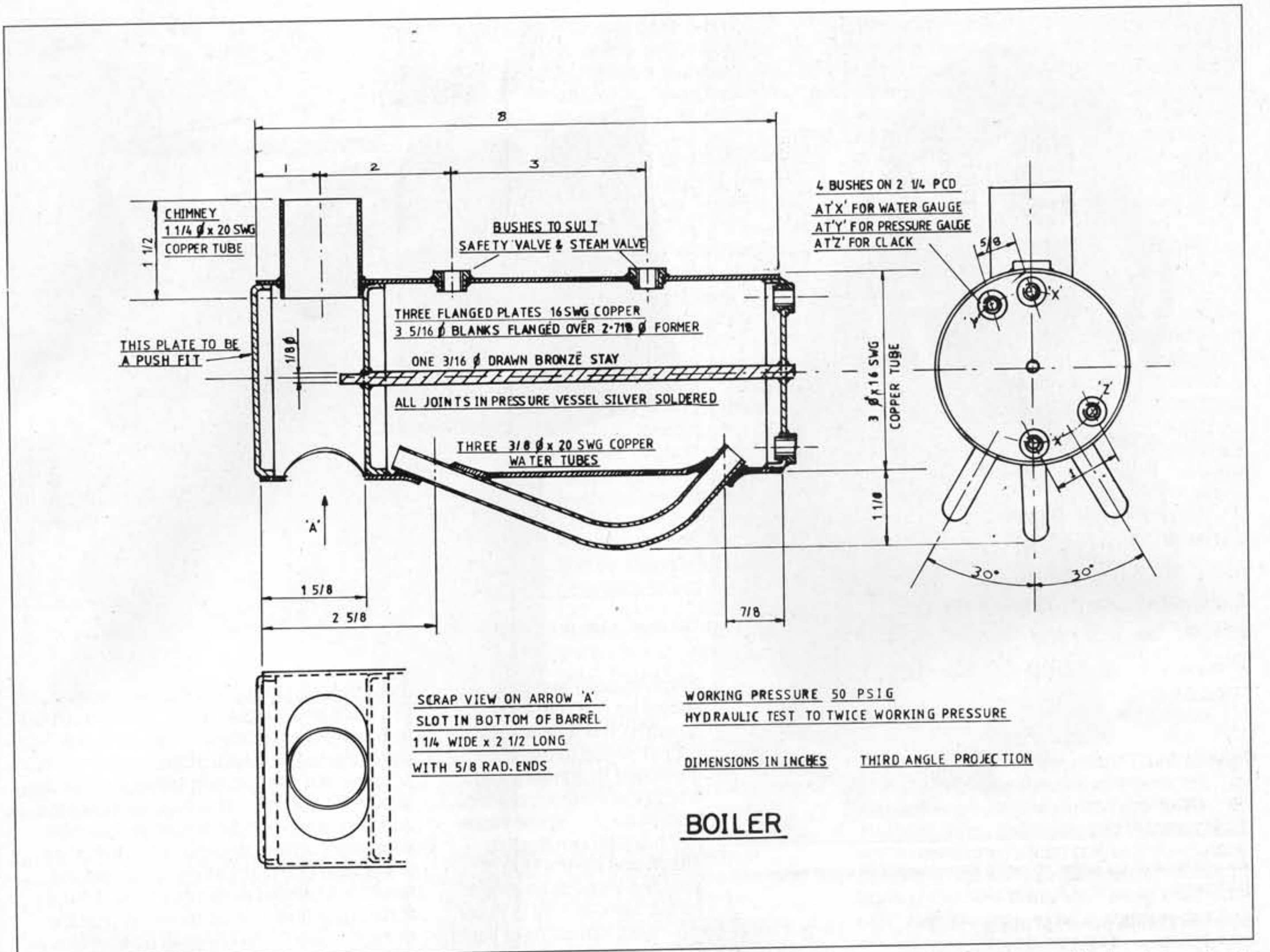
The finished Water Tube Stationary Boiler ready to be connected up to a suitable steam engine.

This little boiler forms probably the most simple exercise in boilermaking after the simple pot boiler. It features two flanged plates in the pressure vessel, with a third, dry end plate closing off the flue space. Three water tubes are added, to take some more of the heat out of the combustion gases, and provision is made for a full range of fittings. It is suggested that, for a first effort, commercial fittings should be used, but if you have the experience required to machine the small components, by all means have a go. Many suitable designs are available for safety valves, steam valves, water gauges and water feed check valves (clacks). Don't at this stage contemplate making your own pressure gauge!

The original heat source was a small butane torch type of burner, to which a flattened nozzle like a paint stripping burner had been added. This worked well enough, but an ideal arrangement is one of the new ceramic burners which have come on the



This underside view of the boiler clearly shows the position of the three water tubes which will actually be heated directly by the burner flame. The slot at the left hand end will allow waste gases to exhaust up the chimney.



market, as these can be obtained with a flat configuration.

Materials

The pressure vessel is constructed entirely from copper and phosphor bronze, silver soldered together. The materials should all be to known specifications and obtained from reputable sources. Throughout this article I am quoting the sizes (in Imperial units) to which the original was made. If metric stock materials are used, then some adjustments to sizes may be necessary, but these should not be too difficult to sort out.

The barrel was made from an 8 in. length of 3 in. diameter copper tube of 16 s.w.g. wall thickness. The end plates are also of 16 s.w.g. material and the water tubes are $^{3}/_{8}$ in. outside diameter by 20 s.w.g. The chimney consists of a short length of $1^{1}/_{4}$ in. O/D tube, the wall thickness not being critical. Phosphor bronze is used for the central stay and the bushes for the fittings.

Boiler Making Equipment

The usual hand tools for cutting and forming sheet metal will be required, along with some form of heating and a brazing hearth for the silver soldering operations.
(A separate article on these items appears later in this publication - Ed.)

The Chimney

Somewhat improbably, the first item I suggest that you make is the chimney. The reason for this will become clear when you start to mark out the barrel. Cut off a $1^{5}/_{8}$ in. length of the $1^{1}/_{4}$ in. diameter tube, filing one end square to the length. The other end is then filed to a radius which sits reasonably neatly on the outer surface of the barrel tube. It must also sit as near vertical as you can get it in both end and side views.

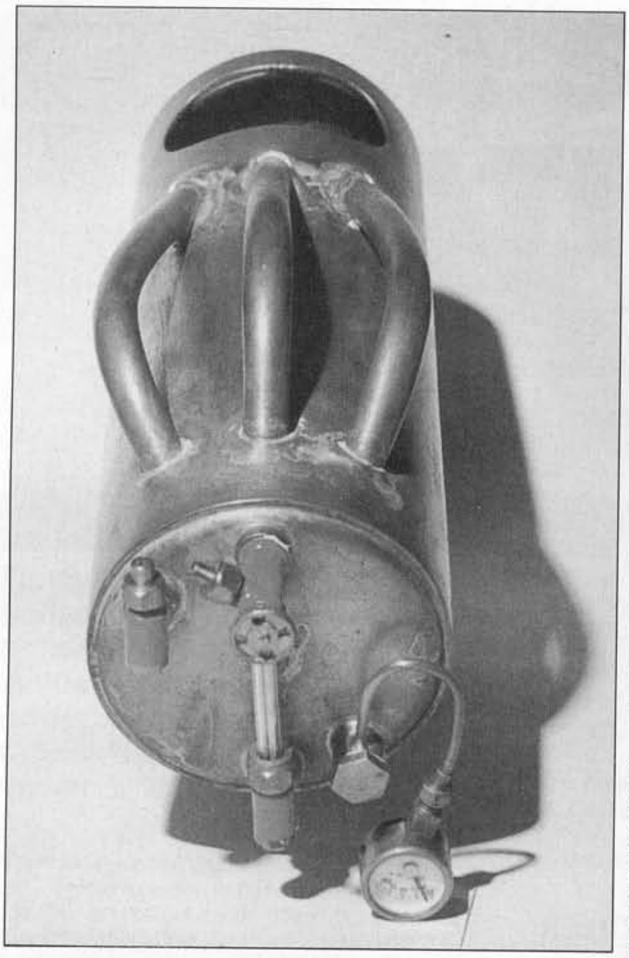
The Barrel

The barrel tube must be first cut to length and the ends cleaned up. Marking a line around the tube square to its length can be achieved by wrapping a sheet of cut paper around the tube so that the edge lines up, then lightly scribing along the edge. A4 size typing or copier paper will do, but it's easier if you can get hold of the larger A3 size, as it gives you a bigger overlap. The ends of the tube can be filed to length accurately enough, checking for squareness frequently with a try-square off the outer surface.

