MINIATURE STEAM ENGINES

by Mike Moore A.M.I.Mar.E., 1st class B.O.T. cert.

Miniature vertical oscillating engine and meths fired boiler shown with a full size ball point pen to indicate the size of the model.

Working steam engines with 1/8 in. bore cylinders may seem impossible but Mike Moore shows you how ...

Utilising the power of steam is not as archaic as many may presume. It was reported recently that the steam "engine" is still there at the leading edge of technology alongside the silicon chip. Apparently a subminiature unit of micronic dimensions is being utilised in state-of-the-art robotics and micro-circuitry. No doubt "round-the-corner" nano-technology will also harness the power of steam.

Here, however, we do not require the resolution of a scanning electron microscope to see what we are doing. Reasonable eyesight or a serviceable pair of bifocals will suffice. We will be talking, essentially, about miniature oscillating engines with a cylinder bore down to, for practical purposes and reduced eye strain, a diameter of around one eighth of an inch (1/8") or three millimetres (3mm). By all means go on down - if you feel up to it!

The accompanying photographs will give you an idea of the scale we are presently concerned with. These show engines developed by the Author and now commercially produced and marketed by Gravett Engineering under the Philcraft mark (see advertisement elsewhere).

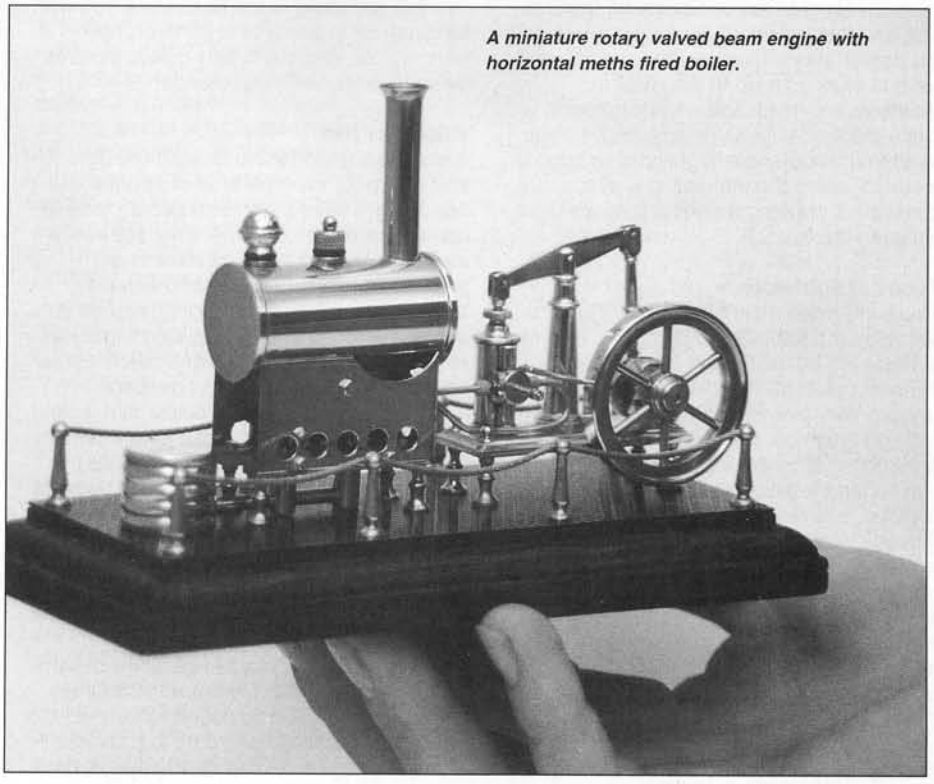
Such models, however, are well within the capability of the newcomer lusting after the joy of creating something from bare, unadulterated metal. Provided, of course, one has the tools and tenacity for the job and takes heed of the basic principles set out below.

The oscillating engine

Despite being the most straightforward engine to build, the oscillator (due to bad and sloppy practise) is probably the most maligned, misunderstood, and under-rated type of power unit there is. It is generally let down by the builder ignoring the essential precept to "get the basics right" - which this brief essay intends to allay. Although there are certain well documented aspects of live steam power that, due to the apparently inflexible laws of Physics, cannot be "scaled-down" from full size practice to the model, others certainly do apply at all points in the size stakes.

