Workshop Equipment

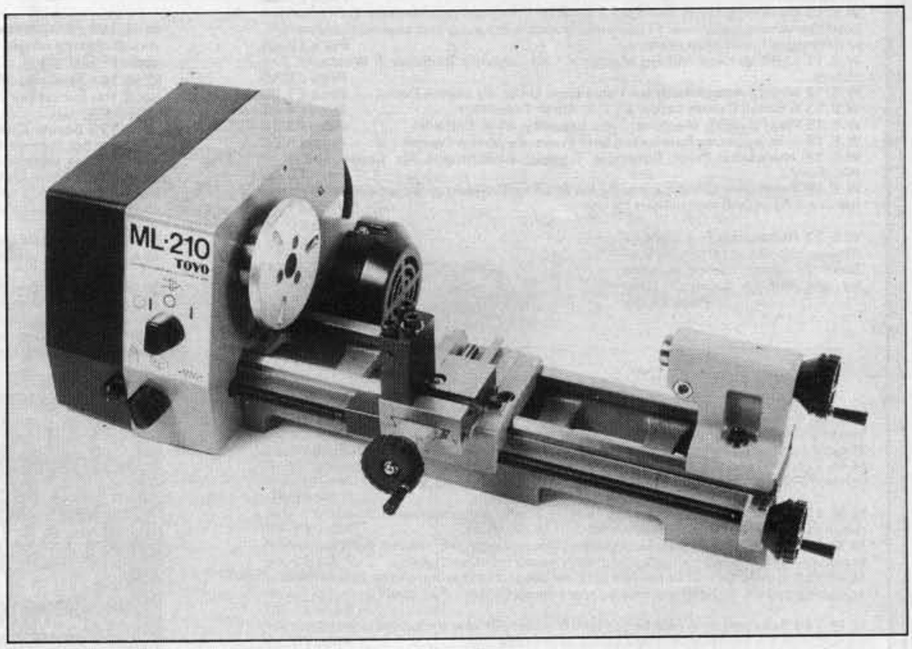
The bare essentials — the equipment you'll need to get started

Over recent years as society has become more affluent, the amount of equipment in home workshops has increased considerably. At one time the only machine the model engineer used was a lathe — nowadays he or she is usually able to obtain more than that. If we look for the reason, then, apart from the fact that such equipment is desirable even if not entirely necessary, the ready availability of cheap, imported machines is paramount. However, this situation is changing gradually, the prices of foreign imports steadily catching up with those of British machines. Another factor that has enabled more equipment to be purchased is the volume of second-hand gear coming onto the market. With factories either closing down or modernising, the old type of machinery has become surplus to requirements and can sometimes be picked up relatively cheaply.

For those with little room, however, the lathe must still be the sole machine tool. Many very fine models have been built with no more than this and, in fact, reference is made to such an occurrence in the chapter on models and modellers. It is not even necessary to have a permanent home for the machine, and again quite a number of first class model engineers use a corner of a room in the house and possibly put the machine in a cupboard after use.

When selecting a lathe, whether new or used, you should try to get one of a size that will suit the type of models you want to make. Unless you are going for high precision work, the basic rule is the larger the better; if you are intending to build clocks or some similar item which requires fine precision work then get a small lathe. The accuracy is usually better and, in fact, if you can spend a little extra go along to one of the specialists such as Bernfield of Potters Bar where they only deal in machines of high precision.

With your lathe set-up, you will need some means of fixing work to it and if it has a faceplate then that will do if a little thought is given as to securing work to it. A combination of faceplate, some metal blocks and an angleplate with some clamping bolts will allow virtually any item to be secured. The next best method is a four-jaw independent chuck (this means that the jaws operate independently of each other). Any type of material can be held in the four-jaw and, with a little



Top, the author with his Myford ML7; probably the most popular lathe with model engineers that was ever produced. Above, the neat little Toyo ML210, capable of tackling loco models up to $3\frac{1}{2}$ inch gauge.

practice, setting it up is not at all difficult, it being simply a case of adjusting each jaw until the work runs true. Although a clock gauge helps in some cases, a four-jaw chuck can be set-up quite accurately using nothing more than a scriber, either secured in the toolpost or in a scribing block resting on the bed.

Personally I prefer a simple holder for a scriber in the tool post as I find that I tend to move the scribing block when making adjustments. A three-jaw chuck with self-centering jaws can only really be used for turning round material to a smaller diameter or drilling. It is not possible to machine a set of cylinder castings or axle boxes with the three-jaw chuck, except by putting the work on the cross-slide and the cutter in the chuck. This is, of course, perfectly good practice if at times somewhat inconvenient.

Before leaving the lathe we should mention the fact that many of the modern ones can be converted into

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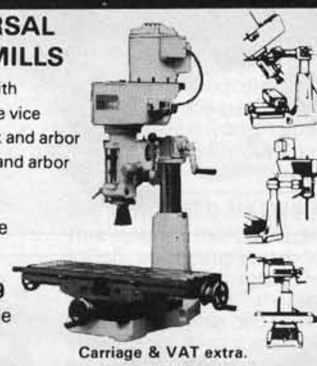

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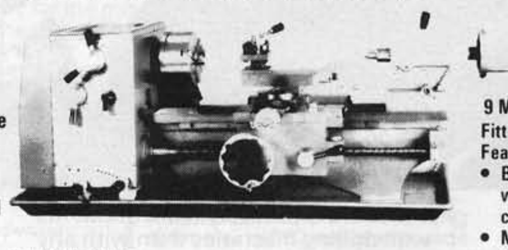

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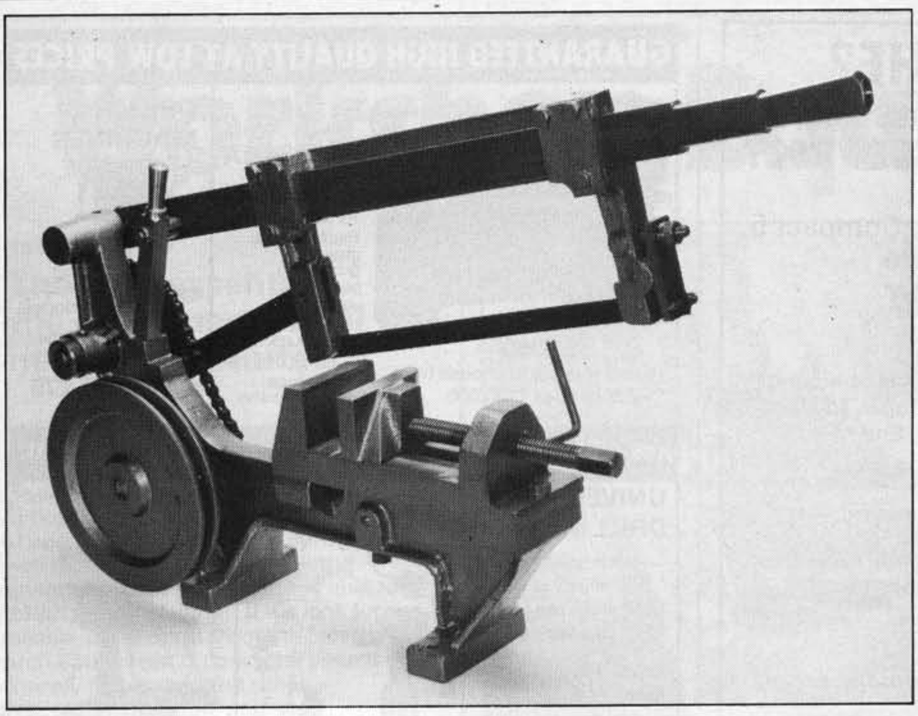
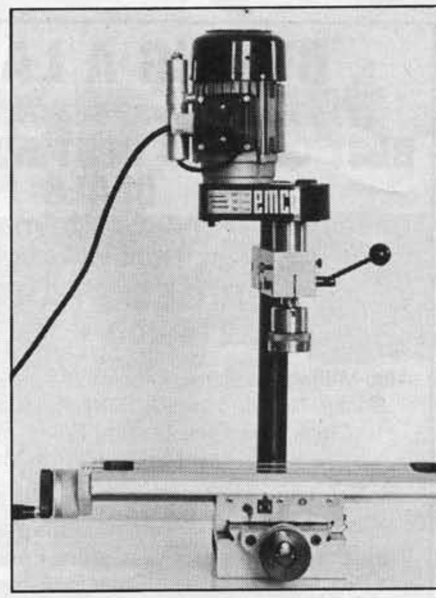
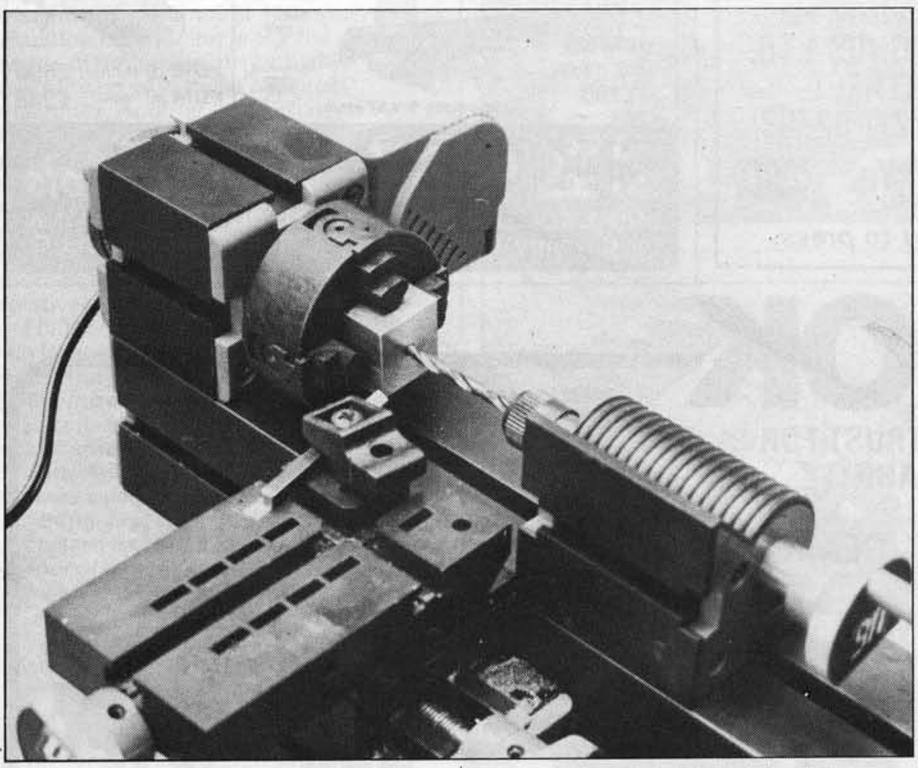
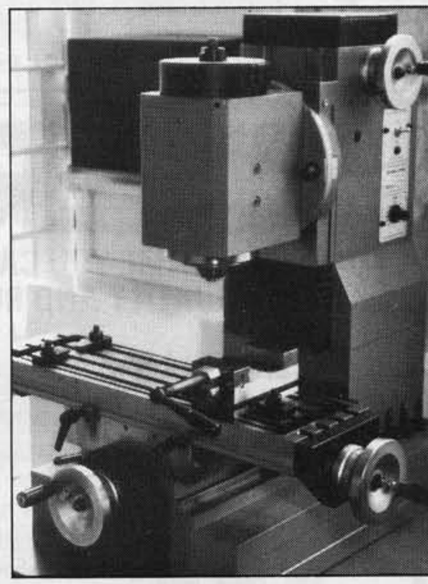




Cutting metal bars can be both tedious and difficult; this hack-sawing machine (top left) marketed by Blackgates Engineering provides the answer. Top right, the EMCO Five milling machine, light but surprisingly robust and rigid, it's ideal for the small workshop. Below, Bernfields of Potters Bar market this Italian Cortini high quality milling machine. At left, the unique Unimat 1 lathe; the smallest on the market, it's made largely from plastic and, although it has obvious limitations, it's not a bad place to start for the youngster.





complete machining centres. It is possible to purchase a bolt-on milling/drilling attachment and this makes a complete workshop in a very limited space. It's certainly worth while considering such a thing if starting from scratch. They come in all sizes so there is no need to be limited in lathe size when selecting.

Whilst drilling holes in flat plate, etc., can be carried out by supporting the work on the lathe cross-slide and putting the drill in the chuck, the use of a drilling machine is better. The range available is very wide and I do not propose to go into the various types here. Work being drilled should, however, be clamped to the drilling table or held in a machine vice of adequate size.

There are probably more accidents with drilling machines than with any other machine. If a piece of metal catches up on the drill and starts rotating, one is left with the horrifying decision of whether to let go of the work and switch the machine off, or let go of the handle in which case the work does its best to lift up. Usually you end up trying to bang your head on the switch to turn it off that way. The third alternative is to let go of both and see if you can break the world's hundred yard sprint record. If the work is secured to the table then one hand is free to switch the machine off if an emergency arises — less exciting, but far better for the heart...

A surprisingly large number of model engineers now own a milling machine of one sort or another and a number of the modern vertical milling machines are also capable of being used for drilling. Whilst I do not think that one necessarily gets the best miller in this way, the machines are very good. There is a tremendous saving in space, not to mention cost, and the drilling machine combined with the compound slide makes for highly accurate drilling. So there is a lot to be said for the combining of the two as far as the modeller with limited space and cash is concerned.