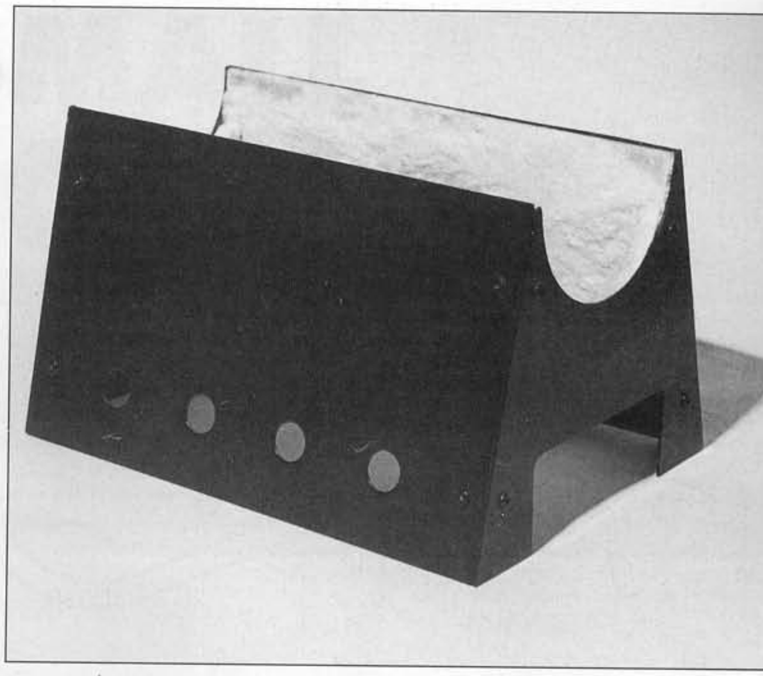
Top and bottom centre-lines are now required along the length of the barrel, so set the tube parallel with a flat surface, in vee blocks if you have them, but otherwise directly on the surface itself. A piece of decent plate or float glass makes an admirable surface plate for such jobs. The line is best marked with some form of scribing block, which is essentially a scriber held firmly in a holder which can be slid along the flat surface while the scriber tip is in contact with the material to be marked. There will be many occasions when such a device will come in handy, so it will be well worth acquiring or making something which will serve. Designs for handy little gadgets such as these appear regularly in the model engineering magazines and books.

Once the top centre-line has been clearly marked, it will also be helpful to find the equivalent on the bottom. Mark where the top centre-line meets the end circumferential surface of the tube, so that it can be seen when viewed from the end. Set the try-square on the flat surface so that the blade is vertical, then rotate the tube against it so that this top centre-line is at the highest point. The lowest position can be marked off from the square and the bottom centre-line scribed along from this point. While the marking equipment is set up, scribe two more lines on the lower surface, one each side of the bottom centre-line at a 30 degree angle. This angle isn't at all critical as the lines are to position the water tubes, so a measurement of about $^{15}/_{16}$ in. around the circumference will suffice.

The positions of the centres of the screwed bushes can now be marked on the top, as can the position of the chimney. The previously shaped chimney tube forms a perfect template for scribing the shape of the hole which must be cut out to accommodate it. Whereas the holes for the bushes can be drilled using progressively larger drills, the hole for the chimney must be treated differently. Select a small drill, say 2.5 or 3mm and set a small pair of dividers to a little over half the drill diameter. Using the dividers as a guide, carefully scribe a second line inside the hole marked for the chimney, such that holes drilled on this inner line with the selected drill will be just clear of the outer line. Now re-set the dividers to a dimension just greater than the full diameter of the selected drill and



An end view of the boiler showing arrangement of water tubes and backhead.



The base ready to accept the boiler.

carefully centre punch at this pitch all round the inner line. I know it sounds a little tedious but, in fact, it doesn't take long and the result is always much better than trying to do it "freehand". After chain-drilling the holes, the centre can often be pushed out, or judicious use of an Abrafile will soon shift it and allow the hole to be filed up a tight fit for the chimney.

The two ends of the sausage shaped exhaust slot directly below the chimney can also be marked out in the same way, then the sides joined up so that the same chain drilling process can be used. This time there is not the same need to be quite as precise as there is no tube to be brazed in.

The remaining holes in the barrel are those for the water tubes and those for the threaded bushes which will house the fittings. Mark their position and drill. The tube holes are the same diameter as the available tube. They will need further treatment later, but this is best done after the water tubes have been shaped, so we'll get on with this job next.

Water tubes

Three pieces of the selected stock, each about $6\frac{1}{4}$ in. long should be cut off and de-burred. The next task will be to bend them to shape, in order to achieve this they will need to be softened by annealing. Prop the tubes against a brick on the hearth and heat them up with a medium sized nozzle on the torch. When they reach a cherry red colour when viewed in daylight, keep them at that temperature for a couple of minutes, without letting them get too hot. Try to avoid letting them get to a bright orange - move the flame backwards and forwards along their length steadily and they should be O.K. Let them cool naturally. It is a fallacy that copper needs to be quenched to anneal it and it is also a dangerous practice. Cold water hitting the inside of a hot tube can flash to steam and eject a slug of scalding water at anyone in range. My own rule is never to put boiler components into baths of liquid unless I can handle the metal with bare hands. Drop them into the pickle and leave them until they are clean.

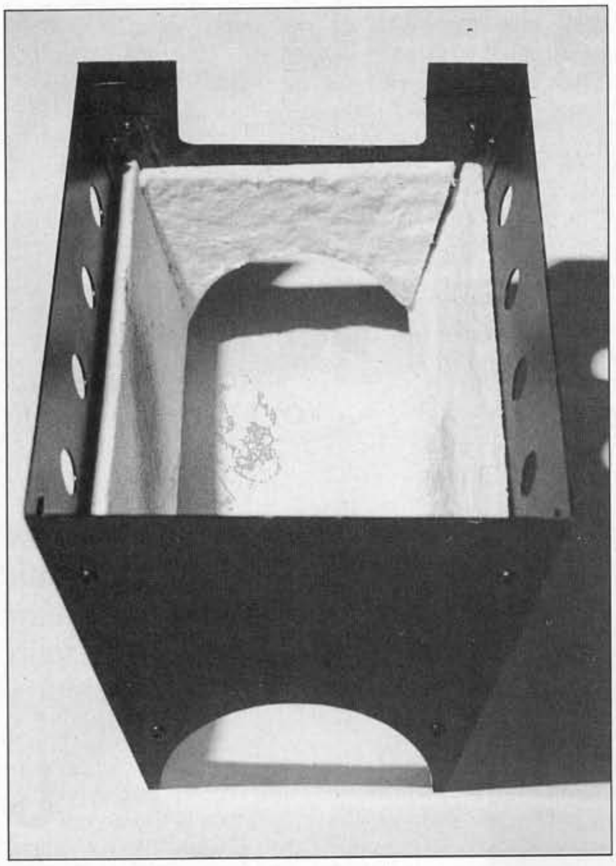
While you have the torch going, also anneal the boiler barrel in the vicinity of the two groups of holes which accommodate the tubes, as we shall need to manipulate these areas very soon.

The tubes can now be formed to shape. The bend starts at about 4 in. from one end, with an inside radius of $1\frac{3}{8}$ in., until an angle of about 70 degrees has been reached. The shape isn't critical, the important thing being that, when fitted, no part of the tube should be parallel with the horizontal centre line of the boiler. This plays havoc with the water circulation! The bends can be put in by hand around a suitable former, taking care not to flatten the soft tube. When you are satisfied with the shape of all three, the barrel can be tweaked to accept them. The tool for this job is a piece of round steel bar the same diameter as the tubes. Put it through each hole in turn and gently lever the locally softened barrel material until it lines up with the appropriate end of the tube. Put these parts to one side while the flanged plates are made.

Flanged Plates

Two more simple tools are required for the flanging process, namely the flanging block and a backing plate. Many materials and combinations of materials have been suggested over the years, around which to flange copper, but in my view, the one which results in an accurately sized flanged plate which requires little or no subsequent re-working is aluminium plate, around $\frac{1}{2}$ in. thick. The block can be machined from bar if you have any suitable stock, but my method is to bandsaw a piece from an off-cut of plate and to drill a hole in the centre which will accept a short stub mandrel suitable for gripping in the lathe chuck. This allows the outside diameter to be turned to a precise dimension, which, depending on the sizes of the tube and plate being employed will result in a flanged plate which has the right fit for subsequent silver soldering. For the materials used in the original boiler this was a diameter of $2\frac{7}{8}$ in. If your copper tube or sheet vary from those I have used, then this dimension will need to be varied. After turning the O/D to size, put a good radius (about $\frac{1}{8}$ in.) on one corner. The backing plate is simply a piece of hardwood of about the same dimensions as the block.