The Author has had a life-long passion for steam engines spanning nigh on... well anyway, in the formative years, it was products from Malin Bros. of Brierly Hill, Birmingham (that's "Mamod" to youthful readers) that were the spur to greater things. These encompassed some forty years in 1:1 scale (full size engineering), including fifteen in the Mercantile Marine reaching Chief Engineer with Union Castle Line specialising in steam turbines.

My pedigree commenced as a Cadet Engineer Officer with "B.T.C." Tankers ("Better Times Coming") in the austere circumstances of the mid fifties. Apprentices were expected to perform any duties that firemen, greasers or donkeymen declined to carry out. One such instance, I well recall, involved hunting for the 2nd Engineering Officer's false teeth. This, however, necessitated my being lowered into the aft well of the stern bilges past a rotating 15 in. propeller shaft under a shower of gland water. Nevertheless, once the noxious task had been successfullyaccomplished,



A miniature rotary valved beam engine with horizontal meths fired boiler.

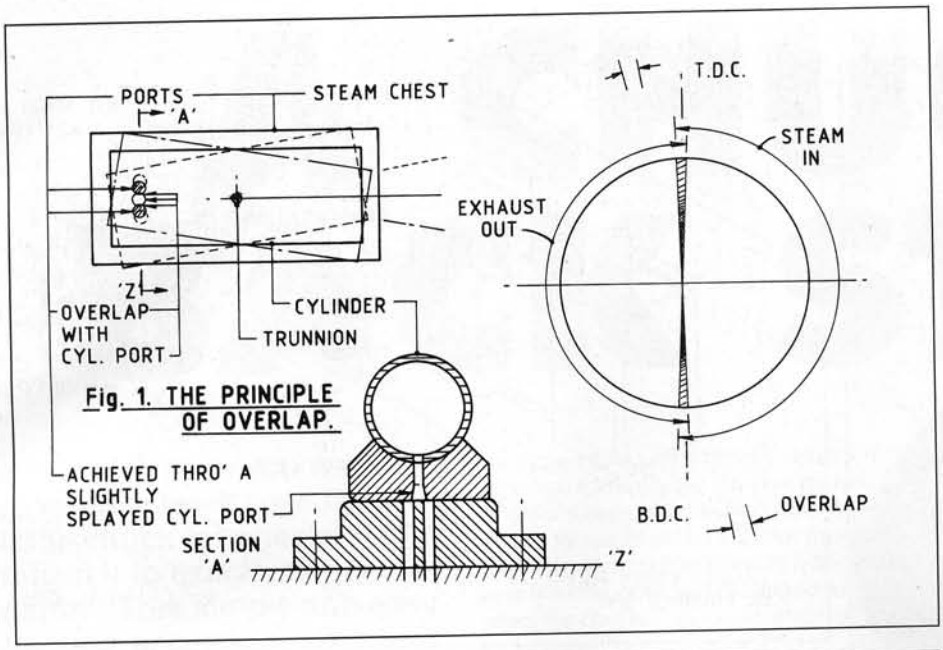


Fig. 1. THE PRINCIPLE OF OVERLAP.