There are plenty of second-hand milling machines on the market these days and I would suggest that, if considering the purchase of one, either a vertical or a universal should be obtained. Horizontal millers are ▶

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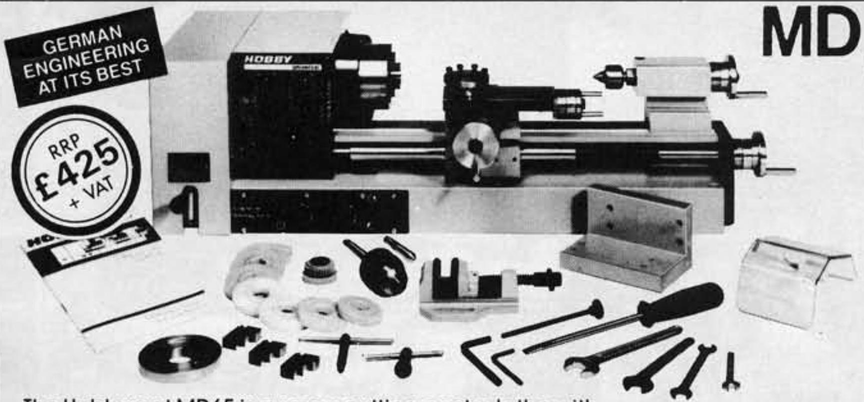

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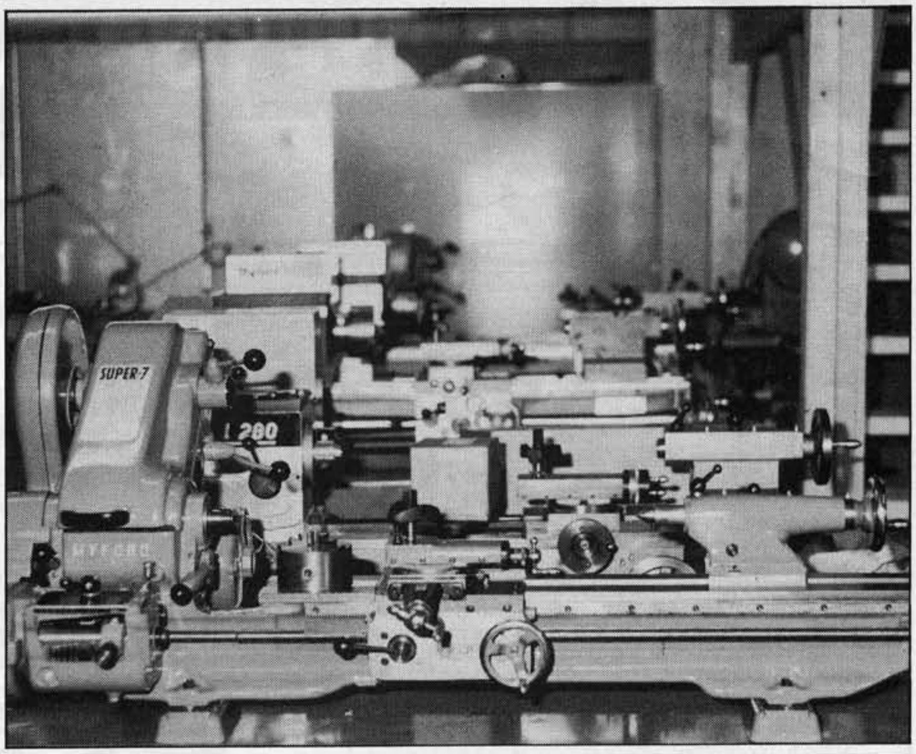
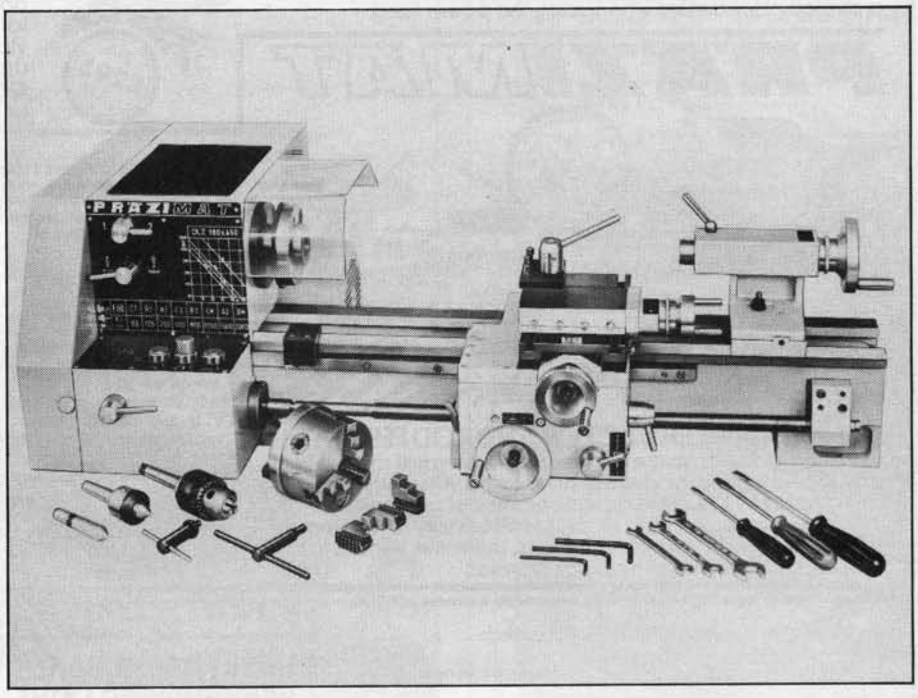


The firm of Whitings specialise in both the sale and renovation of lathes, especially Myford machines like this secondhand Super 7. Below, the Eastern European Prazimat lathe comes complete with all the accessories shown. Imported machines are well worth consideration.



excellent for carrying out very heavy milling operations, but are distinctly limited as far as the model engineer is concerned where usually the need is for a vertical type.

Cutters can also be a problem. Whilst end mills and slotting cutters are comparatively cheap, side and face cutters are very expensive. They also need sharpening from time to time, and unless home facilities are available this can create both problems and expense. End mills can be dispensed with if the worst comes to the worst and, in fact, special throw-away versions are available if required.

One major chore in the workshop is sawing metal to size, at least *I* think it's a chore! Some mechanical form of saw can be quite useful and there is a wide choice available on the market. Quite popular are the combined horizontal and band saws; whilst they will not cut such intricate patterns as will a conventional band saw because of the blade width, it is possible to cut large radii with them as well as using them for cutting up metal bars as one would a hack-saw.

There are also a number of ordinary reciprocating saws available. They tend to be a bit more expensive, but Blackgates Engineering supply one that is, in fact, cheaper than the band-saw type and only needs a motor to complete it. The ordinary small band-saw can also be pressed into service. I have used a Burgess band-saw for more years than I care to remember and, whilst being slower and not quite so accurate as the other types of power saw, I find this little machine very useful indeed.

The machines I have suggested are, in my opinion, those most likely to be used by the model engineer laid out in the order of preference for their purchase. There are, of course, plenty of others also available, but these must be a matter of choice for the individual. ■

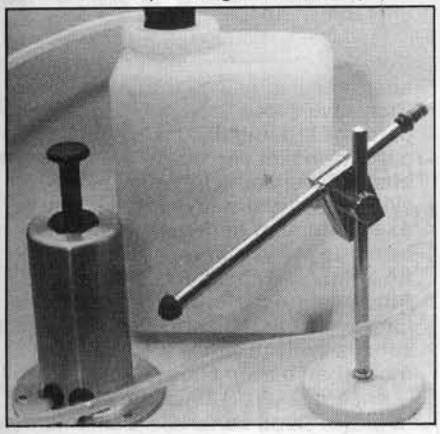
Cutting Remarks

Even in model engineering, the use of cutting lubricants is commonplace. Here's why

Most model engineers know that, when machining some metals at least, a cutting lubricant is desirable. In fact in order to get a really good finish on steel, a cutting lubricant is an absolute necessity. Such lubricants in the small workshop can be quite a problem. They tend to splash all over the place and often leave an unpleasant smell which gets into the clothing and is very persistent. Most of us approach our hobbies as a means of relaxation with which we can fill our spare time and not really to get involved in something that is oily and smelly!

However, we need cutting fluids in order to cool the work down. When machining takes place a great deal of heat is generated at the point of cutting. This causes a welding action to take place on the cutting edge of the tool and for a build-up of the material being cut to take place on the tool itself. Our cutting fluids help to cool things down and at least delay this action. We rely on a keen cutting edge for a good finish, since, if metal builds up on the tool the edge is no longer cutting and the metal is being rubbed away by the built-up metal with the result that the finish is very rough. There is also a cumulative effect as the more the rubbing effect, the greater the heat and the more rubbing we get.

Another effect of this heating up process is to expand the metal we are cutting. The result is that, if it is measured immediately after machining, the measurement taken can be entirely wrong. That is why



This simple coolant system for the home workshop is manufactured by Ajax Engineering; it consists of a container for the fluid and a pump and the jet can be either a clamp-on fitting or held in position magnetically. It directs a very fine jet of coolant onto the work.

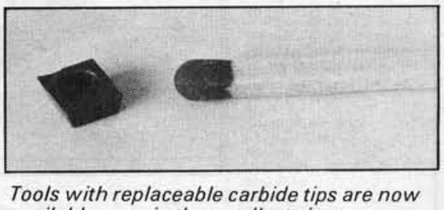
The materials that mainly need coolants are steel and aluminium. Brass, with care, can be machined without and cast iron should *never* be machined with a coolant. However, a better finish will be obtained on the brass with a coolant than without and so the following will also apply to machining it. Firstly we can do a lot to help matters by keeping the tools sharp no matter what metal we are turning since a sharp edge will generate less heat. Setting the tool to an exact centre height will also make a lot of difference. If the tool is above or below the centre, then a rubbing effect will take place and this will generate heat.

The type of tool used can also make a difference, some tool steels heating up quicker than others. This depends on several factors, not the least of which is the hardness of the tool steel. This is fairly obvious as the harder the steel, the less the wear on the edge and so the less rubbing effect we get. It follows, then, that high speed steel tools will stay cooler than those from carbon steel. If we take it a stage further, the modern carbide-tipped tools will do even better. Even here, though, we have an anomaly and, in fact, there is a considerable difference in the hardness of different types of these.

When buying tools with brazed-on tips there is usually no opportunity to know the grade and we must take what we get. We do, however, now have access to tools with a throw-away tip; here we can do a little better and most of the manufacturers will issue a leaflet giving details of the tip qualities that they supply. With the use of a tipped tool it is possible to considerably increase the cutting speeds of metal and, because of this fact, heat does not build up so quickly.

We are now faced with the situation where, if we are not using the tipped type of tool, we need a cutting lubricant. The next question to be considered is how to apply it? The ideal way is to have some form of tank and to let the lubricant flow from this on to the work via a flexible pipe and a tap, the surplus liquid being re-circulated through a pump back to the tank. Go to any engineering workshop and you will see this happening on all the machines. It is this constant flow of cutting liquid that becomes so irksome in the home workshop.

There are, of course, ways round this. The liquid used in the re-circulating systems is soluble oil — a special oil which is mixed with water to a dilution of about twenty to one or more. We can still use this but change our method of application, supplying the oil through a spray, similar to those used for garden insecticides. In this way it is possible to obtain a very fine amount of liquid at the work which is less likely to splash around. Another alternative is to make up a pressurised system and to apply the liquid through this. Such a system can have a very small nozzle — a mere pin hole, in fact. The lubricant will then go direct to the work and the heat will cause it to vaporise and disappear. There are systems of this sort available commercially which are quite effective but, in my opinion, it would be worthwhile if purchasing one to reduce the nozzle for use in the home workshop.

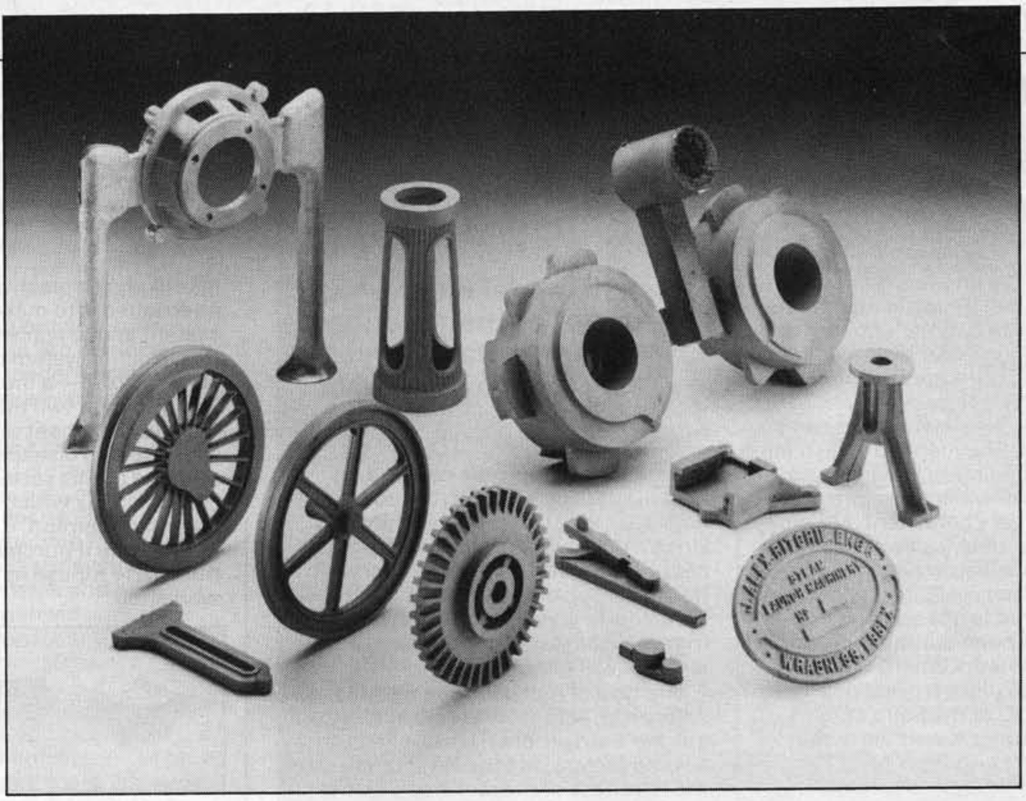


Tools with replaceable carbide tips are now available even in the smallest sizes.