Three plates will be needed, so cut three disks of copper, each $3\frac{5}{16}$ in. diameter. Clean up the edges, then anneal. Pickle them clean every time after annealing because there is no point in hammering the oxides into the surface of the soft metal - it does no good for the integrity of the joint! Centralise flanging block, copper plate and backing plate and grip the sandwich firmly at one end of the vice jaws. Locating it in this position allows you to attack a bigger sector of the flange in one go. Using a soft hammer knock the flange over just a few degrees over the accessible sector. Don't be too greedy and try to bend too much at once because you will find that you are stretching material which you will subsequently have to shrink. Move the sandwich round and complete the first part of the bend, then keep repeating the process in small steps until the flange gets nearer and nearer the block. As soon as any resistance to the hammer is encountered (the hammer will start to bounce), stop and re-anneal and move on to the next plate. Repeat the process until all plates fit snugly round the block, with good, flat faces and square flanges. It is only at the final stages that I may give a final dressing with a polished hard hammer to achieve the finished shape. A light clean up on the belt linisher takes out any slight



Underside view of the base showing lining of insulating material and air holes in sides.

undulations and the same tool will put a chamfer on the edge of the flange, which will assist assembly.

The two pressure plates will require central holes for the stay (remember they are of different diameters), and the one which will be the boiler front can also now be drilled for the threaded bushes.

Central Stay

This is simply a length of 3/16 in. diameter phosphor bronze rod, with ½ in. at one end reduced to ⅛ in. diameter

Threaded Bushes

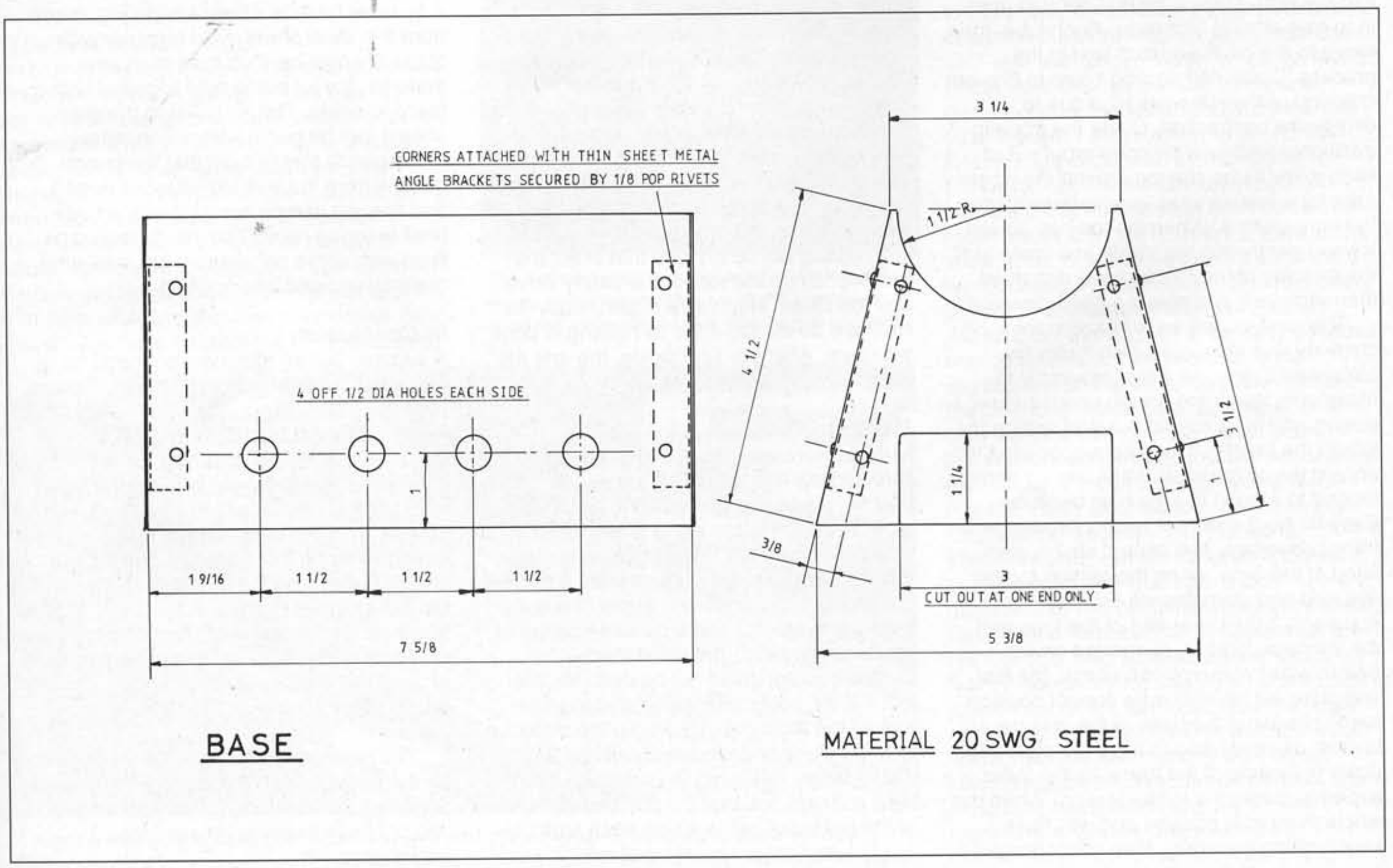
These should all be made from bronze or gunmetal bar, but not from brass. The water encountered in some parts of the country can leach the zinc content out of brass, leaving it like a sponge, with no residual strength. The threads in these bushes will obviously need to match the chosen fittings, but in recent years I have made it a rule to avoid anything finer than 32 threads per inch in copper alloys. A good old favourite used to be ¼ x 40 t.p.i., but I find this vulnerable to damage, especially in the soft condition after brazing. One tip is to put only the taper tap a few threads into the material at first, then to finish the thread after the bush has been brazed in.