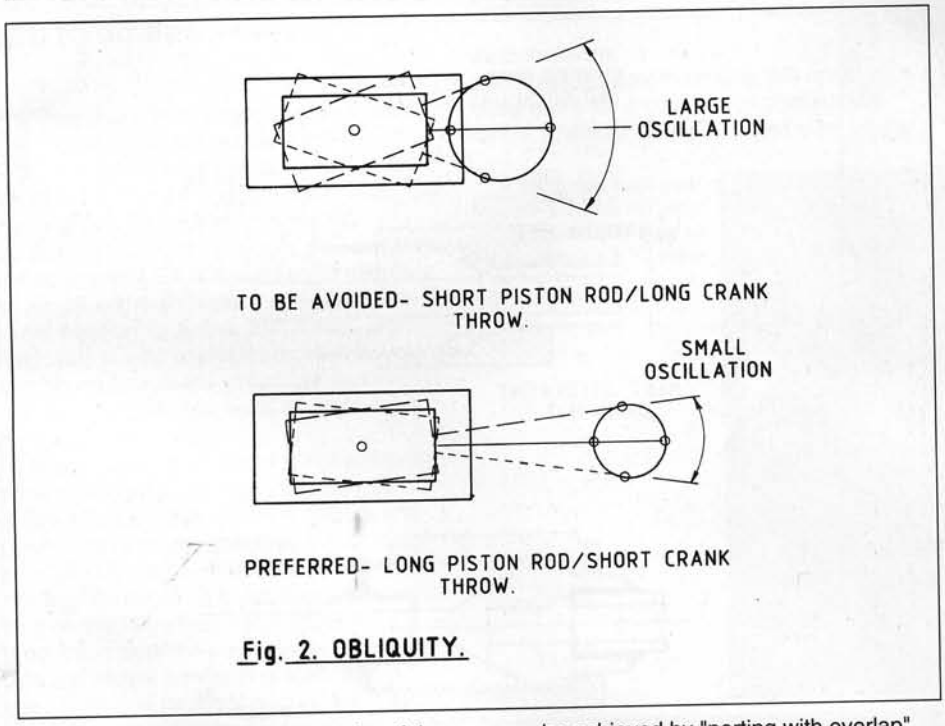


Fig. 2. OBLIQUITY.

preferential treatment was the order of the day, leading to even greater achievements.

Having "swallowed the anchor", the twilight years are now devoted to refinement, development and refurbishment of somewhat smaller engines. Nevertheless, whether it be 50,000 h.p. steam turbines or 0.0005 h.p. mantlepiece oscillators, certain principles are common to both.

The principle of overlap

The "prime" problem with small steam engines is condensation and the solid water thereby produced. Water is virtually incompressible - it is not long before hard-earned experience proves that running up full size reciprocating and turbine steam engines with water is generally catastrophic. Fortunately, however, at our scales the end result is more cerebral. It is, nevertheless, a prerequisite consideration for stress-free operation and can be alleviated, if not eliminated, primarily in two ways.

Firstly, if condensate does accumulate, it must be able to escape readily. In the absence of snifting valves, drain cocks or relief valves (as in full size operations), this can be achieved by "porting with overlap" allowing water, if any, to escape without detriment to the engine.

Determination of optimum porting can be aided by employing a strip of clear Perspex to simulate the action of cylinder port, cylinder, piston rod and connecting rod while allowing the steam chest ports to be continually observed.

Secondly, or perhaps it should be firstly, the aim should be to allow only "dry saturated" steam into the cylinders. It is important to appreciate that truly "superheated" steam is not a requirement (nor, in fact, desirable) and to achieve it requires the employment of exotic materials and techniques. However, a minimal amount of "wetness" is desirable for lubrication of the internal friction faces. Saturated "wet" steam on the other hand causes problems. Production of the correct type (and amount) of steam is, of course, the job of the boiler unit. As an adjunct, however, consideration must also be given to insulating the steam feed route once it leaves the boiler. There are many methods; lagging being ubiquitous, including the employment of a dense fibre heat insulating gasket, as in "Mamod" models, between the port face and the engine mount or framing (see Fig.3).

The principle of obliquity (in which relieving and lubrication are referred to)

Once the right quality of steam has reached the piston face it is time to use it as efficiently as possible. At sea we were really 'chuffed' to achieve 20% or more power output to fuel energy consumed. Here we need only content ourselves with an engine that can run smoothly and slowly on steam pressure of around 5 to 15 p.s.i. without stalling, or running fast without immediately exhausting the boiler and running out of steam, so to speak.Hopefully, a glance at Fig. 2 will indicate what is to be aimed for. We'll define obliquity in simple terms as "the degree of oscillation which the cylinder and its integral port face are required to travel through during half a revolution of the crank". The less the better - high obliquity is inefficient whereby essential inertia energy is being lost and given up in the oscillating motion rather than being conveyed to the crank where the work is really required. It will be noted that the piston rod length to crank throw ratio is crucial, while also dictating the port events. Essentially, a short piston rod can create too much inertia over a short time period.