There are a number of neat cutting oils on the market. They were designed for industry where high cutting pressures are used and, whilst obviously they work out more expensive than the soluble type, they are very effective and some are comparatively odourless which is a big advantage. A useful one for the home workshop is Gold Spot which is marketed by Titex who also market, at quite reasonable prices, an applicator bottle and an applicator to fit a five litre can. Both these applicators give the fine jet we need. The firm of Edgar Vaughan market Evcut which is, in fact, quite a pleasant-smelling lubricant and very suitable for our purposes; the firm are specialists in cutting fluids.

There are plenty of firms specialising in cutting oils who make similar products and these include all the big names in oil such as BP, Shell and Castrol. The use of neat cutting oils means that less quantity is required on the work and so application can take a different form. A small squeezy bottle such as used for liquid soap is a good idea but, personally, I use a pipette. This is something used by chemists and is a little plastic bulb with a tiny hole that allows a small quantity of oil to be placed directly on the work. Some companies supply cutting oil in bottles that are designed to allow the oil to be squeezed direct on to the work.

So much for the commercial oils. Now let us give a thought to some alternatives. For brass and alloy, white spirit is about the best lubricant one can get. Liquid soap works well with both copper and alloy. Aluminium requires a good flow of lubricant; it breaks up the swarf and definitely prevents the metal build-up on the tool. For steel, tallow or lard is useful. It is easy to apply, melts as the work heats up and will give a very good finish. Both are also useful for tapping operations. ■



A number of model castings which illustrate the three methods of moulding – gravity die (using all-metal moulds), shell moulding (using resin-bonded sand) and hand moulding using sand impacted by hand around a wooden or metal pattern. In this picture the nameplate, fluted column and loco wheel have been formed by the hand moulding method. **Photo: Stuart Turner Ltd.**

CASTINGS

Much of model engineering concerns the machining of castings; but what are they and what are the benefits?

If we look at it objectively, model engineering consists simply of cutting and shaping pieces of metal and joining them together to form the finished shape we require. This means that, if we want to build a locomotive, we can do so by obtaining pieces of solid metal and cutting them to shape for a start. Later we can assemble all those pieces together and we have our model.

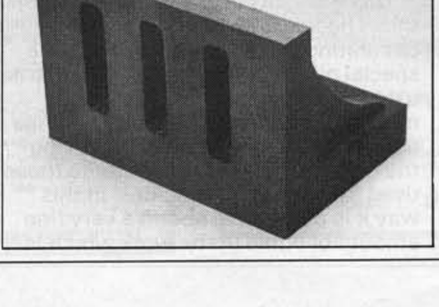
So we can, but how laborious it is to cut out dozens of wheel spokes and to cut a solid block of metal to shape for the cylinders! Nevertheless it has been and still is done. I have a locomotive which was made by obtaining some bronze from the scrapyard and shaping the cylinders from that, a twist to the story being that, at that time the price of copper and brass was rising so quickly that, when I had finished the cylinders I was able to take the remaining bronze back to the scrapyard and not only get my money back but make a profit! Something that is unlikely to happen now . . .

That is all very well for cylinders but, when it comes to cutting out the spokes of wheels, for me at least that is another thing altogether. Again, it certainly *has* been done. The late Gordon H. Tidey made a model locomotive on which he did just that — in fact, he had hardly any facilities at all and he went to Brighton to measure the locomotive and make drawings and then came home and set about making it from solid material. Very good it was too; I had the pleasure of overhauling it later in life and it ran beautifully.

As usual I digress. What I am getting to is the fact that we can get over all this hard labour by using castings and, in point of fact, most model engineering is about machining castings. However, there is no reason why, if they are not available, solid metal should not be used.

Let us have a quick look at what a casting is and how it is made, as this is important to our progress in the hobby. Most castings are produced by laying a simple pattern in a steel box containing specially bonded sand. The box is prepared in two halves. The pattern is now removed, leaving an imprint in the sand. If molten metal is poured into this, when it cools it will have taken up the shape of our pattern. Why, you may ask, bother to make a pattern and cast it? While doing that, the proper part could be made from solid. This is very true if only one of the components is needed, but if we want six wheels, say, then making a pattern for one and casting the others makes sound sense. It makes even more sense if a design has been published and a stockist makes a pattern and sells the castings. The component can be duplicated by the thousand if need be.

A nice hefty angleplate made by the author from a casting by College Engineering Services; this firm can offer a wide range of useful castings which will add considerably to the versatility of the workshop.



Casting can still be the thing to do if only one of an item is needed. The pattern for the casting can be made from wood, which is easier to work into intricate shapes, and the casting will then save a lot of machining. Most patterns are initially of wood as the pattern-maker can easily add or remove bits while shaping the main block. When the pattern is ready, if it is to be used a number of times a casting will be made in aluminium and this will be finished nicely to shape, and used in future as the pattern. Wood will last a long time, but the abrasive action of the sand is likely to cause wear on it far more than it is on alloy.

The finished castings are likely to be in one of three materials: aluminium (or a similar alloy), gunmetal, or cast iron. There will be castings of brass where a particular finish is required and one or two other metals will be used from time to time but let us not complicate matters too much. Alloy is useful for many things and it is extensively used in internal combustion engines. It is also used a lot for stationary engine parts, particularly bases, etc.

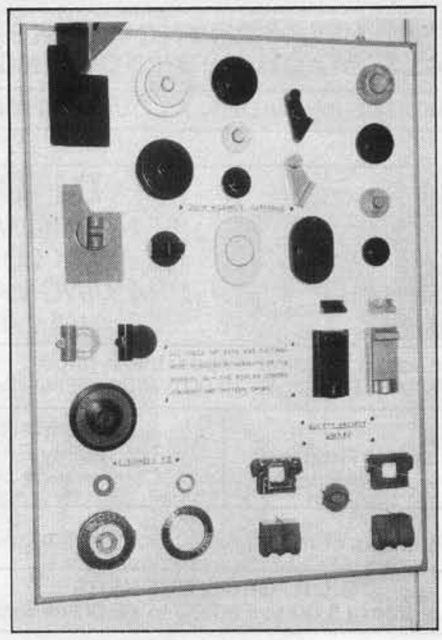
Gunmetal is mainly used for components where a lot of wear will take place such as cylinders and pumps. It is less susceptible to corrosion than the other two metals

and so is valuable in these situations. Cast iron will almost certainly be used for components requiring strength such as wheels, frame stretchers, etc. It is also used for cylinders on steam locomotives quite extensively these days. If cylinders are made of cast iron then, after use, they should be protected from rusting with a suitable oil.

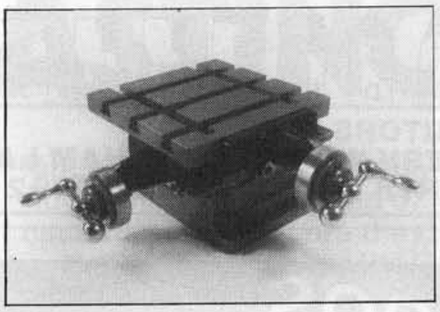
When we receive our commercial castings there are almost certainly going to be some irregularities where the mould has been joined. Hopefully, these will merely take the form of a thin line of very minutely raised metal. There will also almost certainly be marks from the sand. Sand is rough in texture and this will show on the outside of the castings. Occasionally a foundry will sand blast the castings and leave a nice smooth finish but this does not often happen. Filing with a sharp file will get these marks out, or it is possible to do it with a mixture of sand and water in a drum that is kept moving. It takes a long time but the finish in the end is excellent. For this system a drum must be made to rotate slowly and such a machine is not difficult to make. Most of us, though, are happy to clean up with a file.

Because the patterns have to be withdrawn from the mould without damaging the shape that has been indented in the sand, they have to be made sloping and there can be no sharp edges. This must be remembered when machining castings. The slope that has been required for the pattern must be removed before a true datum face can be achieved. This must also be remembered if you decide to make up your own patterns and take them to a foundry to be cast. I would suggest reading the subject up before making a pattern if you have never done it before. Once the art is achieved it is comparatively easy for simple patterns to be made.

One other problem we are likely to come across when machining castings is blow holes. These are caused by air entering the molten metal and causing a hole inside the casting that is not obvious from the outside. It is standard practice for commercial castings to be exchanged when such holes are discovered since it can be most annoying to find one at the last stage of the machining. It is always as well to consider whether or not the hole is going to have any real effect on the working of the component. If it is not, then it can be filled. This is done by mixing up an epoxy resin such as Araldite and putting some very fine dust from the material being used into it when it is mixed. The hole can be filled with this and, when it is dry the surplus removed. It is a lot easier than machining the whole thing again and it is standard practice in industry so why not in model engineering? Blow holes cannot be helped — they are always likely to happen; chemicals are added to the molten metal in an attempt to stop them but they are not always successful.



Many modellers should be capable of making patterns for their own castings; like these neat examples made by the members of a single model engineering society.



Made from castings, this useful compound table is a handy addition to any workshop; it allows precision hole spacing when drilling or could even be used with a Potts milling spindle to form an inexpensive milling machine. Reeves of Birmingham can supply castings and drawings.
Photo: A. J. Reeves & Co.

A problem that can be encountered with cast iron is chilling. This is caused through a casting being cooled too quickly, frequently through being tipped from the mould on to a concrete floor. The effect is to make the casting so hard in places that it is impossible to machine. The only way to change this is to heat the casting until it is red hot and then allow it to cool slowly. Iron castings improve with age and are less likely to distort when machined, any distortion being caused by the stresses on the outside of the casting suddenly being relieved. It is a good idea to obtain the castings well before you really need them and to keep them out in the garden where they will go rusty. This rust is only a surface effect and it does relieve stress on that surface. If you visit a supplier and he has a dozen castings of the type you want, pick the rusty one not the nice, bright, clean-looking one!

You may also hear of castings in the terms 'lost wax' or 'shell moulded' which are different forms of making castings which give a finer finish. They are usually (but not always) used for smaller components. The finish on the outside is very much finer in both cases and better small detail is possible. In one case the casting is made using a wax pattern which is melted out of the mould as the metal is poured in. The other involves a complicated system of putting a bakelite shell on the mould.

There are other types of casting but it is unlikely that they will come into the model engineering field. One, for example, uses a rubber mould and is a process which can be done at home but the finished parts would be more suitable for decoration than for hard wear. ■

The Magic of Steam

Steam, in any shape or form, has a fascination all its own. Why is this and how does the magic work?

Steam has always held an enormous attraction for modellers and it is difficult to know exactly why it is as popular as it seems to be. It could be because steam is basically so simple that models using it as a source of power are fairly easy to construct — or it could just be nostalgia! Again, it could be that, in operation, a steam model has a fascination not seen with other types of power. The various aspects of steam-driven models will be dealt with in other chapters, but a look at steam itself and how it works may be worthwhile, as no matter what is to be driven, the principle of the engine will be the same.

The main property of steam when used as a power source is the fact that it expands, and it is that expansion which provides the power. The story is often told of James Watt watching the kettle lid lift, which led to his development of the steam engine. This is a rather romantic story, and certainly he did not *invent* the steam engine; whether or not his efforts which, without doubt, caused a big advance in steam engine design, were brought about by the boiling kettle we will never know. The principle is there, though, and the reason the lid of the kettle lifts is because the steam expands. If we take a tin with a push-on lid, put a drop of water in the bottom, no matter how small the amount, and apply heat, the lid will blow off. Which proves that the expansion is very great indeed.