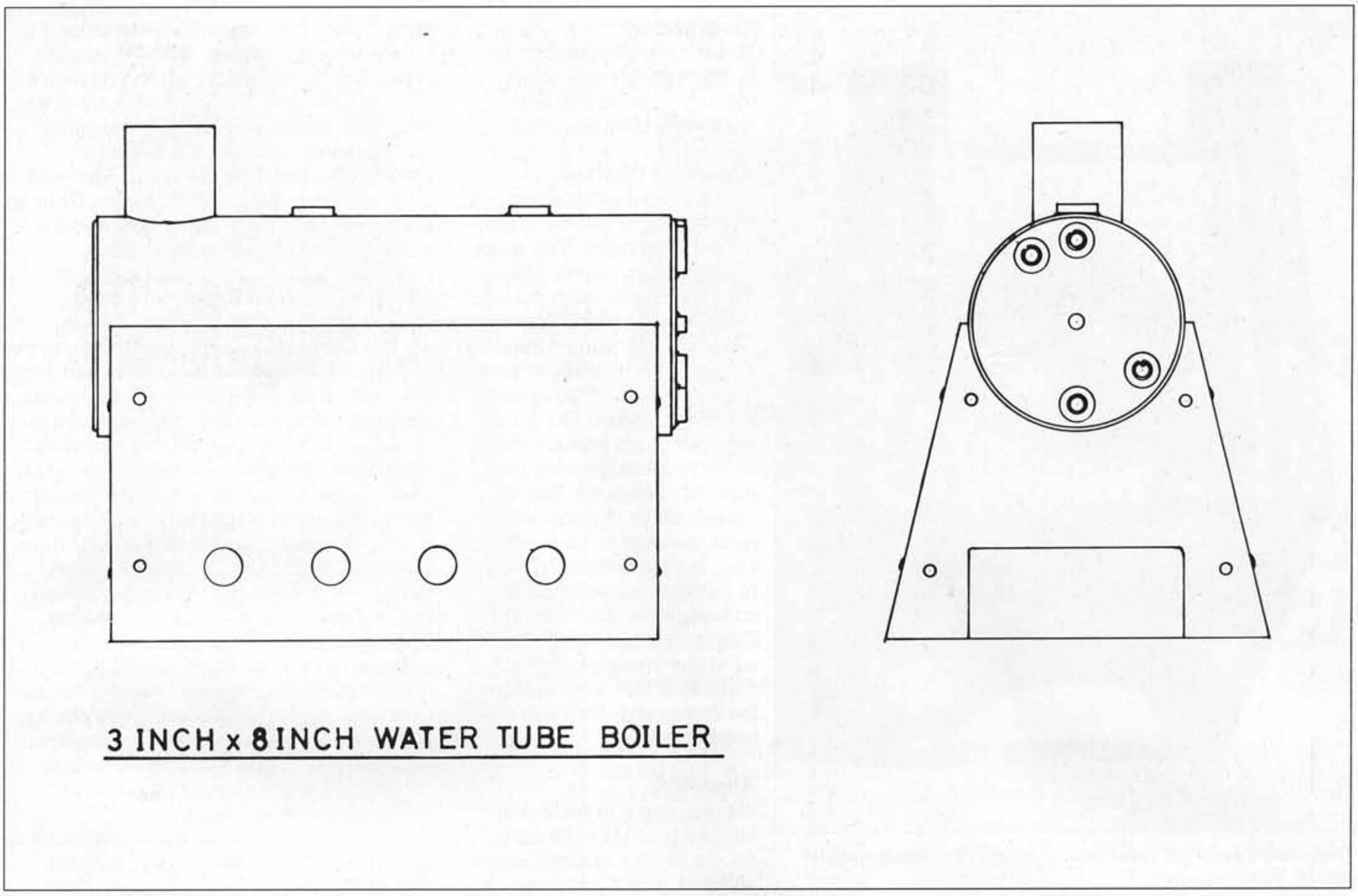
Assembly

We now come to the exiting bit! The process to be used is known as step brazing, where alloys of differing melting points are used in succession, hottest first, to allow the assembly to proceed in stages. It is sometimes argued that this is an over-complication for beginners and that only a low melting point alloy, such as Easy-flo No.2 need be used. This is all very well if the assembly can be completed in one heat, which often it can not, or otherwise the difference in melting temperature between the initial melt and a subsequent re-melt has to be relied upon. Using this phenomenon, which is due to a change occurring in the constituents of the alloy at high temperature is, to my mind, adding complication for the beginner. I therefore recommend the use of Silver-flo 24 (melting range 740-780 degrees C) or an equivalent for the first steps, followed by Easy-flo No.2 (608-617 deg.C.) or equivalent for the later ones. One slight complication is that two fluxes will be needed to suit the temperature ranges.

The first heating will fix the tubes into the barrel. Give everything a clean up and wash off and assemble the tubes into their holes. It may be necessary to finally trim them to length, depending upon how the bending went. When they are in position, mix some of the higher temperature flux to a smooth paste with a little water and liberally anoint the joint areas inside and out. When I have demonstrated boiler making, comments have been passed on the amount of flux I use. My response is that flux is cheaper than silver solder and as long as it's not going to run where I don't want it, I would rather have more than not enough. It must be remembered that the flux is neutralising oxides which are forming during the heating process, and it could become exhausted before the joint has been formed and so affect the quality of the joint.

Set the barrel on the hearth, surrounded by firebricks (the reflective sort) with the joint areas accessible. Remember when arranging any brazing job that the alloy will flow towards the hottest point so, if possible, heat from one side of a joint and feed the brazing rod from the other. This will be difficult in this case, but the principle is always worth remembering. With a medium nozzle on the torch, heat the job gently at first to evaporate the water from the flux, then turn up the heat and concentrate on





one end of the barrel. For Silver-flo 24, a good red heat will be needed, when it will be seen that the molten flux is keeping the joint area clean. Warm the alloy stick in the flame and dip it into some dry flux powder, so that a coating builds up on the end of the rod, then touch it on the joint area when it will soon be obvious when things are hot enough, as the silver solder will flow freely into the joint. Make sure that enough goes in to give a good fillet round each tube, then move to the other end and repeat the process. Controlled cooling helps to prevent cracking of the still weak joint due to differential contraction. Cover the job with additional firebricks propped around it or keep a low flame playing around the whole area for a few minutes, gradually reducing the temperature. When the job has cooled, lower it gently into the pickle and leave until the majority of the oxides have dissolved, then remove it and give it a good clean up.

The next job will be to braze in the chimney and the plate which forms the backhead. Carry out a trial assembly to make sure that there are no snags before fluxing with the Easy-flo flux and setting the job on the hearth. It may be a good idea to anneal the chimney so that it can be gently tapped to a good fit in its hole because Easy-flo No.2 does not have extreme gap filling properties. The central stay is also fitted at this time, when the reason for the reduced end diameter will become apparent. If the lower end of the tube and the stay are carefully supported on the hearth with fragments of firebrick, the first end plate will be held in its correct position, hard up against the base of the chimney. It is most disconcerting to have the plate slide down the inside of the barrel as the latter expands during the initial heating! When the whole thing is in position and well fluxed, start heating generally, then concentrate on the area near the chimney, applying the Easy-flo stick from the inside as soon as the flux runs clear. With the flame on the outside and the stick fed from the inside, the capillary action will be apparent. There will be no need to approach anything like a red heat this time - watch the flux for the temperature change. Follow round the plate to barrel joint until the chimney position is reached again, then seal the central stay. Repeat the cooling/pickling/cleaning cycle while soldering the bushes into the boiler front with Silver-flo 24. This sub-assembly can then go into the boiler, making sure that the water gauge bushes are on a vertical line, otherwise the whole thing will look odd. This plate, which goes in with Easy-flo No.2 should be prevented from dropping in by the additional friction of the central stay. The last heating will be the one that seals the two bushes on the top for the safety valve and the steam stop valve. Again, Easy-flo No.2 will do the job if the re-heating is done with care. After the final pickle, the unit will be ready for pressure test.

Pressure Test

It will be necessary to make up some screwed blanking plugs for the boiler bushes; these can be sealed in with PTFE tape. Hexagon brass bar is useful here. One connection will need to accommodate a union which will take a pipe from a test set consisting of a small hand pump (the boiler feed pump will do) and a sizeable gauge of known calibration - the small model pressure gauge must not be used for this job. Fill the boiler with water, making sure that all the air is out of it. Pump the boiler up to twice working pressure about half a dozen times, releasing the pressure each time. You will find that the soft components of the boiler will settle a little each time.

The test proper must be at twice working pressure (which in this case will be to 100 p.s.i.), which should be held for 30 minutes without any appreciable drop in pressure. As all the seams on this boiler are easily reached, it will be possible to seal any small leaks with Easy-flo No.2 before re-testing again to 100 p.s.i.

The Base

A suitable base is a very simple job, made from thin steel sheet, held together with strips of angle bent up from the same material, the lot being held together with a few pop rivets. The air holes in the side sheets can be put in with a ½ in. sheet metal punch (make sure that the punch goes in from the outside - it looks better) and the unit can be sprayed with a black heat resisting paint. The inside should be lined with some non-flammable insulating material epoxied into position.

In Conclusion

A suitable burner may now be made up or purchased from one of the Trade suppliers (*see the Suppliers Listing elsewhere in this issue - Ed.*) and the boiler may be tested under steam. When steaming for the first time, raise steam slowly to allow the boiler to expand gently (after remembering, of course, to make sure that the boiler is about threequarters full of water). A careful eye should be kept on the pressure gauge and the safety valve to ensure that it will, in fact, "blow off" at the maximum working pressure of 50 p.s.i. Always make sure that you have at least half a glass of water showing in the gauge glass whenever the boiler is in steam.

The next job will be to make an engine for the boiler to run (if you have not already done so), so start looking for your engine and continue to enjoy your model engineering. ■

CONFESSIONS OF AN ARMCHAIR MODEL ENGINEER

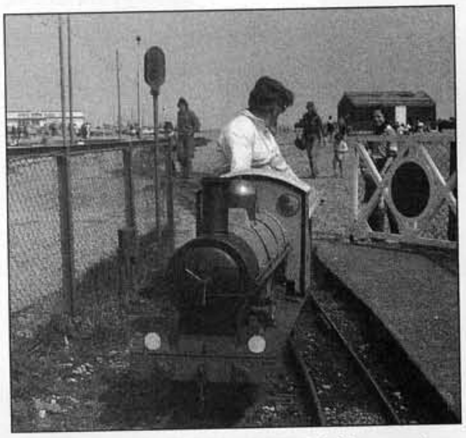
by Kevin West

Kevin's reminiscences about his exploits show just how much fun and enjoyment may be had from the model engineering hobby ...

Just what can you get out of this Model Engineering hobby if you don't own a locomotive of your own, or while you spend 'X' years building your first locomotive. Well, I have been involved in model engineering now for 22 years and although I now have a number of Gauge '1' locomotives I have never owned a steam locomotive of any larger scale. However, through my membership of several Model Engineering Clubs and Societies I have made many friends and had some very enjoyable times, so if you are thinking that model engineering may be for you, find your local club and take a look, and have some fun.