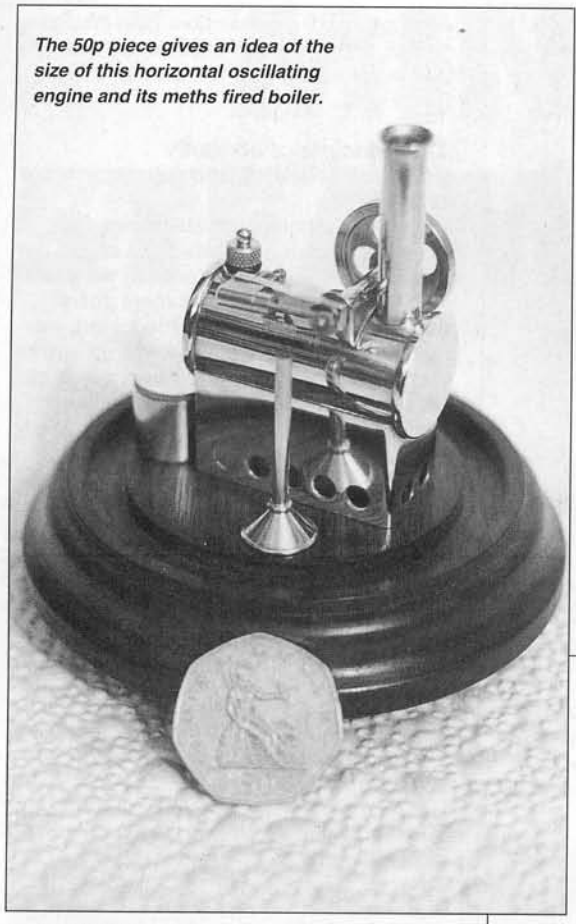
Lubrication and relieving

A further aspect of utilising the energy of the steam efficiently requires that this is not dissipated to any great extent into the working surfaces of the engine. The key here is correct lubrication employing the dictum of "little and often". At the miniature level - where loads are light, piston speeds are low and duration unsustained - the ubiquitous displacement type lubricator providing oil internally can be dispensed with. Generally, a light steam oil applied externally is adequate.

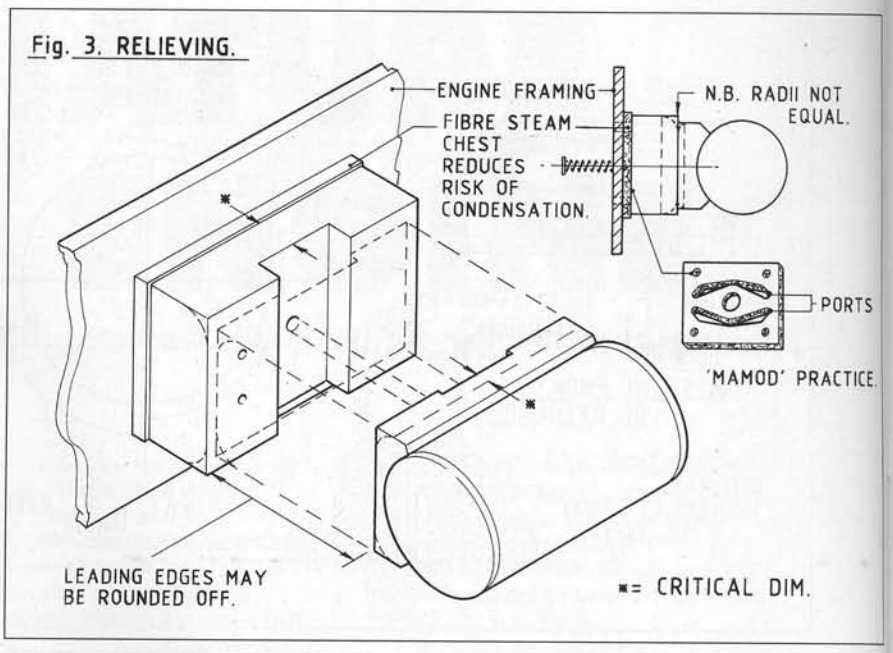
Given, then, that the energy must be optimally transferred to the rotation of the crank by minimising wastage, we now turn to a requirement of oscillators with contradictory aims (see Fig.3).