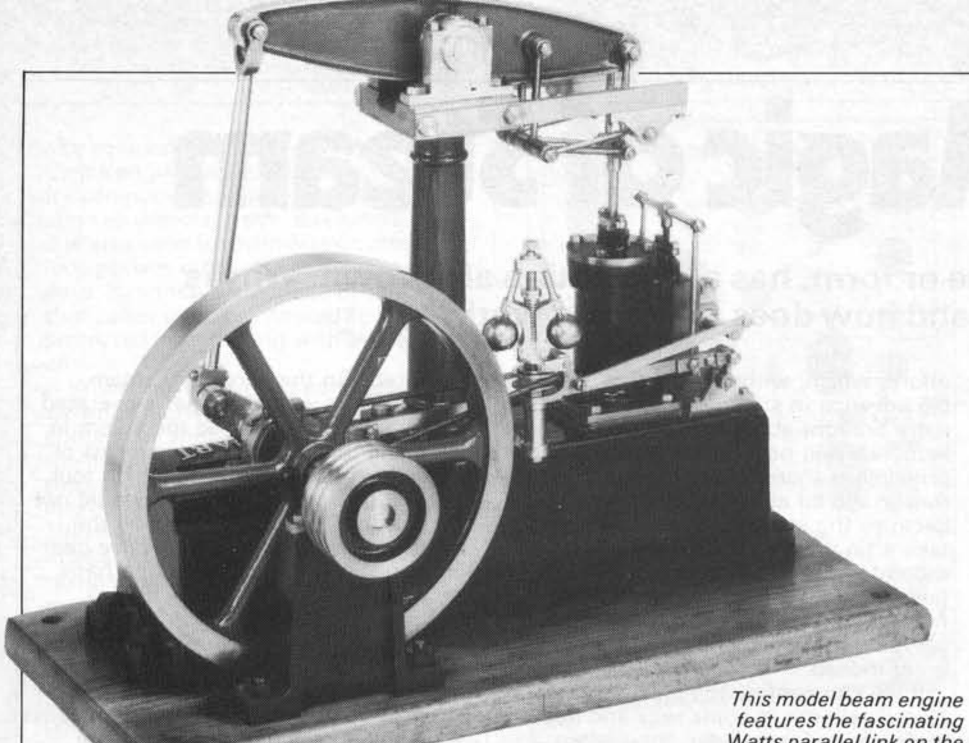
If we can confine the steam to a closed cylinder in some way and have a piston in that cylinder, then when the steam expands the piston is forced down and this can be converted to rotary motion if required. If we can then induce steam to the other end of the piston we can get further power by blowing it back again. Most steam engines work on this principle, although some are only single-acting and only have steam introduced to one end of the cylinder.

In order to get the steam into the cylinder, some sort of valve is required. On the very early steam engines this was often hand-operated and a workman allowed the steam in by using this. Later, various forms of valve gear were produced which took care of this automatically. It would not be possible to explain in full all the various types of valves and valve gear in a Special such as this, but perhaps a couple of basic descriptions will assist.

The oscillating engine is, possibly, the simplest type of steam engine for any modeller to construct. It is, more often than not, the type used in steam toys and, as such, has a bad name amongst serious modellers! In fact, it was used in industry and also in boats to excellent effect. A good oscillating engine can make a very attractive model and can be made to be quite authentic-looking; equally, it can be made in an extremely simple form for the beginner or junior modeller. It has the advantage of being very cheap to make and is ideal for experimentation.

There are no valves as such on most oscillating engines. A simple

This engine typifies the traditional steam engine construction with an open slipper and pillar support. The engine shown is the No. 1 Stuart Turner model that gave birth to the world-famous engineering company more than 80 years ago.
Photo: Stuart Turner Ltd.



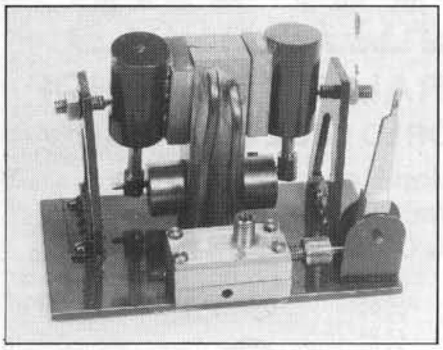
This model beam engine features the fascinating Watts parallel link on the piston rod. **Photo: Stuart Turner Ltd.**

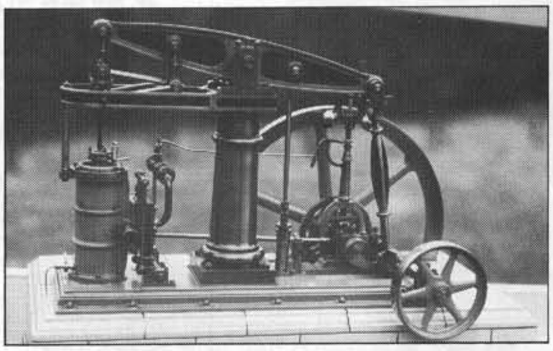
hole at the end of the cylinder allows steam in and pushes the piston down. The cylinder features a flat plate that lies flush to a second flat plate. This second plate is known as the 'steam block' and it is here that steam is introduced. There are two holes in this block, one of which is connected to the steam supply. The cylinder is able to oscillate on the block and, when the hole in the cylinder lines up with the one on the block, steam is introduced. This forces the piston down and causes the cylinder to pivot over. The hole at the end now comes into line with another hole in the block which allows the steam to exhaust or escape, thus allowing the piston to rise again.

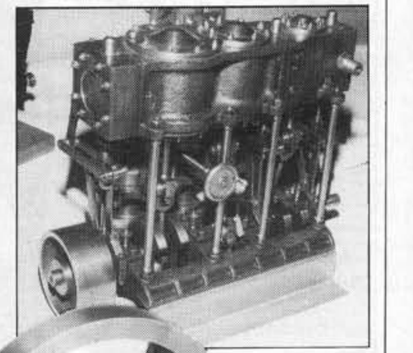
As you can see, the method is simplicity itself. If the steam supply is reversed and the exhaust hole becomes live steam then the engine will run in the other direction. Take it a stage further and seal off the lower end of the cylinder and introduce two holes; now steam can be introduced when the top hole is open to exhaust and the piston is then under power going up as well as coming down. We have doubled the efficiency! Add other cylinders working in harness and even more power is produced. In the case of a single cylinder engine a flywheel is needed to keep the engine rotating to negate the chance of its stopping when at the top or bottom of its stroke.

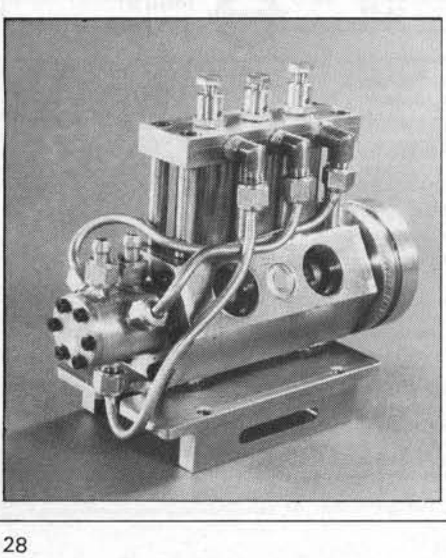
From here we move to slightly more complicated valve forms. The slide valve, for example, consists of a block of metal with a hollow in it. Three slots or holes appear in the top of the cylinder which, again, is in the form of a flat surface. The hollow in the valve covers two of these openings and the one that is left open receives the steam and causes the piston to work, while the steam that is exhausting can escape via the hollow in the valve. As the valve is moved by the valve gear so the other end of the cylinder has steam introduced.

Other types of valve work on the same principle and the various types of valve gear are designed to make the valve operate at the correct time. Mostly they have one thing in common — some form of eccentric which causes the valve to operate in advance of the piston. An eccentric can be a simple circular piece of metal with a hole drilled off centre at a predetermined distance or it can be more complicated. If you want to learn more about valve gears then I can do no better than to recommend you to the excellent book on the subject of locomotive valve gears by Martin Evans. The valve gears on locomotives apply equally to other types of motive power, although some stationary engines feature other types of gear. If building a model, then the drawings should tell you all you need to know. ■

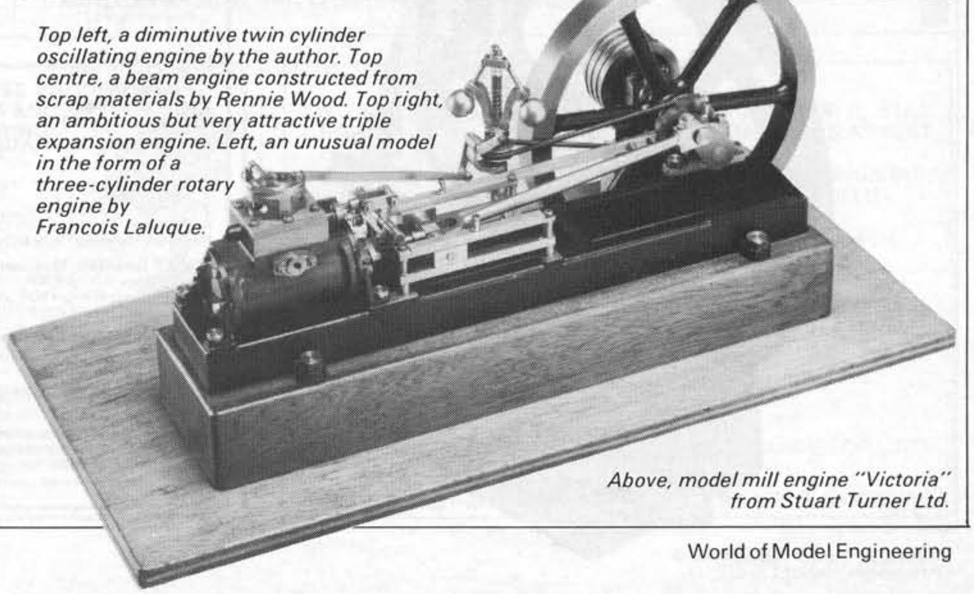




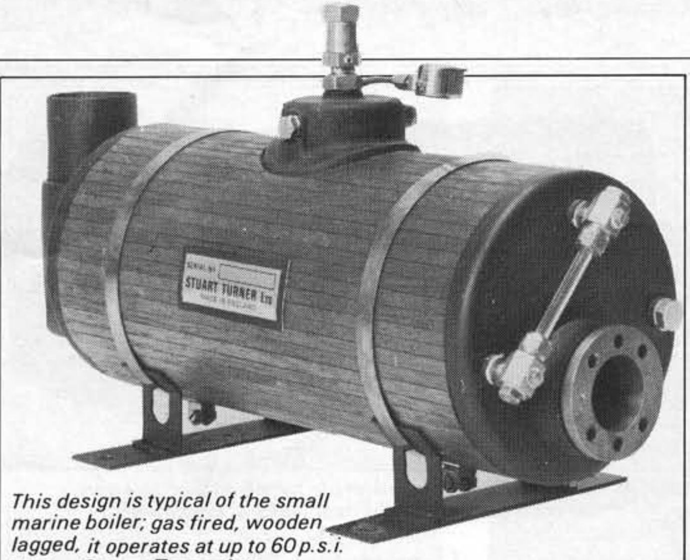




Top left, a diminutive twin cylinder oscillating engine by the author. Top centre, a beam engine constructed from scrap materials by Rennie Wood. Top right, an ambitious but very attractive triple expansion engine. Left, an unusual model in the form of a three-cylinder rotary engine by Francois Laluque.



Above, model mill engine "Victoria" from Stuart Turner Ltd.



This design is typical of the small marine boiler; gas fired, wooden lagged, it operates at up to 60 p.s.i.
Photo: Stuart Turner Ltd.

Basically Boilers

Every live steam model needs one, be it stationery engine, locomotive or traction engine

In order to run a steam engine, whether fitted to a vehicle or stationary, it is really necessary to have a boiler, although stationary steam engines can be run on compressed air if one wishes. There are nowadays numerous highly professional boiler-making firms if one wishes to purchase the boiler ready-made and most of these will make, to order, any type of boiler that may be required. Of course, the cost is higher than making your own, but some may feel this to be justified. My own personal view on this is that boiler-making is a very interesting aspect of the hobby and, once the fear of making a start has been overcome, then there is a lot of satisfaction in building a boiler for yourself.

Boilers come in various types and for a basic stationary engine a simple boiler will do. For a model boat the boiler needs to be more sophisticated and for locomotives we need a special type of boiler if the locomotive is to be coal or gas fired for passenger hauling. For smaller locomotives, say gauge one or under, then simpler boiler types will do and they can be spirit-fired. For traction engines, boilers need extra strength as, in fact, they form the main support for the whole engine, but these are dealt with in the appropriate section.

Copper is probably the most common type of material used for boilermaking. It has the advantage of being easily worked with hand tools, and is easy to solder with silver solder providing it is properly cleaned first. It has the disadvantage that heat will dissipate along it very rapidly so that a great deal of heat will be required to solder it. Heat can be conserved by packing the metal with coke or fire brick.