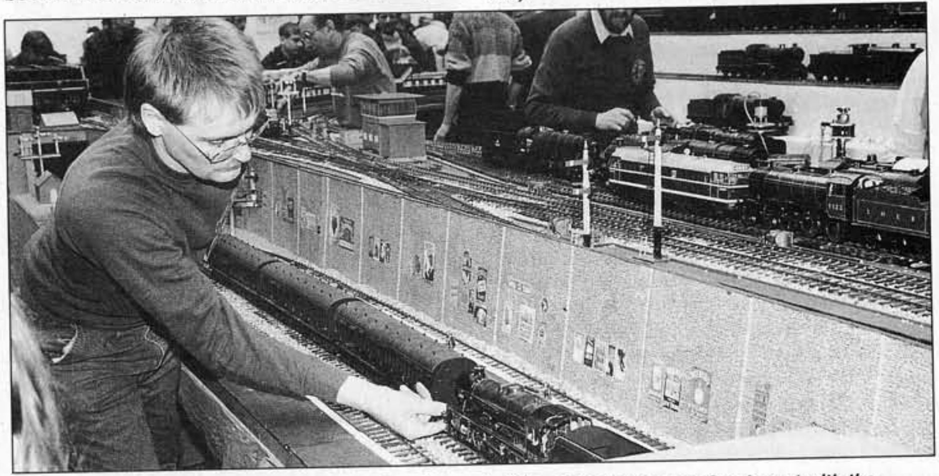
The first sparks

From my earliest days I have always had an intense interest in railways. This has developed into an interest in primarily steam powered railways, although not to the total exclusion of other forms of motive power or transport. I blame it all on my grandfather who, before I could walk, had built me a large model locomotive out of scraps of aluminium from the Handley Page aircraft factory in Cricklewood where he worked. I'm not sure what specification the material was but it must have been of the highest quality as Handley Page were just finishing off the last of the Victor bombers at the time! The locomotive had eight wheels, if I remember correctly, and was about 5" gauge although the wheels had no flanges. The body was well proportioned, although totally freelance, and was fitted with a cab/bunker big enough for me to squeeze inside. If I still had it now it could easily be fitted with a new chassis and electric drive for use on a track by my own children. Alas it went to that great scrapyard in the sky many years ago.



The 10.1/4 " gauge Bullock 0-6-0 Firefly seen at Hastings miniature railway in 1977.

The Author's wife, Sue, driving Frankie - the 5" gauge petrol locomotive - with the bodywork removed. (Was this to help with engine cooling! - Ed.)



A scene from the MRC Easter exhibition showing part of the extensive Gauge One layout with the Author coupling up an electrically powered loco on the low level line and live steam locos on the upper.

As a child, I must have been one of the last to grow up with a Hornby 'O' gauge tinplate train set. A BR green liveried, clockwork 4 wheeled locomotive and tender with three 4 wheeled coaches and a circle of track with a couple of points to form an inner loop gave many hours of enjoyment and were later added to with several other locos and items of stock.

Progression

Later, a Triang 'OO' layout was acquired from the next door neighbour and I started to assemble my own first models, Airfix kits of station buildings and wagons. Later the 'OO' was exchanged for an 'N' gauge layout which went through several forms until disposed of in the early 1980's. By the late 60's, though, I was starting to attend the Easter show organised by the Model Railway Club. I had been taken by my parents in the mid 60's but don't remember much about it. In 1970 I spent 2 days at the show, most of which was spent watching a layout called 'Winterbourne'. This had been built by The Gauge One Model Railway Association and was an electrically powered branch terminus. Two years later the Association had another layout known as the 'dogbone' because of its shape. This time it was steam operated and I was hooked, but enquiries to join the Association revealed that I was too young by a few months. I was directed to my local Model Engineering Society - The Harrow & Wembley SME - which I was able to join straight away and who had in their membership two committee members of the Gauge One Association! In September the Harrow club held an exhibition at which my first 'N' gauge layout was being shown, but I spent most of the day looking at the larger exhibits and the Gauge One portable track just across the hall from my own layout. Having reached the required minimum age I joined the Association and have been modelling in Gauge One ever since.

Kevin West running Paul Counsell's live steam, spirit fired, LMS Patriot No. 5519 Lady Godiva at the MRC Easter exhibition.

The Author driving the 7.1/4" gauge LMS Royal Scot off the turntable at the Country Park referred to in the text.

First Club

The Harrow club had a very good junior section and a number of members who were prepared to allow the younger members to drive a couple of laps of the track at the end of the day. Learning the techniques of using injectors, controlling the by-pass and where to put coal on the fire (not just throwing coal in through the hole) and all the other jobs involved in running a locomotive made for enjoyable Sunday afternoons. Later on I was joined on these Sunday afternoon club visits by my girlfriend who also soon joined the ranks of junior drivers - and very good she was too. Many were the times us men were left watching her lap the track while we stood drinking tea.

It was during one of these runs that I learned to expect the unexpected. The locomotive was a $7^1/_4$" gauge Midge, finished in GER livery and loaned to the club by its builder. It was well made and did sterling service on the portable track for many years, rarely running elsewhere as the club did not have $7^1/_4$" on its track at this time. The engine was fitted with steam brakes which were a little temperamental. On this trip, which was thankfully with no passengers, I set off down the track building up to a reasonable speed until shutting the regulator about halfway along. Coasting towards the end of the track the steam brake was applied to finally stop our progress, but to no avail. The engine hit the stops more than just a kiss causing all the water in the side tanks to surge forward pushing the filler plugs out of the tank tops. The plugs simultaneously pirouetted forward to land on the tank top in front of the filler holes. Never again did I rely solely on the steam brake, I always had my hand ready to apply the hand brake just in case!

On another occasion the track had been booked to appear at a local fete. On arrival we were shown to our location which was on a path through an ornamental garden. The path chosen was just wide enough for the track and led from the edge towards the centre of the garden where there was a statue. We just had enough length to erect the track between the statue in the centre of the garden and a hedge behind where the station was to be. The other problem was that the garden was not flat. In fact we found that the track dropped towards the statue end by about 4 feet over the 200 feet length of the track!

The engine never came out of reverse gear all day and passenger loading had to be carefully done to ensure the engine was not overloaded. The driver had to sit on the train with his feet on the ground holding it back while passengers were being loaded so that it did not roll away down the hill. When ready to leave, the driver just lifted his feet and the train would roll down hill gaining speed. Steam was applied about half way along the track with the gear in reverse to slow things down, along with generous use of the steam and hand brakes. When the train had come to a stand it was full regulator and full gear to push the train back up to the other end of the track, 1 in 50 all the way, by which time pressure had dropped back due to the amount used in getting the train up the hill.

As a ride consisted of two trips, the blower was now put on hard to build up pressure and the trip down hill done as slowly as possible to allow sufficient recovery to get the train back. The exhaust beat sounded lovely and I don't think the loco ever worked harder in its life. It was also one of the busiest days ever with the portable track. I'll never forget the feeling of being pushed down the track by the weight of the train behind me, getting nearer to the statue which was looming over the top of the buffer stops.

A transport problem

On one occasion several years later, I arranged the loan of Midge for a visit to a local track that had $7^1/_4$" gauge available. The loco was to be delivered to my home after a portable track event the week before the visit and be taken the following weekend to the other track in my father's car. The problem arose when we tried to load the engine ready to depart. The engine was too heavy to lift into the boot, so the only way to get it in the car was to remove the front passenger seat and push the loco into the space up a wooden ramp!

Later I acquired a 5" gauge 4-wheeled petrol locomotive. This had outside frames and was powered by a 63cc Villiers 2-stroke lawnmower engine with a vee belt primary drive to the rear axle and chain drive between the two axles. A wooden body of basic design was fitted, complete with the name 'Frankie' as it was a bit of a monster! The 'clutch' was a vee belt which slipped on the output shaft pulley from the engine and the rear axle pulley until tension was introduced by a lever with a jockey wheel which ran on the back of the belt. One Sunday morning while some track work was being done, the engine was left on the main line of the Harrow ground level track with the engine running while we went into the hut to get a cup of tea. On coming out of the hut we found that the loco had gone and it could be seen gently plodding away across the other side of the track. The vibrations had made the clutch lever drop and slightly engage. With only low revs, speed was very slow so we just sat down on the platform and waited for it to come back!

A club visit

Visits to other clubs and tracks are a part of the social side to many Model Engineering Societies, and Harrow was no exception. On one ocassion half a dozen friends who belonged to a neighbouring club, and myself, were invited to visit a $7^1/_4$" gauge track in a Country Park. The operator was waiting for us and gave us all a good welcome as we looked around the station. The organiser of the trip knew the operator, but the rest of us were strangers. The stock shed doors were still closed as it was early, but the operator invited us to steam and run whatever engine we wished for the day and promptly disappeared into the shed via a side door. As he opened the main doors the

'On the big stuff' - The Author (left) with Mike on the footplate of Superior ready to depart from the engine shed at the Whipsnade Wild Animal Park 2'6" narrow gauge line. This is what friendships in the model engineering world can get you into!

loco stud revealed itself - over a dozen locomotives, mostly 2-6-0's & 4-6-0's. "Take your pick", he said, and we did, one each!