Here we are employing port face relieving, lapping and trunnion spring tension to minimise steam leakage before it impinges on the piston. All these, however, induce undesirable friction requiring a delicate but crucial balance to be reached. Usually the static port face is cut away as shown and the cylinder face is sometimes treated if tolerances permit, although this reduces the amount of metal for the trunnion pin mounting. Relieving around the trunnion pin increases the contact face pressure generated by the spring and also provides a "well" for lubricating oil. Spring tension is obviously critical but determining this is unfortunately not an exact science and essentially comes down to experiment.

Finally, it is essential to "lap" the two faces of the cylinder and port face to provide both a steam-tight union and the minimum of friction. A light abrasive such as "Brasso" or, preferably, jewellers' rouge is applied to a sheet of glass. Each face is then patiently scoured in a figure-of-eight motion until a dull, even, "frosted" appearance is achieved. Once this is carried out these faces must be



The 50p piece gives an idea of the size of this horizontal oscillating engine and its meths fired boiler.



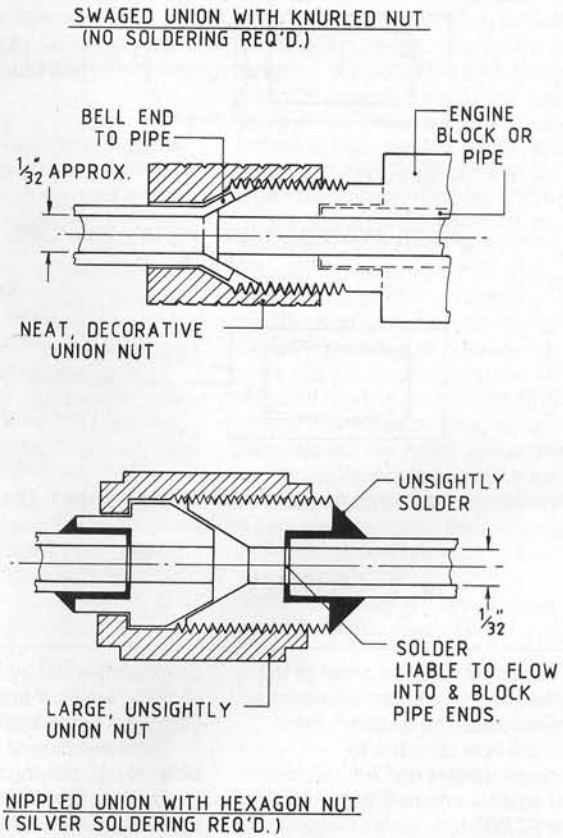


Fig. 4. SWAGING.

scrupulously protected from abrasion. The outside edges may be rounded to reduce the risk of knocking due to face scouring in use.

Final testing

Once the components of your little engine are honed to "perfection" and brought together to form a harmoniously working unit, it is worth doing some final testing on air. A small household aquarium pump is quite adequate for this, producing around 5 p.s.i. pressure. Even if you cannot acquire this facility, the correctness of the porting events can be "felt" when rotating the crank manually.

Another more sophisticated method is to employ a strobe light with the engine on high revs. The strobic flashing induces an optical illusion which apparently slows the engine permitting the motion to be observed.

When all is performing sweetly, the momentous moment dawns for the first steaming. Now that we are ready to connect up to a boiler, a neat little device pinched from refrigerator technology comes into play (See Fig. 4)

You will find that the swaged union is both more aesthetically pleasing to the eye and a lot easier to achieve at these miniature levels. The essential point being that no soldering is required; even the "expert" will find that the silver solder will tend to run into the small bore pipe (l/32 in. bore) spelling disaster.

The boiler

Oh! the boiler? Well, as we seafarers are prone to prevaricate, "that's another story ..... "

At this juncture, suffice to say that adequate dry steam with a small degree of superheat is to be aimed for. The seeker will find innumerable tomes expounding the methods of generation but, if the will can be summoned, a follow up treatise on this topic may well appear. In the meantime.... bon voyage!