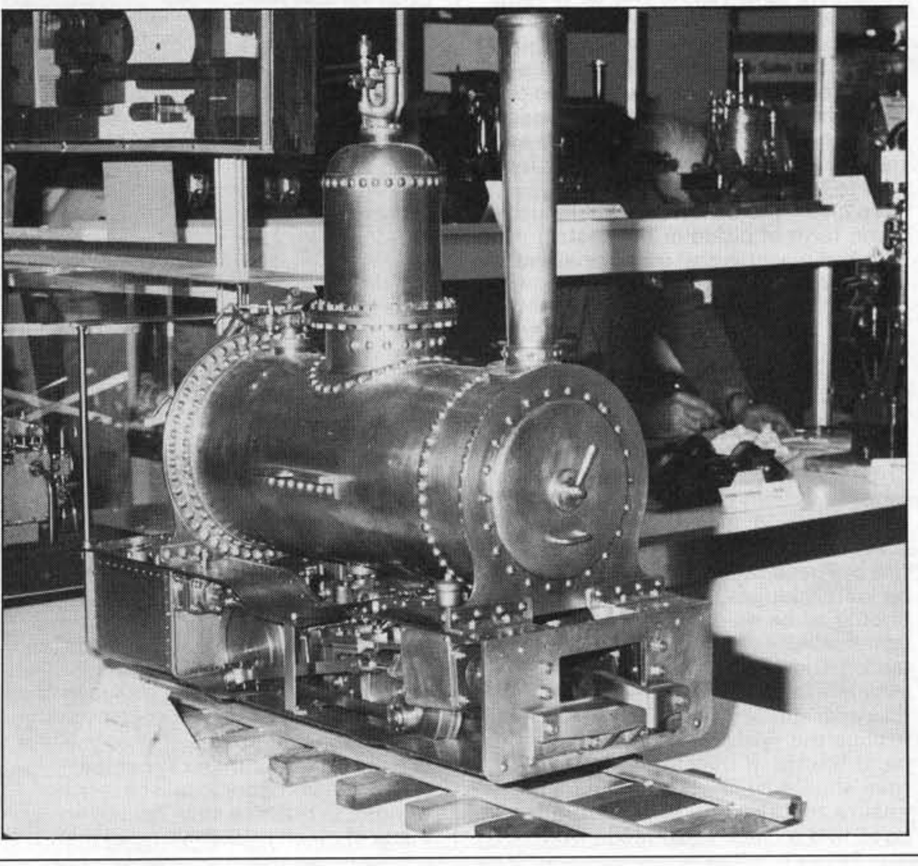
The construction of a copper boiler is by flanging the various plates that are to form the ends of the components and riveting these to the parts to which they are to be soldered. Silver solder must be used for strength and, as most silver solders do not fill gaps very well, joints need to be close-fitting. Flat surfaces will have to be stayed to prevent the pressure in the boiler pushing them out of shape.

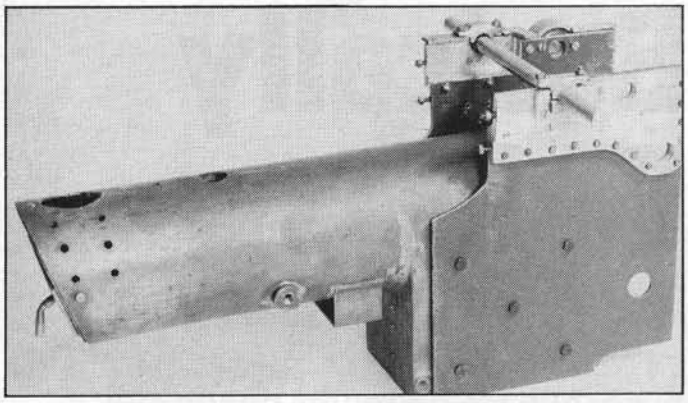
When finished, the boiler must be pressure tested to ensure that it is safe. This is accomplished by filling it with water and then increasing the water pressure to about twice the pressure at which the boiler will be working. This pressure should be held for about half an hour and during this time the boiler should not distort in any way. Providing either a recognised design is made or that the boiler is properly designed then there should be no problem. Of course, during testing all holes that are present to hold fittings at a later stage should be blanked off.

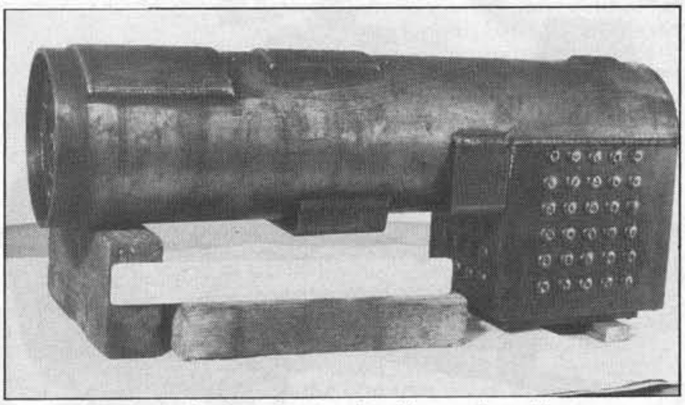
To make a boiler from copper, it is essential that there be enough heat. Apart from packing the boiler as already mentioned, a good quality blowlamp will be required. It must be man enough for the job but, at the same time, if the boiler is properly packed it is surprising to what extent the amount of heat can be reduced, which means that a much smaller blowlamp can be used if the packing is efficient.

Before soldering, the boiler must be fluxed well and brought to a temperature where the silver solder melts on the metal and not in the flame. Usually this means the copper is just beginning to turn a dull red. Most blowlamps these days work from propane gas, but many years ago large paraffin lamps were popular. They were quite fearsome beasts and

An excellent example of an unusual model locomotive under construction. Spotted on the stand of the Society of Model and Experimental Engineers at the 1986 Model Engineer Exhibition, it illustrates a superb example of boilermaking.







Left, a boiler in 2 inch scale destined for a model Aveling & Porter steam roller. At right, the boiler for a Fowler ploughing engine, this one constructed from steel; note the strengthening points which are required on a traction engine boiler and the neat welds of the qualified pressure vessel welder. **Photos: John Haining.**

have lost their popularity. Natural gas from the mains can be used with a suitable blowlamp, but more air will need to be mixed with the gas for efficiency, and it is probably as well if working with natural gas to use a small compressor to supply extra air to the work.

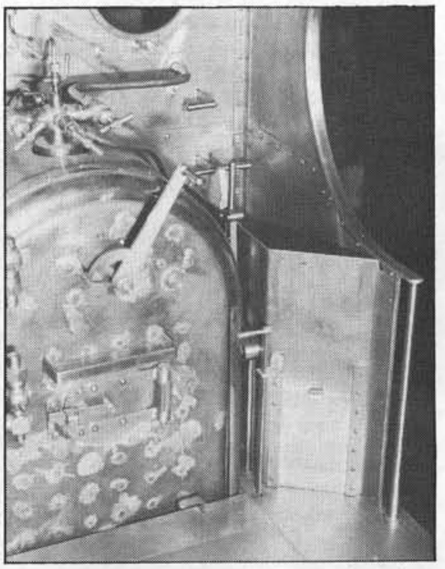
These days it is possible to purchase small propane/oxygen, or acetyline/oxygen sets, but the very small ones are not suitable for boilermaking. Although enough heat is generated at the flame tip there is insufficient volume, and so the work will not heat up properly. With the larger sets, boilers can be made successfully, but it may be advisable to use propane as well. The work can be brought to near the correct temperature with a propane lamp and then oxygen mixture applied. The result is a nice neat joint as the heat is much more localised.

It is possible to solder the boiler without the pre-heat with propane, but a very large nozzle will be required to prevent the heat running away before the solder can be applied. At one time it was thought that the use of oxygen mixtures was liable to cause holes to be burnt in the copper; this myth is now largely dispelled as the heat travels away too quickly for that to happen.

To clean the boiler we usually use some form of pickle or acid bath. Sulphuric acid is the usual one and it will clean copper very well, but is, in my opinion, nasty stuff to have around. Also the fumes are quite toxic and can cause rust on any tools in the area. Whilst it is the most efficient method, safer alternatives can be found. Powdered Alum mixed with water will do quite well and so will ordinary vinegar. Both, however, take longer to clean the copper than sulphuric acid.

All boilers require bushes to be fitted. These bushes take fittings such as water gauges, regulators, etc. They should all be made of bronze. Brass, whilst easier to obtain and work, can suffer from a chemical reaction which, after a few years, causes it to disintegrate. The same applies to the fittings themselves which should also be of bronze. If they are of brass then they should be checked regularly to ensure that there is no deterioration. I have had a clack valve made from brass just fall away from the boiler due to this problem.

Boiler fittings are another item that can be, and often are, purchased ready-made. Personally, I always wonder why as they are not difficult to make and there is a great deal of satisfaction on so doing. Among the types of fittings required are clack or check valves. These are one-way valves that allow either water or steam to pass in one direction only. They are used for various functions but mainly for putting water into the boiler or preventing it flowing back through a pump. The usual form is a ball-bearing on a seating which prevents the water flowing past. When water or steam is applied to the other side of the ball it lifts from the seat and allows free passage. Blow down valves and stop valves, are really only taps, the latter operated by a screw or lever. Water gauges speak for themselves as do pressure gauges.



The rear of a boiler (backhead) on a model currently under construction by Bob Moore.

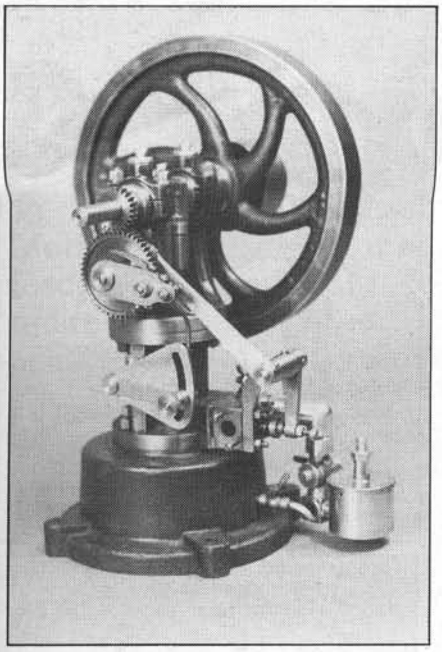
With the high price of copper, many people these days have made the move to steel boilers. It is difficult to be certain if there is any advantage in this in small boilers, but there can be in the case of the larger sizes. Although steel is much stronger than copper and therefore, in theory, could be much thinner, in practice steel boilers are made of much thicker material than are copper ones. This is to allow for the extra corrosion that is likely to take place.

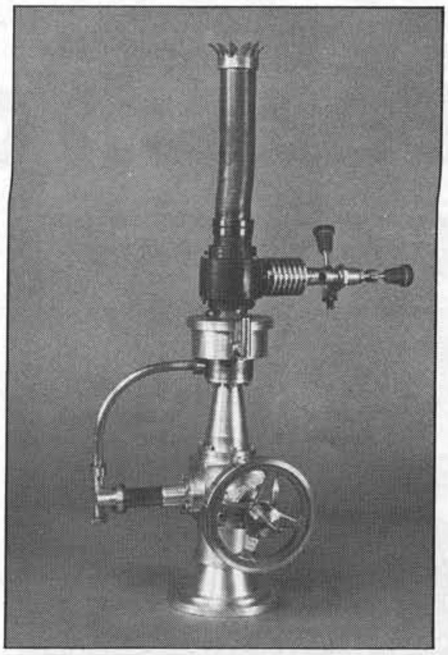
Steel is much harder to work with and bending it can be a problem. Fortunately flange plates are not required, the plates just butting up to the rest of the boiler. Staying is, however, just as important. When making steel boilers only proper recognised boiler plate material should be used and a good steel stockist can specify this.

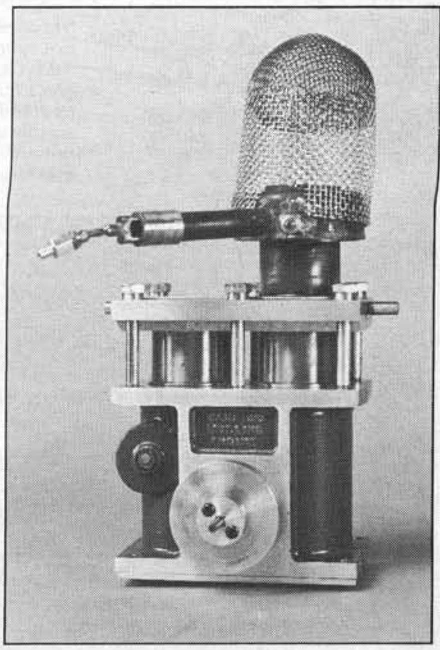
Steel boilers are welded together using arc welders, gas welding being highly unsuitable. The small DIY type of welder is not of sufficient power to weld a boiler successfully, although in highly skilled hands one of the modern higher powered MIG welders might do. I would not go so far as to say that a steel boiler must not be welded by the ordinary model engineer as there is no doubt that some will have the ability to do so. However, the number likely to be able to weld to the standard required is small and so, strictly speaking, if a steel boiler is being considered it should be welded by a tradesman who is certified as a welder of pressure vessels. It is doubtful if an insurance company would accept a steel welded boiler unless it was manufactured by such a person.

After construction, boilers must be well looked after. The copper boiler should be cleaned out once a year at least to remove scale and dirt. This can be done by pumping in a half-cupful of vinegar and filling with water. Leave it for about a week, and then heat it up and raise pressure to about twenty-five pounds per square inch. Let the pressure drop to about five pounds per square inch and then open the blow-down valve. Allow it to cool and wash it through several times with cold water. After running, the boiler should be blown down and left empty.