Very soon the shed area was filled with 8 locomotives all raising steam; 2 Royal Scots, 2 Greenly 'Maid of Kent' 2-6-0's, at least one Black 5 and a couple of smaller tank engines. A grand day was had by all! We ran from before midday till well after 9 o'clock, each having a go at all the engines. A public service was being run for visitors to the park and there were plenty of passengers to keep us busy. The regular staff were kept busy all day supplying both the needs of engines, with coal and water, and the drivers, with tea and food. What a way to enjoy a day! Having said that, I did have a couple of exciting moments that day.

I was driving a fine model of a Royal Scot, hauling a full three car train of passengers around the track. The section out of the main station was on a gentle up gradient which levelled out as you entered the loop. On this run the train had no trouble in breasting the summit of the climb despite the load and was running at a good speed. Just as we approached the crown of the loop the boiler gauge glass blew, sending steam and water back into my body. After a second or two of getting over the shock of what had happened, I seemed to go into automatic mode, leaning back and uncoupling the train from the tender and giving it a gentle shove backwards to get the train away from the engine, then putting my hand into the cab to turn the blower on as hard as I could, followed by stuffing my driving rag into the chimney to divert the steam back into the firebox and dampen down the fire.

None of the passengers had been injured, although a couple of small children were a little disturbed by the noise, but the front of my overalls were soaked by the steam and water. The following train pushed us all back to the shed where the engine was soon repaired and back in service, but not before blowing another gauge glass as steam was being raised for the second time! A bit more investigation showed the fittings to be a little out of line and as soon as this was rectified no more problems occurred.

Miniature railways

It is not only the smaller scales that interest me. From my childhood I can remember family trips to the south coast which normally ended up at Hastings or Littlehampton. Whilst the rest of the family stayed on the beach I would end up watching the trains on the miniature railways at these places. At Hastings at the $10^1/_4$" gauge line on the sea-front, the operator (who I now know as the late Jim Hughes) was a delightful man who would show an interested youngster the inside of the locomotive shed and, if you were lucky, let you sit on the engines stabled inside. This was probably my first footplate experience and on one occasion I was allowed to drive the Bullock 0-6-0 Firefly up and down the yard. The other locomotives at Hastings at this time were a GWR 4-6-0 Saint class Hampton Court and the only Bassett-Lowke built $10^1/_4$" gauge LMS Royal Scot 4-6-0. The line still exists but steam power has given way to internal combustion, although the steam locomotives do still exist, the Scot is in the USA.

Steam driving in Norfolk

Several years later I was invited to visit a private $7^1/_4$" gauge line at a holiday site in Norfolk where some of the Harrow SME members were spending the week running the railway. It was decided to make it a family day out, so after arriving and having a picnic lunch I left the rest of the family on the beach and walked to the railway where running was in full swing.

Several trips around the circuit as passenger were made before being offered a drive of a Black 5. Having had a couple of trips I thanked the host and made my way back to the beach and the family. On the way I noticed several strange looks given to me by people on the street, "I can see you've had a good time" was my wife's first comment. My face and clothes were covered in oil splatters and soot from the engine! Soon we were all back at the railway where my daughter, then about 2 years old, spent a couple of hours having a ride behind all the different engines in steam while I got back on the footplate.

The following day I told a friend, Mike, about the day and it was decided we would both go back later in the week for a full day on the line. The Thursday was selected and, having been running almost continuously since the previous Saturday, some of the drivers were glad of a rest. We arrived just before lunchtime as the engines were coming back on shed after the morning running and were lucky enough to be offered one each to run whilst the owners were eating. When the owners returned after lunch, about 2 hours later, we were told to carry on, so we did until about 8 o'clock in the evening.

The Author, in the driving seat of the $7.^1/_4$" gauge LMS Royal Scot, approaches the balloon loop points on the Country Park line refered to in the text.

On the big stuff!

On the way home, Mike talked about hearing that the 2' 6" gauge line at Whipsnade Wild Animal Park was looking for staff and, as he had had such a good day driving on the $7^1/_4$", he was going to see if he would be considered for the big stuff! Well he was, and very soon after I joined him for my first day firing on the line. The line is a two mile circuit which runs through the animal paddocks and is used to transport visitors and get them nearer to the animals. There are six locomotives, three steam and three diesel, all different with the exception of two of the diesels. The railway runs very differently to most steam leisure lines as the main aim is to let the public see the animals, so slow running through the paddocks is the order of the day and the animals have right of way! No two trips are ever the same as the animals seem to be all over the paddock on one trip and twenty minutes later they have all disappeared!

The last climb into the station, up a 1 in 38 gradient on a sharp curve, always gives the engine plenty to do. Given a good fire, good coal and plenty of water in the boiler, the engines are master of the job. But a new batch of coal from a new source can give all sorts of problems. One batch of coal gave excellent results for about half a day, with plenty of heat, and no need to use the poker. Then, suddenly it would clinker all over the grate, leaving a solid mass across the firebars which had to be dug out. Everyone was caught out by this coal until the correct firing technique was found.

In summary

Most of the events recalled above came either through my membership of a club or through the friendships made with other club members. The Model Engineering fraternity is full of people like those mentioned and they are all very willing to offer help, advice and opportunities to take part in this most enjoyable hobby. I have recently acquired the chassis of a 5" gauge loco that requires finishing, so maybe one day I will be able to offer to a newcomer some of the help and experience given to me.

So go on, join that club, learn, and have some fun. ■

PHOTOGRAPHING YOUR MODELS

By Mike Wade L.B.I.P.P

Taking good photos of your models can be done quite easily when you know how ...

Modellers like to keep a photographic record of their models for several different reasons. Very often it may be just to show friends and relatives what the model looks like or how well it is progressing during its construction. It is also useful to have photographs of the model to show the police etc. if the model is stolen. Perhaps the modeller may want to submit a photo for the front cover of a magazine or to illustrate an article etc.

Whatever the reason for taking the photograph, it is always worthwhile making a good job of it. Unfortunately, there are many reasons why the average modeller's photos do not turn out as well he may like. Photographing scale models is not the same as taking pictures of the family or the usual holiday snaps; it does require an understanding of the basic functions of the camera and how to use its various controls to achieve the desired result. However, it is possible for the average modeller to take better photos with basic equipment once he knows how - and this article should provide you with enough knowledge to improve your results! So, read on ...

Types of camera

Compact cameras: Most families will have a compact camera in the house these days. The average compact camera uses 35mm film and has a fixed lens which cannot be removed from the camera body. These lenses generally have a minimum focus distance of around 3 feet and this is its major limitation as the small scale models need to be photographed much closer in order to 'fill the frame' and produce a decent size image on the print. Compact cameras are therefore not really suitable for photographing scale models.

Single lens reflex cameras: These cameras mostly use 35mm film (although one or two use 120 roll film) and they have interchangeable lenses which can be removed from the camera body and replaced by other lenses of different focal length (wide angle or telephoto). The minimum focus of these lenses will vary according to the focal length being used but the standard lens supplied with the camera will usually have a minimum focus of around 2 feet. Inserting extension tubes between the body and the lens will enable the lens to focus at much shorter distances and this is what makes the single lens reflex camera the best tool for model photography.

The ideal setup will depend on the type and size of model to be photographed but a good outfit for most modellers would include a 35mm SLR body and standard 50mm lens (which is what most people would own already) and a set of extension tubes to enable the lens to focus closer. The addition of a short telephoto lens of around 100mm (or, better still, a macro lens of that length) would be useful and a 35mm wide angle lens would also be worth having.