Grateful acknowledgements

It has been a long and enthralling voyage through the realms of steam power accumulating barnacles of knowledge along the way. In preparing this all too brief note, however, my greatest thanks must be expressed to one Gordon McLellan who prepared the diagrams and guided the text. Whilst appreciating the risk of being invidious, recognition has to be given to "Dr." Deryck Goodall, Phil Gravett and Mike Wade, just three of the many valued friends along the way.

Those in the Society of Model and Experimental Engineers, the Gauge "1" Association, the "0" Gauge Guild and the Association of 16mm Narrow Gauge Modellers will know who they are. On a special pedestal, however, there will always be Val, a member of the stalwart band behind the whole scene. Yes, indeed... "the long suffering wives". ■

A CHUCK BACK STOP

How often have you wanted to remove work from the lathe chuck for checking and return it to exactly the same depth? This simple and easy to make accessory allows you to do this easily ...

The chuck back stop provides a fixed point within the chuck which will enable components to be replaced in the chuck to the same depth each time. This can often be necessary when facing something to a specific length, you can take the component out of the chuck to measure its length and then replace it in exactly the same position for further machining. The back stop is also useful for repetitive machining operations when making several identical components, such as three axles for a locomotive etc.

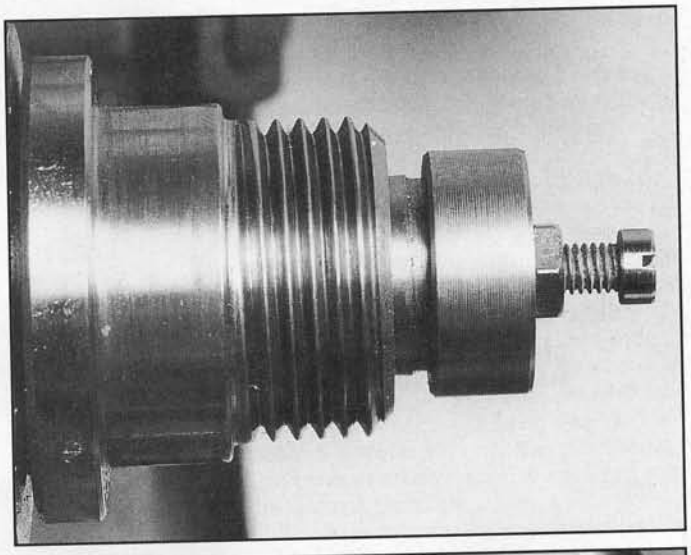
Many commercial lathes and machining centres are used with very long bar stock which is fed through the lathe spindle and positioned to length by bringing it up to a stop fitted in the tailstock turret head which has been brought up to another positioning stop on the lathe bed. For repetitive production work this system can be very fast and allows hundreds of identical components to be made accurately. However, this would be far too complex for the model engineer, whose needs are for a simple and versatile method of positioning single components rather than production runs of hundreds of components.

The chuck back stop described here is simple to make and it is easily fitted in place in the lathe spindle taper before fitting the 3- or 4-jaw chuck. After adjusting the stop screw to its approximate position, the work may be mounted in the chuck against the stop screw and machining can commence. If the work needs to be removed from the chuck for any reason it may be replaced against the stop screw before retightening the jaws and will always be back in its original datum position.