Steel boilers should always have some form of water treatment added to the water. Whilst they can be blown down after use, they should not be left empty but should be filled so that no air remains in them whilst they are standing. Take care not to leave any air as there is a real danger of rusting along the waterline. They should be cleaned regularly by washing out with cold water. ■







HOT AIR ENGINES

What are they, how do they work and are they difficult to make? A brief look at a fascinating branch of the hobby

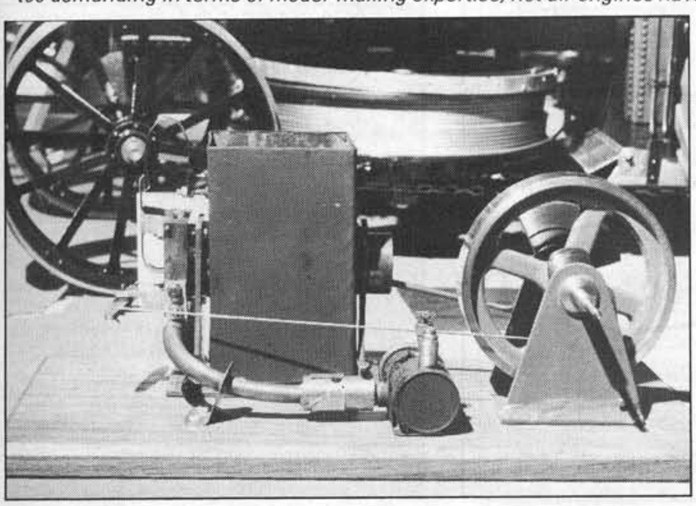
Fascinating models, these, and not too demanding for the novice builder. They also have the advantage that they can be built from scrap material as well as from castings and a number of suppliers have drawings and material available. There are also several designs in the *Model Engineer* Plans Service. When completed the models will run for hours with little heat required for their operation and they are absolutely silent.

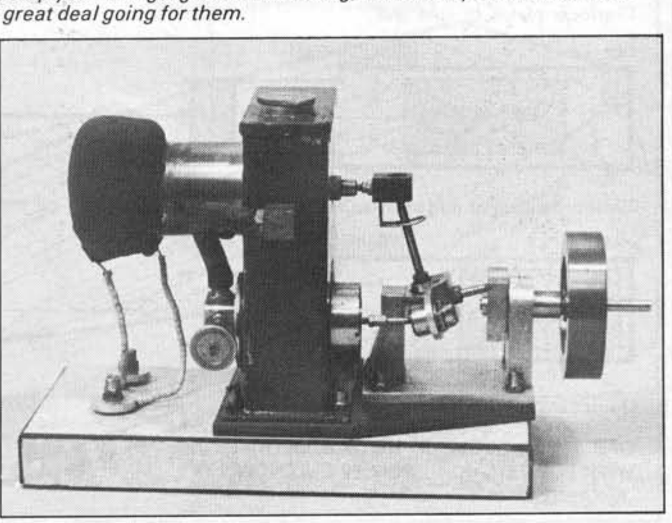
It is important to have some idea of how a hot air engine works if you are considering making one. The engine basically consists of two cylinders. One is a heat regenerator, the other supplies the power. A loose-fitting piston or displacer which is made as light in weight as possible is fitted in the heat regenerator and a normal piston in the other. When air is heated at the front of the larger cylinder it expands and this pushes the displacer back. A flywheel allows the displacer to return taking colder air into the regenerator.

In the meantime, the air that has been displaced goes into the power cylinder and operates the power piston which is linked to the shaft holding the flywheel with a simple strap linkage. When the power of the air is used up, instead of exhausting into the atmosphere, it is returned by the power piston to the displacer. It is, of course, by now cooled down and when the displacer moves backwards the air that was used to drive the power piston moves to the front of the regenerator to be reheated and to start the cycle all over again.

There have been a number of successful designs of hot air engine, the most common being known as the Stirling Cycle. The only really important factors in the construction of a hot air engine are the need to keep the air in a closed cycle, and to cut down friction as much as possible. Given these two factors, a hot air engine is the simplest form of mechanical power plant. ■

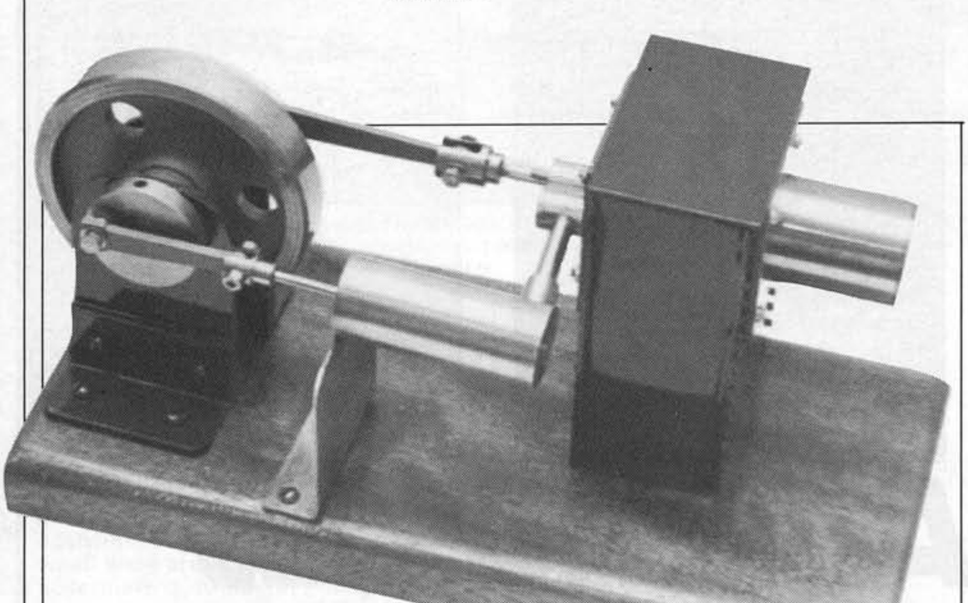
The hot air engine comes in an amazing variety of shapes and sizes and can be both simple and complex in appearance. Nevertheless, the principle on which it operates (see diagram overleaf) is one of the most fundamental and the construction of such an engine is a challenge that many modellers find unable to resist. Like all the other aspects of the model engineering hobby presented in this Special, plenty of plans and castings are available for hot air engine designs so there's really nothing to stop you having a go! Silent running, remarkably efficient and not too demanding in terms of model-making expertise, hot air engines have a great deal going for them.



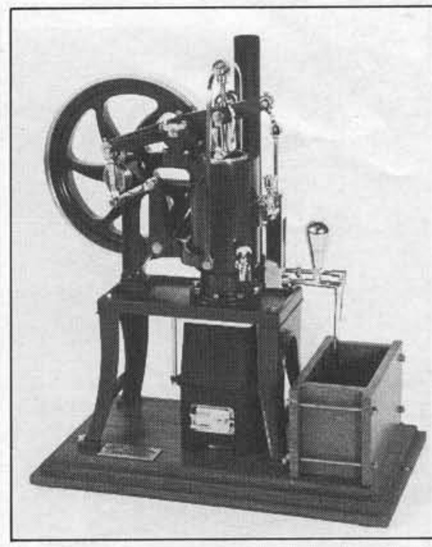


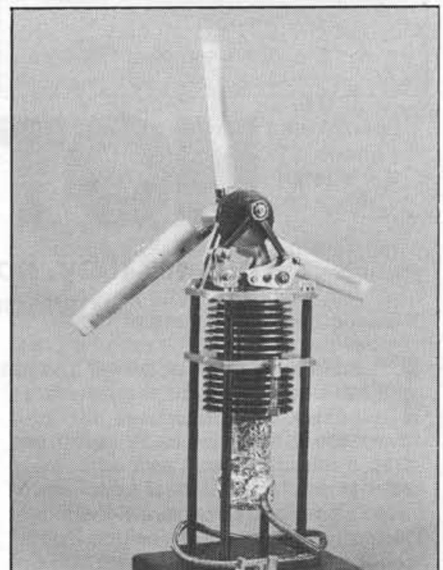
HOT AIR ENGINES

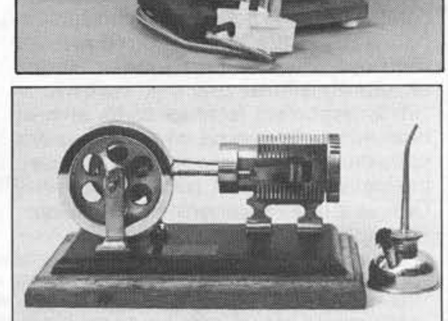
Hot air selection; from top to bottom, a neat Rider-Ericsson hot air engine, castings for which are available from Camden Miniature Steam. An interesting electrically heated model driving a fan. A spirit burner heated hot air engine is third down and, at bottom, this simple design was built from scrap materials; nevertheless, it can run for hours on end without attention.

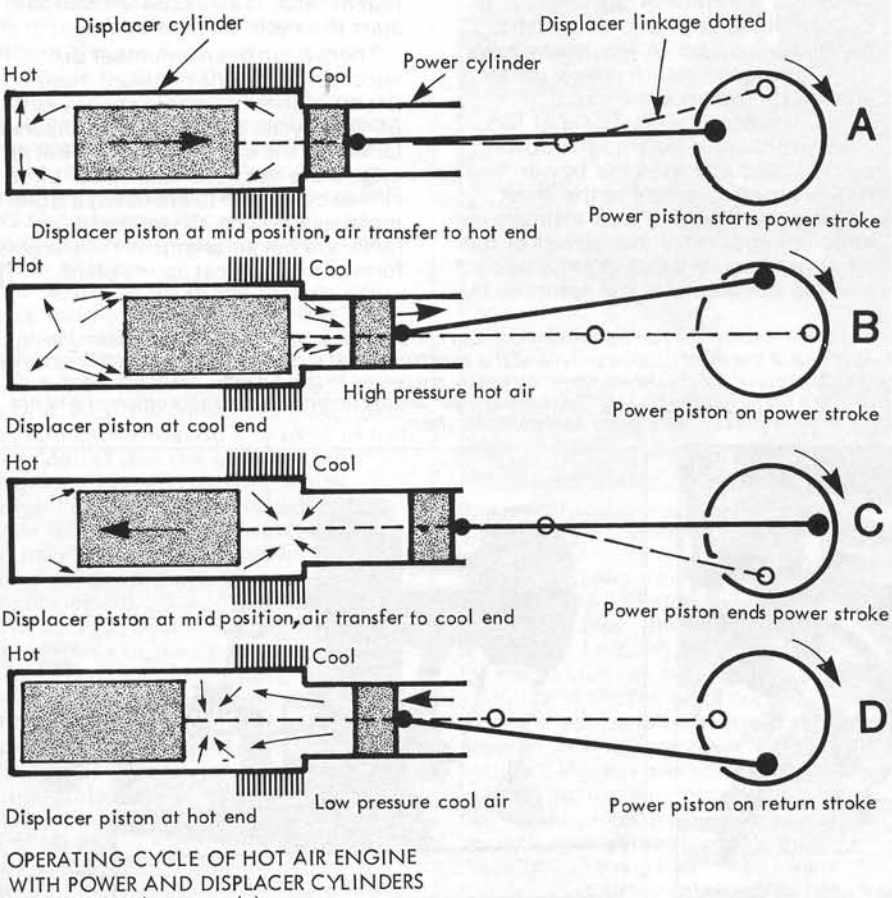


Above, a simple hot air engine built by the author and subject of a constructional article in Model Engineer *magazine. Plans for it are available from ASP and it is particularly easy to build, relying mostly on material from the "scrap box." Below, sketches illustrate the operating cycle of a typical hot air engine.*





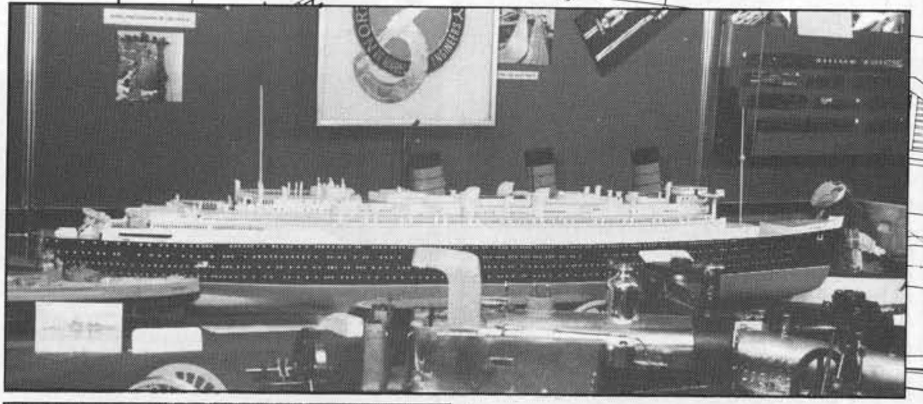


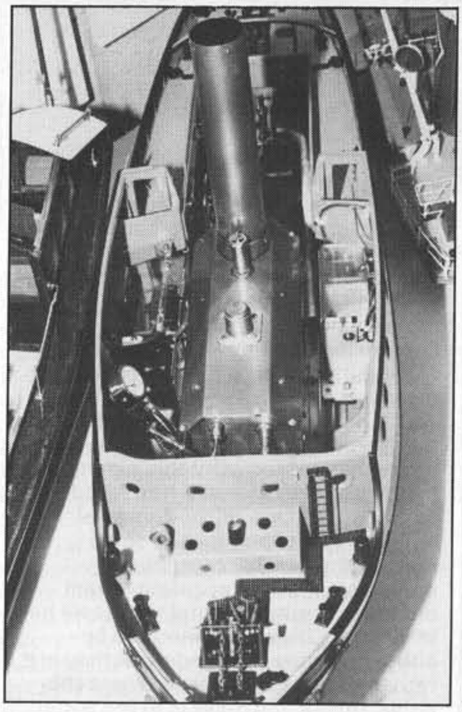


OPERATING CYCLE OF HOT AIR ENGINE WITH POWER AND DISPLACER CYLINDERS IN TANDEM (not to scale)

Down to the sea

Model boats represent a fascinating aspect of model engineering — and the scope is enormous!