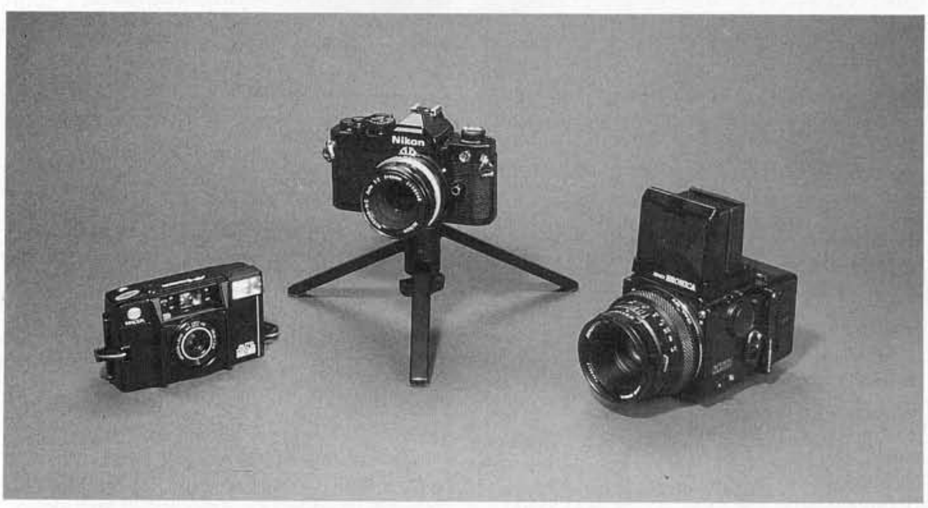
Understanding the basics

Although this article is written around the 35mm SLR, the basic concepts apply equally to all camera types and formats. A camera consists of a body to hold the film and a lens to focus an image of the subject on that film. There are three main controls on the camera: the Shutter, the Aperture and the Focussing Ring. Let's take a look at each of these in turn.

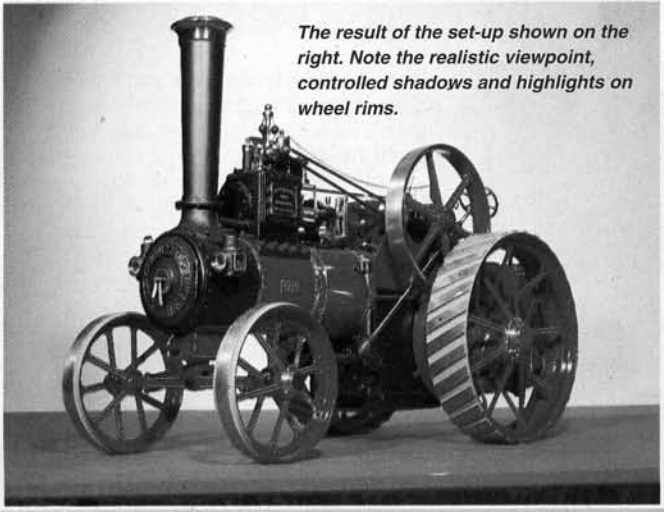
The *Shutter* is usually mounted in the camera body and its function is to control the *time* that light is allowed to reach the film. Typical shutter speeds range from a fast 1/1000th of a second down to slower speeds of ½, or even whole, seconds.The *Aperture* is normally found in the lens and has a variable hole diameter which is used to control the *amount* of light which can reach the film. A large aperture such as f2 allows a lot of light to pass and a smaller aperture such as f16 only allows a small amount of light to reach the film. Confusion often arises with the numbering system for different apertures: try and remember that large apertures have smaller numbers (like f2) and small apertures have larger numbers (like f16). Another point to remember is that apertures are often referred to as 'f' stops.

The *Focussing Ring* is used to make the

A good outfit for model photography: (l - r) 100mm macro lens, small flashgun, 35mm SLR with 50mm lens, 35mm wide angle lens.



Different types of camera: (l - r) 35mm compact, 35mm single lens reflex, 6x6cm medium format.



The result of the set-up shown on the right. Note the realistic viewpoint, controlled shadows and highlights on wheel rims.

The Author photographing a traction engine at an exhibition. Note the camera position (low down on left hand side) and position of the studio flash lights (main light on left, fill light in centre, snooted effects light on right). This photo was taken before we put a paper background roll behind the model.

lens produce a sharp image of the subject on the film in the camera body at different camera-to-subject distances.

Exposure

Film needs to receive a specific amount of light in order to register the image correctly so that it will produce a good print or transparency. A meter is used to read the amount of light on the subject and will give a combination of shutter speed and aperture size needed to register the subject correctly on the film.

Each change from one shutter speed to the next will either double or halve the time during which light can reach the film. Each change from one aperture size to the next will either double or halve the amount of light which can pass to reach the film. It follows, therefore, that an increase of one shutter speed combined with a decrease of one aperture size will give the same actual exposure. This means that we can actually choose to use, say, a specific aperture to suit the requirements in hand and then achieve the correct exposure by 'balancing' it with a suitable shutter speed. Understanding this basic concept is very important when photographing models, as we shall see in a moment.

Depth of field

Control of the 'depth of field' in a picture is vitally important when photographing scale models because this is what controls the amount of sharpness in the picture. The most common problem which modellers encounter is getting all of the model in focus from the back to the front. In simple terms, the Depth of field is a zone of acceptable sharpness which extends in front of and behind the point at which the lens is focussed on. To be precise, ⅓rd of this zone falls in front of the point of focus and ⅔rds fall behind it.

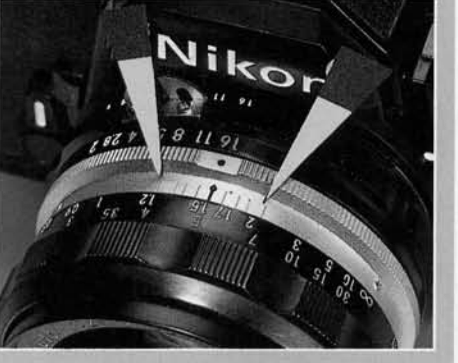
In order to give some indication of where the zone of sharpness will fall, most lenses have a series of marks on the lens barrel with aperture numbers next to them.

A realistic viewpoint and suitable background can make your model look quite impressive.

The shutter speed dial. This often incorporates the film speed setting as well.

The aperture control ring is usually found on the lens barrel.

With aperture set at f4 and lens focussed at 5 ft., anything from 4 ft. 9 in. to 5 ft. 6 in. will be in focus. (Shallow depth of field).



With aperture set at f16 and lens still focussed at 5 ft., anything from 4 ft. to 7 ft. will be in focus. (Greater depth of field).

Some lenses have the marks colour coded instead (see the accompanying photos). Once you have focussed on the subject these marks will give a fair indication of the depth of field when read off against the distance scale on the lens. Bear in mind, though, that these readings are not particularly accurate and will only give a rough guide. The most accurate way to determine what will actually be sharp is to use the depth of field preview lever fitted to the camera body. This lever manually closes the lens diaphragm down to the aperture set on the aperture ring. (Unfortunately most modern cameras are not fitted with a preview lever these days, so you will be stuck with the 'rough guide' marks as your only means of determining the depth of field at each aperture). Perhaps I should point out, here, that all lenses will be set at the largest aperture until the shutter button is pressed to take the picture. This is done to provide the brightest possible image for composing and focussing the shot. When the shutter button is pressed, the reflex mirror in the body swings up out of the way, the diaphragm closes down to the set aperture and then the shutter opens to make the exposure on the film. Once the exposure is made, the shutter closes, the diaphragm opens up to full aperture again and the mirror returns to its original position. All this happens in a minute fraction of a second - that's what I call good engineering!

As you can see from the accompanying photographs, large apertures like f4 have a very shallow depth of field and small apertures like f16 have a much greater depth of field. When photographing your models it is generally better to use smaller apertures in the f16, f22 or f32 range and to focus on the model at a point roughly 1/3rd of the way in from the part of the model which is nearest the camera. If you can't quite get it right it is better to have the closest parts in focus, even though the farthest parts might be slightly out.

Obviously the use of smaller apertures will force you to use slower shutter speeds in order to get the exposure right. This will mean that a tripod will be needed to support the camera in order to avoid a loss of sharpness caused by camera shake. It is generally reckoned that most people can't hold the camera steady at speeds below 1/60th second, and the use of f16 etc. will mean using speeds of 1/30th second or longer with medium speed films (unless, of course, you are using flash). This brings us quite neatly onto the next subject ...

Lighting the model

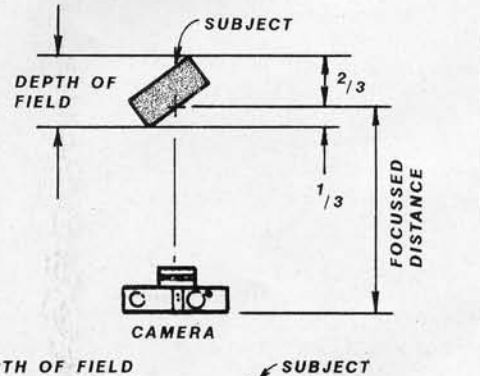
Without light you can't see the subject, so lighting is probably the most important thing in photography. As far as model photos are concerned, getting the right light on the subject can make all the difference between an average picture and a really first class photograph.

Don't worry, you don't need to go and spend a fortune on professional studio lighting to get good results. All you need is to learn the right techniques and how to control the lighting. The best light source of all is available to you absolutely free! Daylight is a wonderful light source but, unfortunately, it is very unreliable (especially in our part of the world!). So you can either wait for a nice bright but slightly overcast day, or you can use artificial light such as flash or tungsten. Whichever you use, being able to control its effect and direction will enable you to produce much better photographs.