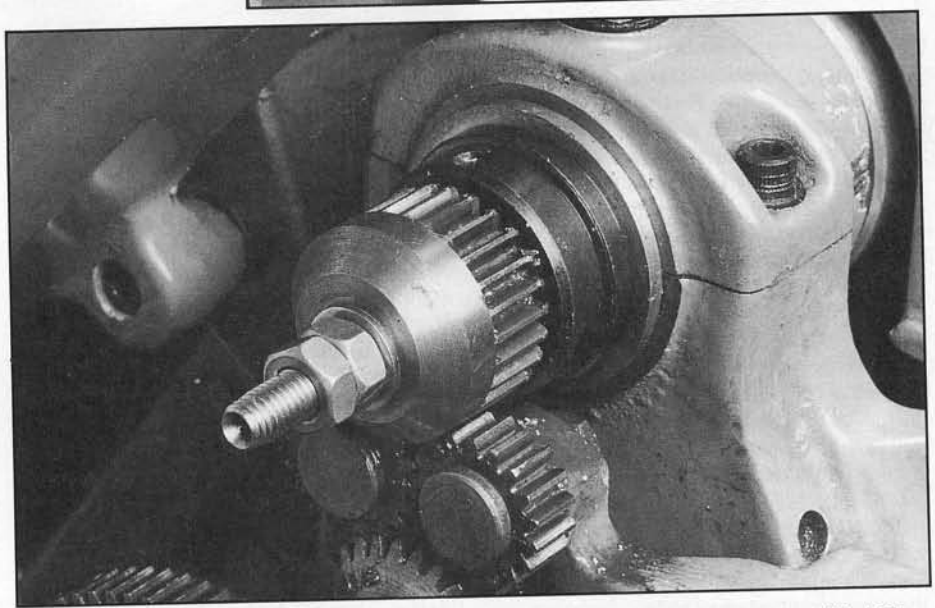
Two important points should be mentioned before starting to make the back stop. Firstly, the size of the boss which will be inside the chuck body is very important. If it is too big in diameter it will not pass through the hole in the body of the chuck and if it is too wide it may foul the chuck jaws when they are closed and prevent them from gripping the workpiece. I have mentioned this point for those readers who may wish to modify the dimensions to fit different makes of lathe. Secondly, I think it is very advisable to fit a drawbar through the lathe spindle to prevent the back stop body from working loose and moving forward within the chuck. This would obviously affect its accuracy!

Construction

The drawings accompanying this article give dimensions for a chuck back stop suitable for the Myford 7 Series of lathes such as the ML7 and Super 7. The body is designed to fit a No 2 Morse taper spindle. It would be quite easy to adapt the design to fit other lathes by altering the relevant dimensions of the taper or the boss as needed. The main component is the *Body* and by far the easiest way for the beginner to make it is to use a "blank end arbor" with a No 2 Morse taper - these are readily available from some of the model engineering trade suppliers and usually have a hardened taper section with a 'soft' boss end which may be machined as required. I would