Above, a fine model of the "Queen Mary" liner on display at a model exhibition. Left, this model tug has a fully working steam plant as power.

It is not so very many years ago when models of boats were a very regular feature for constructors in *Model Engineer* magazine. At any model engineering exhibition, be it a local club effort or one of the bigger shows, there will always be plenty of model boats on display. Look at the club stands at the annual Model Engineer Exhibition and it is most unlikely that there will be one that does not have one or more boat models on show. Why, then, is it that they are no longer featured as often in *Model Engineer* magazine?

There are two answers to this. Firstly, few contributors are forthcoming these days with articles on the subject and, secondly, there are magazines on the market that cater specifically for the marine side of the hobby. This does not, of course, alter the fact that it is a fascinating aspect of modelling and well worth the attention of the very experienced modeller who has not tried his or her hand at this particular branch of things, as well as being a very suitable medium for those taking up some form of modelling for the first time. The beginner, in particular, can find this an invaluable way of learning how to construct models and nowadays the boat building hobby is largely dominated by kits, which are useful starters.

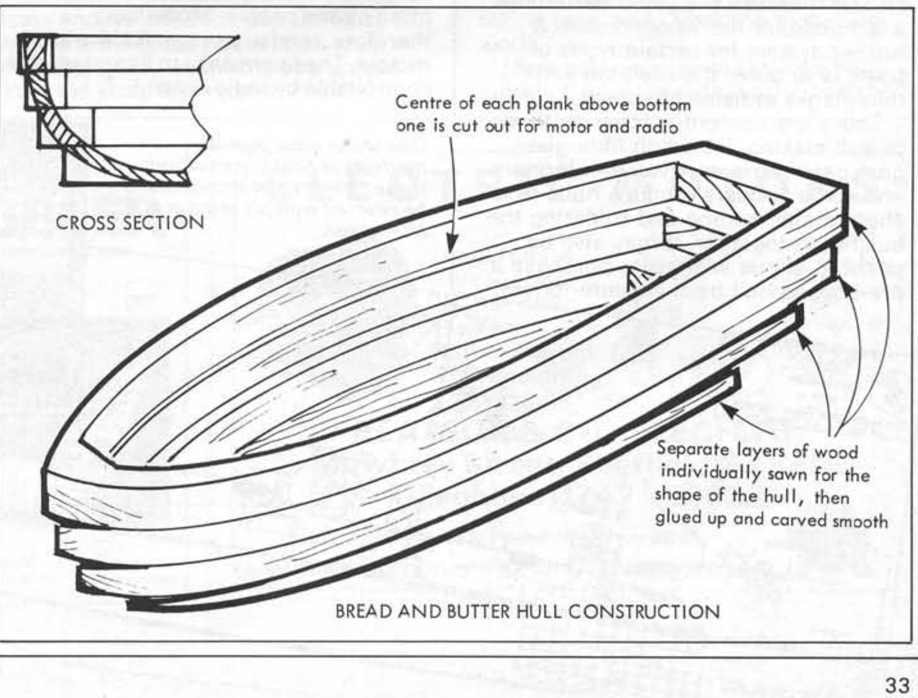
Let's forget the kits for a moment but come back to them later, for they have an important part to play in the hobby, and give a little thought to how model boats can be constructed from scratch. The first thing that will have to be obtained is a drawing, unless the modeller can draw the plans for himself. There are numerous sources from which plans can be obtained. For a start, there's the ASP Plans Service which offers a wide selection and Bassett-Lowke Ltd., one of the oldest model firms in the country, also carry a large range. Others that readily spring to mind are Taubman Plans Service of New Jersey, and David MacGregor of London, but there are plenty more and, between them, it is possible to obtain a plan of almost any vessel that one requires.

As soon as we look at a boat it becomes obvious that the biggest problem lies in hull construction. If that is mastered, then the rest is, by comparison, easier and mainly detail work mostly on the superstructure.

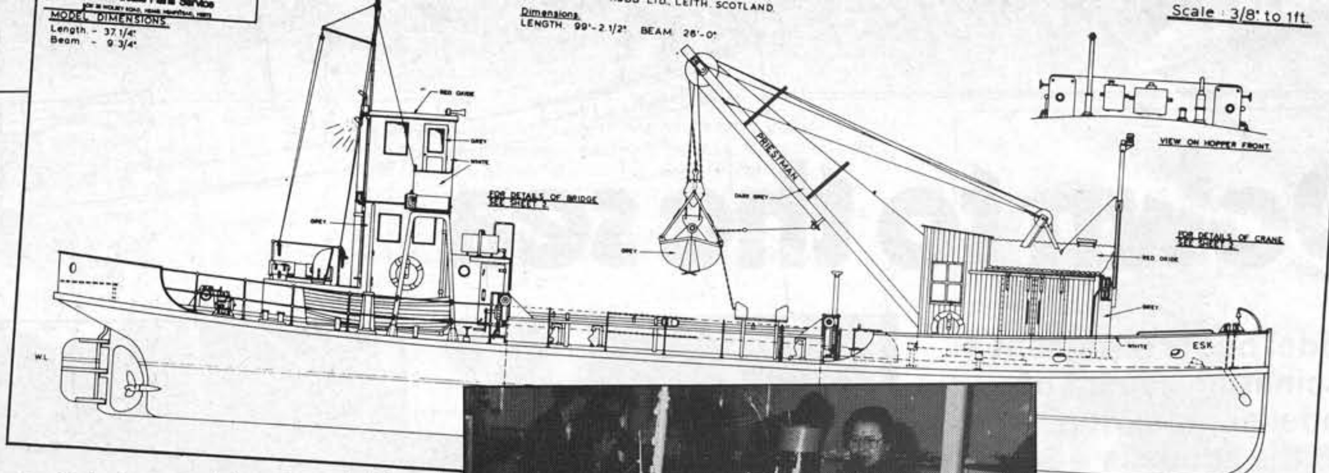
There are three basic ways of making hulls, the first of which is to carve from solid wood. With the high cost of wood of decent quality these days this method has largely gone out of fashion for boats that are going to be working models. It is still used, though, for static models, particularly small ones.

The system employed is to make a series of templates of the cross-section of the hull from cardboard, getting them accurate by laying them on the plan. The wooden block can then be shaped to the template starting either at bow and stern and working towards the middle, or starting in the middle and working outwards towards the stern and bow.

The second method, which again has gone somewhat out of favour, but which we still find used occasionally ▶



BREAD AND BUTTER HULL CONSTRUCTION

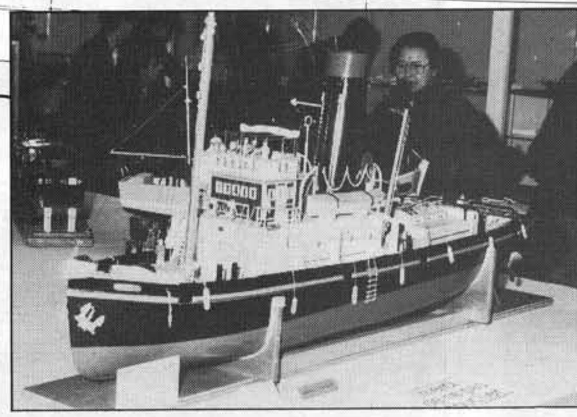


and which, in my opinion, is probably the easiest, is known as the 'bread and butter' method. Pieces of wood (the 'bread') are shaped for the outside of the hull and cut out in the centre. Each piece can then be glued (the 'butter') to the one above or below it.

The resulting structure can then finally be shaped as one piece and then finished off when everything is right. The big advantage of this method is the fact that the pieces can, if you wish, be held together in a temporary way until all are complete. Then, if things are not quite right, they can be separated and each piece re-shaped individually rather than trying to shape the whole hull. If anything unfortunately does go wrong, only a small part of the work is destroyed. Plans are available specially designed to aid the constructor making a bread and butter hull.

The third method is to make wooden formers that are, in fact, the bulkheads and to position wooden stringers lengthways along them to produce something which looks like the skeleton of a hull! This is then covered with thin ply and takes up the finished shape. The method gives a highly satisfactory result, but is somewhat tricky for the inexperienced. The difficulty is knowing quite how to cut the outer skin to get it to fit. It is therefore as well to cut the shape in paper first of all and then use the paper pattern as a template for the wooden skin. A further system for certain types of boats is to cover the skeleton with thin planks of balsa or spruce.

There are numerous other methods of hull making, including fibre glass, gum paper strip over wooden formers and some builders produce hulls from sheet metal, cutting and soldering the bulkheads together. It may also be possible, if one wishes, to purchase a pre-shaped hull from vacuum-formed plastic, these now being easily obtainable.



Models of "working" boats are among the most popular and, as you can see, a wide range of plans exists to cater for everything from tugs and dredgers to rescue launches and paddle steamers!

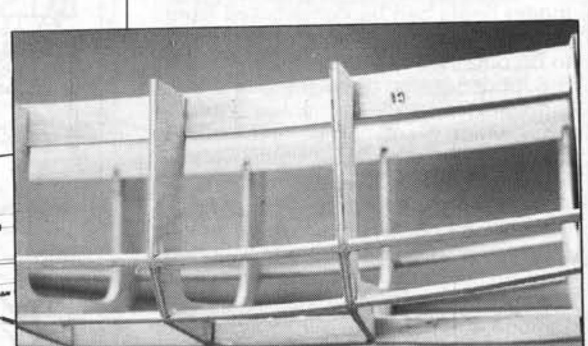
The various kits available come in a variety of forms but the majority consist either of pre-cut bulkheads and outer skin which the constructor glues together, or are of moulded plastic. Either way, the result is a well-finished model with some of the more anxious moments of construction removed. Even so, some of the kits can be fairly tricky to make . . .

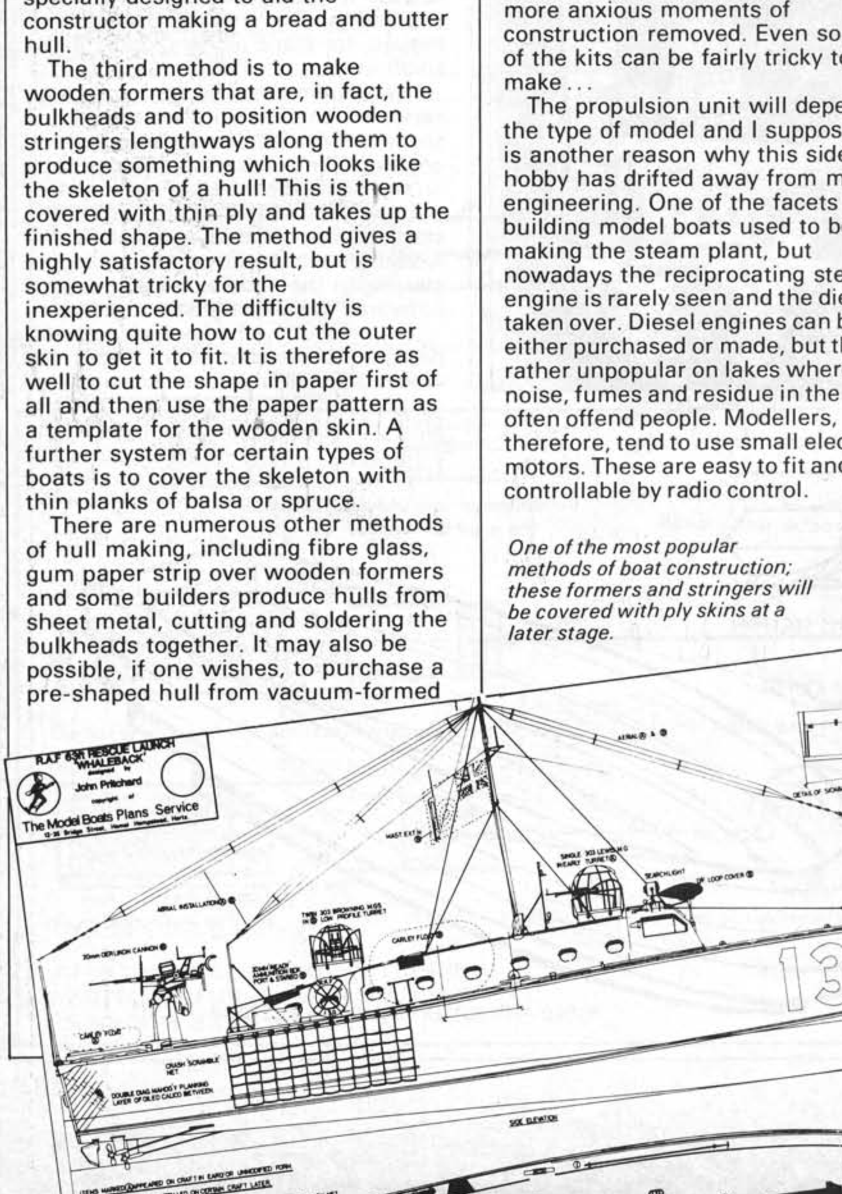
The propulsion unit will depend on the type of model and I suppose this is another reason why this side of the hobby has drifted away from model engineering. One of the facets of building model boats used to be making the steam plant, but nowadays the reciprocating steam engine is rarely seen and the diesel has taken over. Diesel engines can be either purchased or made, but they are rather unpopular on lakes where the noise, fumes and residue in the water often offend people. Modellers, therefore, tend to use small electric motors. These are easy to fit and readily controllable by radio control.