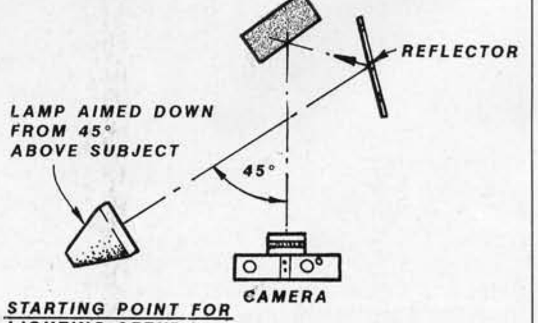
The same basic principles of lighting control apply to all the different forms of light source. As far as model photos are concerned we just need a few of the controls and these are reflection, diffusion, direction and quality. The *direction* which the light comes from determines where the shadows will fall - light from the left hand side will cast shadows of the subject on the right hand side of it and this is usually a good starting point for lighting a model shot. As we read books etc. from left to right across the page, we also 'read' a photograph from left to right (I bet you didn't realise that until now!).

It is also more natural for the light to come from above the model - think of the most natural light source, the sun; it is above us for most of the day. So, we have already established a starting point for the lighting. Try it out on your model by using an anglepoise lamp indoors in a darkened room so that you can see the effect of the lamp only and you will get an impression of what I am talking about.

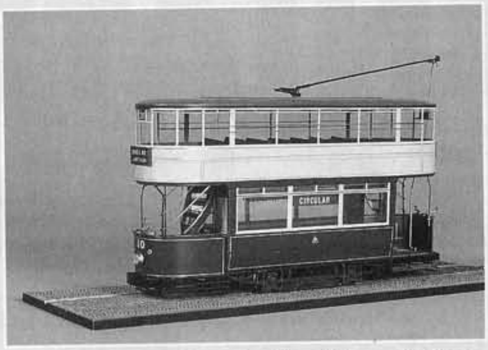
You will probably find that the shadows are much too dark and 'heavy' looking. Now is the time to introduce a *reflector* which should be placed on the right hand side of the model. A piece of white card or a white ceiling tile will do the trick. Move the reflector about and watch the effect it has on the shadows, they will become less dark and less obtrusive. Bring the anglepoise lamp round towards the camera and watch the effect on the model and how the shadows move towards the back of the



DEPTH OF FIELD



STARTING POINT FOR LIGHTING SETUP



This left hand shot looks natural because we are more used to seeing trams from street level. Compare this to the right hand shot which makes the model look less impressive because of the high viewpoint used.

model. There is no 'correct' position for the light and the reflector, it is just a case of using trial and error until you get a result that looks pleasing and realistic.

Now try putting a *diffuser* in front of the light - be careful not to put it too close because the heat of the bulb could set fire to it! Suitable diffusing materials could be a close-weave net curtain, a piece of white nylon material or a sheet of tracing paper. Experiment with different materials to see what effect they produce. You will find that the model takes on a 'softness' as the light now seems to wrap around the surfaces and the shadows also become much softer and more pleasant.

Make sure you use white materials for reflectors and diffusers because, if you are using colour film, any colour in the material will change the colour of the picture. Also be careful about any strong colours in the background which may be near the model itself - especially if there is any polished metalwork or light coloured paintwork in the model - because these can be reflected in the model and spoil its appearance.

What you have been doing with reflectors and diffusers has altered the *quality* of the lighting. This 'quality' of light is difficult to describe but try to think of it in terms of hardness (with a direct light) and softness (with a diffused light). Soft light is more pleasing to the eye because there is less contrast between very bright areas and the darker areas, therefore the eye doesn't have to work so hard to take it all in. However, too much softness or diffusion will make the model look uninteresting, so you need to provide some 'highlights' or brighter areas to create the interest. It is all a question of creating a careful balance between the two.

Types of light source

There are three main types of light source suitable for photographic purposes. The first of these is *Daylight* which is produced by the sun. Direct sunlight from a clear blue sky is a very strong and 'hard' type of light with too much contrast for the film to handle. A thin layer of cloud will act as a diffuser and soften the sunlight and thus reduce the contrast, whereas heavy cloud cover will reduce the strength of the light too much and take away the contrast completely. So it is much better to photograph your models on a bright day which is 'overcast' with a thin layer of cloud. You can still use reflectors etc. to control the lighting and position the model in respect to the sun to get the right direction of light.

The next light source to consider is *Photographic Flash* and this is probably what most modellers will want to use. These days electronic flash is used almost exclusively and flashguns usually derive their power from batteries. The battery voltage is boosted to a much greater level and then stored in a capacitor. When the flash is triggered the capacitor is discharged rapidly through a glass tube containing an inert gas causing it to heat up rapidly (in a few milli-seconds) to something in the order of 6,000 deg. Centigrade and this produces a very bright burst of light which is equivalent in power to daylight.

Tungsten light comes from a light bulb similar to the ones used in most homes. An electric current is passed through a wire filament inside a sealed glass bulb which contains an inert gas. The current causes the wire to heat up and glow red or white hot depending on the electrical resistance of the wire. The filament in a 500 watt bulb will glow brighter than the filament in a 60 watt bulb. Photographic lamps usually have a pearl (or frosted) coating on the glass itself to diffuse the light and make it spread out more evenly. Lamps suitable for general photography are available from 275 watts up to 2,000 watts but are usually only to be found in specialist photographic shops. All the different tungsten lamps burn at different colour temperatures so they must be balanced to suit the colour balance of the film you are using in the camera. A 100 watt tungsten lamp burns at a warm orange temperature and this is why colour pictures taken indoors come out orange!

Choice of film

It is always important to choose the right sort of film for the type of photography you are doing. These days most people tend to use colour film all the time; they are easily available, fairly cheap and easy to get processed. Colour films are now readily accepted by magazine editors because the computers used to make up the magazines can import colour pictures and use them as colour or black and white as needed.

There are two types of colour film; colour negative film is used to make colour prints and colour transparency film produces positive colour slides. Although it is possible to make prints from a transparency (and vice versa) you will always get better results if you use the right film in the first place.

Something that a lot of people do not seem to know about is *Colour Temperature*. Colour films are manufactured to be exposed to a particular temperature of light. The colour of light is measured in degrees Kelvin (deg.K). You do not need to know the scientific principles behind all this, all you should remember is that noon daylight on a clear day has a colour temperature of 5,500 deg.K. All the commonly available films sold for the amateur market are 'daylight' balanced, i.e. for 5,500 deg.K and are therefore suitable for use outdoors in daylight. (The time of day or cloud coverage is taken care of by the film's tolerances). Also all electronic flashguns are designed to give out light at 5,500 deg.K so they can be used with daylight film. Tungsten light burns at a much cooler temperature of around 3,200 to 3,400 deg.K and this has the effect of making daylight films appear 'warmer' or orange. This can be corrected by the use of a correction filter over the camera lens and an 80B blue filter will give a reasonable result with most photographic tungsten lamps and daylight film.

Colour balance is obviously not a problem with black and white film!

Film speed is the other thing to consider. The emulsions coated onto the film need to receive a certain amount of light through the camera to give a correct exposure. As mentioned in the earlier section on exposure, we can control the light admitted to the film with the aperture and shutter speed but this control is, to a certain extent, limited; it won't cope with extremes of light. To overcome this problem, film manufacturers make a range of films which react to different amounts of light. Slow speed films of 25 ISO will need a lot of light to give a good exposure, while fast films of 400 ISO will react to a small amount of light. What you must remember is that the faster film speeds will show a marked increase in the grain structure of the negative and this will show up quite strongly in the prints.

The best recommendation is to use the slowest speed film you can, bearing in mind the amount of light available on the subject. In practical terms I would recommend sticking to film speeds around 100 ISO as these will cover most types of model photography and produce good results. 200 ISO colour film tends to be a bit on the grainy side and 200 ISO transparency films are not really suitable for enlargement to front cover size on a magazine, especially in the 35mm film format.

Aiming for realism

The main objective for modellers is to make a model which looks as close to the real thing as is possible. It should be reasonable, therefore, to expect that their photographs of the model should make it look like the real thing.

Think about the full size prototype. Where are you standing when you look at it? Is your eye level, above or below it? Does it look much bigger than you? How much bigger - a little bit or a lot? Is it smaller than you? The answers to all these questions will help you to decide where to photograph the model from.

Give it a try ...

It isn't that difficult to take better photographs of your models and it is well worth the little bit of extra effort when you get the results back from the processors and see just how good your model can look. ■