Steam is still not dead though, and there is evidence that interest in building steam ships is growing. There are a number of plants available on the market and some plans for construction of engines suitable for boats are published from time to time, a very successful design in the form of "Miranda" being one of the most recent. Stuart Turner make castings that are suitable for building engines for larger boats and boilers (as discussed previously) can be very simple indeed.

That briefly sums up the situation as far as model boat construction is concerned. It is a fascinating side of the hobby and one much neglected by the model engineer. There is plenty of room for the experienced modeller to experiment with propulsion plants and the main advantage of this sort of construction is that it can be done on a the small lathe of the Toyo, Cowell, Unimat type. Unlike large scale locomotive construction, no workshop is needed — any spare bit of room in the house can be pressed into service for one's model-making. ■

One of the most popular methods of boat construction; these formers and stringers will be covered with ply skins at a later stage.



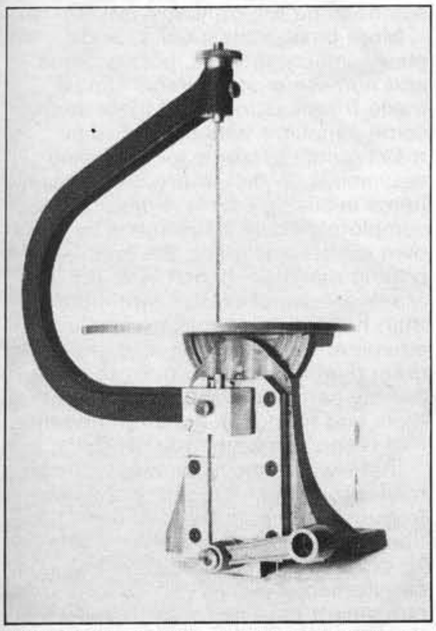


Tools of the trade

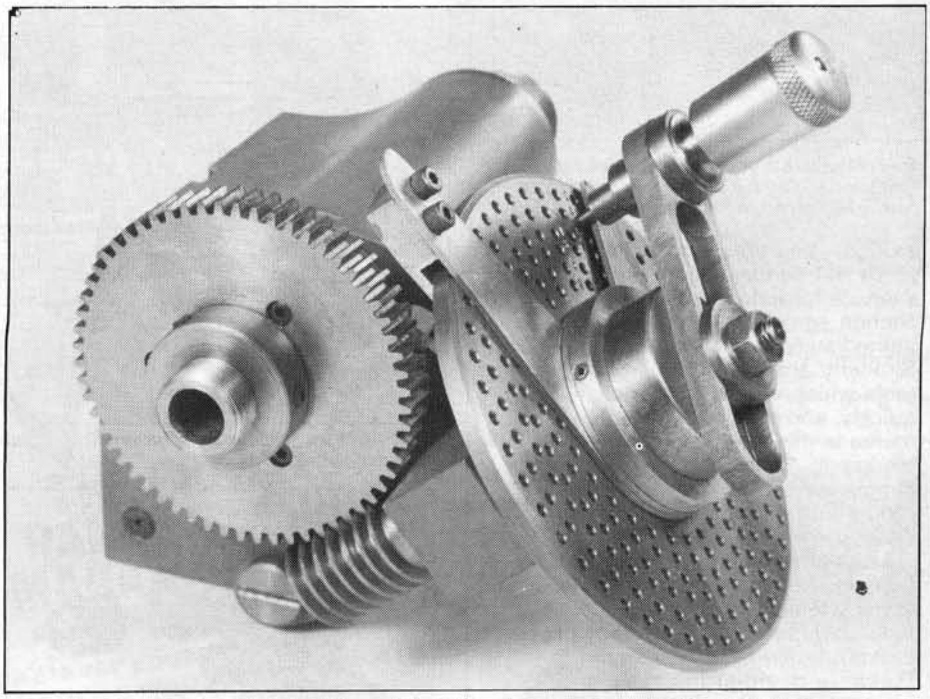
You can buy them, of course, but it's more fun to make your own

A frequent remark heard from model engineers when the question of making workshop equipment comes up is, "I would rather spend my time making models than messing about making *things for the workshop.*" This is fair enough as far as it goes, but over the years I have decided that it is not practical to just spend one's time modelling at the expense of equipping the workshop.

Of course, many workshop items that the modeller will require are available from dealers as the finished



This sawing and filing machine can be built from castings and drawings available from Woking Precision Models; it's intended as a lathe fitment but could be independently driven if desired.

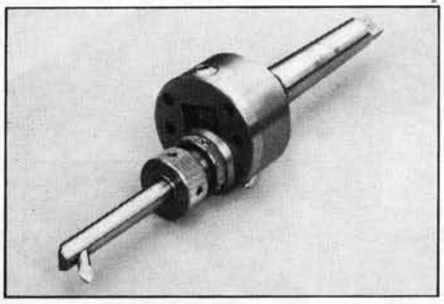


Drawings and castings for this useful dividing head are available from Blackgates Engineering.

item, but many are not. Also, unless one lives within easy distance of the dealer who has the required item, a great deal of time will be taken up sending for it in the post and awaiting its return. This destroys the time argument straight away, particularly if the dealer himself needs to send to his supplier, thus involving a great deal more delay.

If you were to visit any engineering workshop you would find that, stacked away on shelves and under benches, there are numerous jigs and similar fixtures that are needed for special purposes. Without these life would be virtually impossible for the engineer. The model engineer also needs such items and, without the use of them, models are not built as well as they might be. Take, for example, a simple eccentric strap and rod, or, rather, several of them. The straps need to be connected to the rods (particularly if they are for valve gear) in such a way that the bearing bushes are *exactly* the same distance from the centreline of the strap. Doing this by measurement is virtually an impossibility and, in order to get things right, a jig must be made up. It only needs to be simple, but it is essential. The making of such a fixture takes little time, and later will save hours both of work and frustration. There are numerous such instances and, of course, jigs cannot be purchased ready-made for the purpose. So here we can see that making jigs does not always mean taking time away from the modelling work.

More advanced tools can also be quickly fabricated without the need for ►

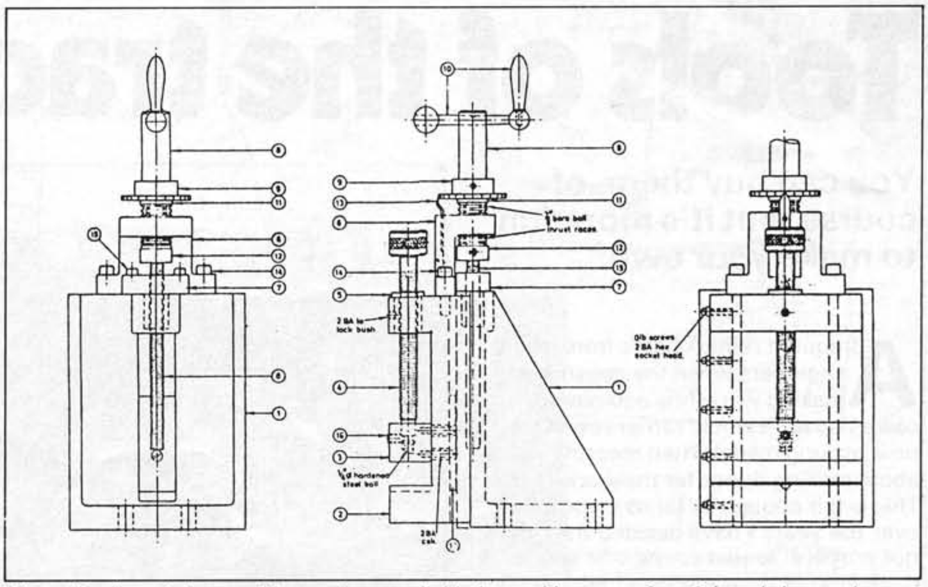


This is the latest offering from Woking Precision Models in the form of a neat little boring head; they have castings and plans.

castings, and these tools over the years will be used again and again — a device for indexing the lathe using change wheels is an example that immediately springs to mind. Similarly, there are numerous small tools which we can make easily and quickly, and in so doing vastly increase the flexibility of the workshop. Such tools can range from simple scribers to more complicated radius turning tools and slotting attachments, etc.

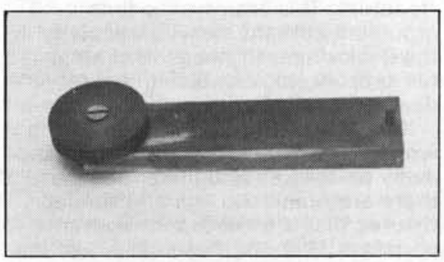
Most of the main suppliers will be happy to supply castings and plans for various tools and even some machinery; for example, many people build their own milling machines. Purchase of either the basic or part-machined castings means that a milling machine can be obtained considerably cheaper than it can be bought. If we do not wish to go to the trouble or expense of building a complete milling machine then a Pott's Milling Spindle, mounted on a vertical slide will do most of the work required by a model engineer.

Sharpening milling cutters can be a problem and there are several sets of castings available for making special machines to do this work. Again, at first glance, such an effort may seem a waste of time and effort, the cost of the castings and the time spent making the machine would seem to be offset simply by purchasing new cutters. This is fine, providing the cutter can be obtained there and then, or it is not a highly expensive side and face cutter. Whilst not everyone will

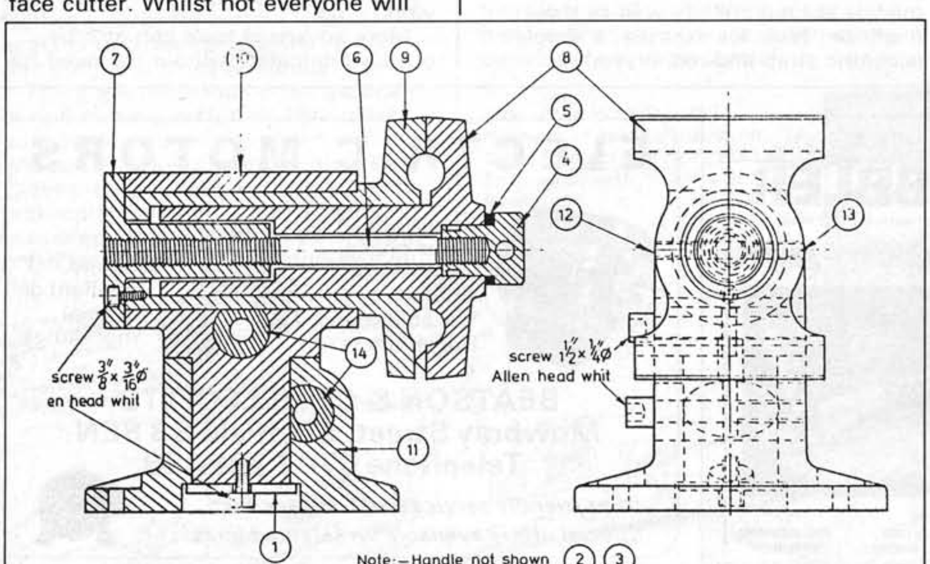


Plans like these (above and bottom) are available for a wide range of useful workshop tools and jigs.

Above, the Potts Milling Spindle is not difficult to make and is highly popular; can be fitted to the lathe or built up as a miller in its own right. Woking Precision Models supply the parts.



This very simple jig for locomotive eccentric straps is the sort of item most modellers will need to make.



want to make such a machine, I have little doubt that most would like to own one and making it yourself seems to be the only answer.

More basic tools such as angle plates, machine vices, boring heads, and numerous other items can be made from castings and there are some suppliers who specialise in making only castings for workshop equipment. In fact, there are so many items available that it is possible to completely equip a workshop by one's own efforts, including the lathe drilling machine, bench vice, etc. Many people, of course, are more than happy just to make workshop equipment and nothing else and get a great deal of pleasure from so doing. For my part, I find that making small tools and fittings is good fun and the end result can be highly satisfying.

If the workshop equipment is to be made from castings, etc., purchased from the suppliers then all the other items needed such as silver steel can be ordered at the same time for simultaneous delivery. If the equipment is to be fabricated, then the acquisition of a certain amount of metal in advance is necessary. Several popular sizes of silver steel should be kept in stock, and so should some small but hefty chunks of mild steel. The best way to get these is to visit either a scrap-yard or a local engineering factory. Explain your wants and no doubt a box-full of pieces will be acquired quite cheaply.

Pieces of mild steel some two inches square, plate three inches by three quarters of an inch, hefty round bar, and various small, but chunky sizes are what you are after. A small box-full, once you have staggered home with it, will last for years and years, and give you endless pleasure. It will also, of course, ensure that you always have a piece of metal to work with when you require it, rather than having to waste time getting it. A few spare bolts are also worth having and keeping in stock, but don't go too mad with the stocking-up, just make sure that a few items are always available when required. ■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