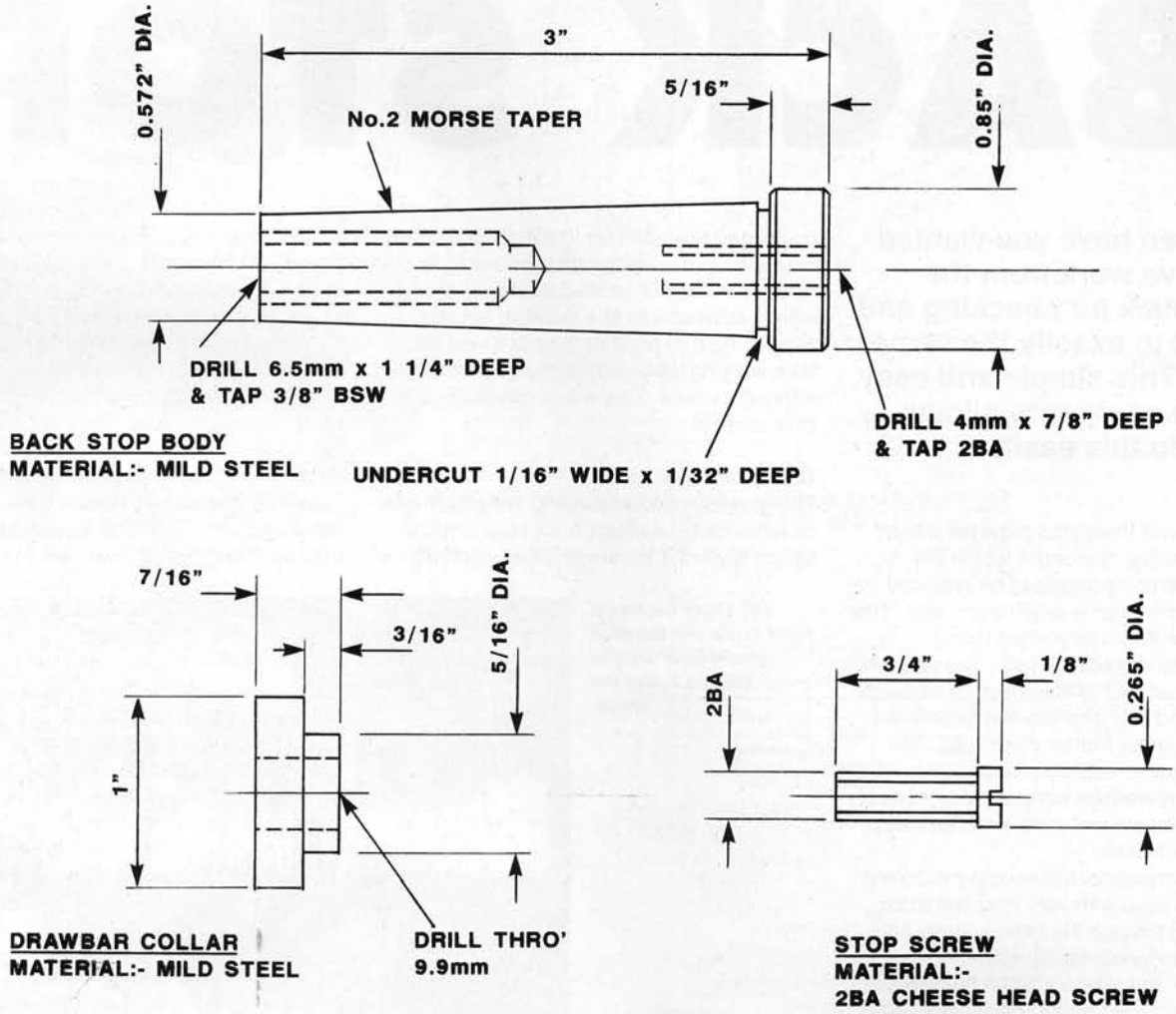


The chuck back stop fitted in place in the lathe spindle taper prior to fitting a 3- or 4-jaw chuck.



The drawbar collar in position against the end of the lathe spindle, with the nut and locknut fitted. The collar shown here is a slightly different profile to the simplified collar shown in the drawings.

A CHUCK BACK STOP

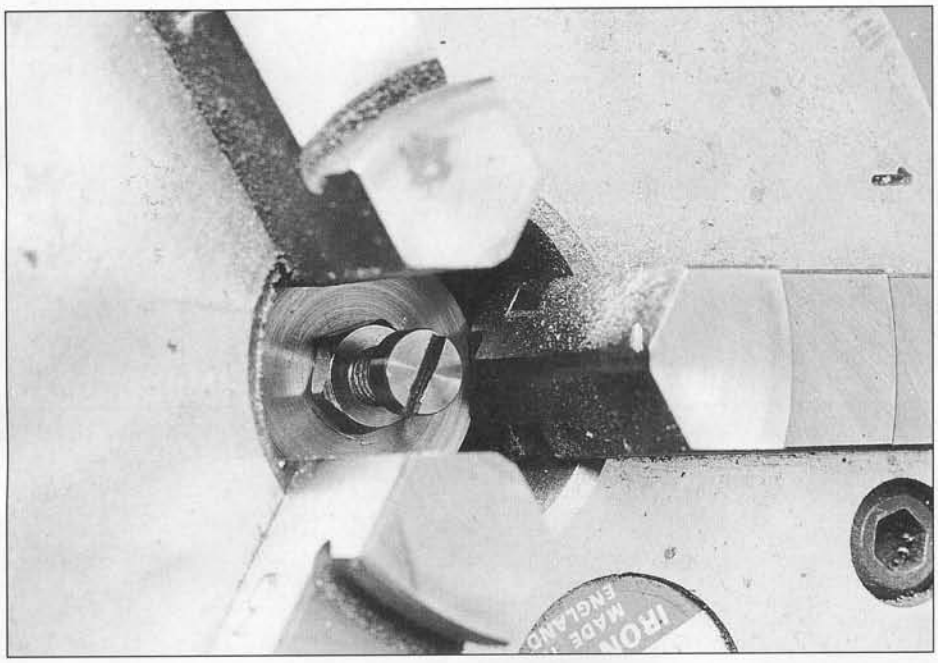


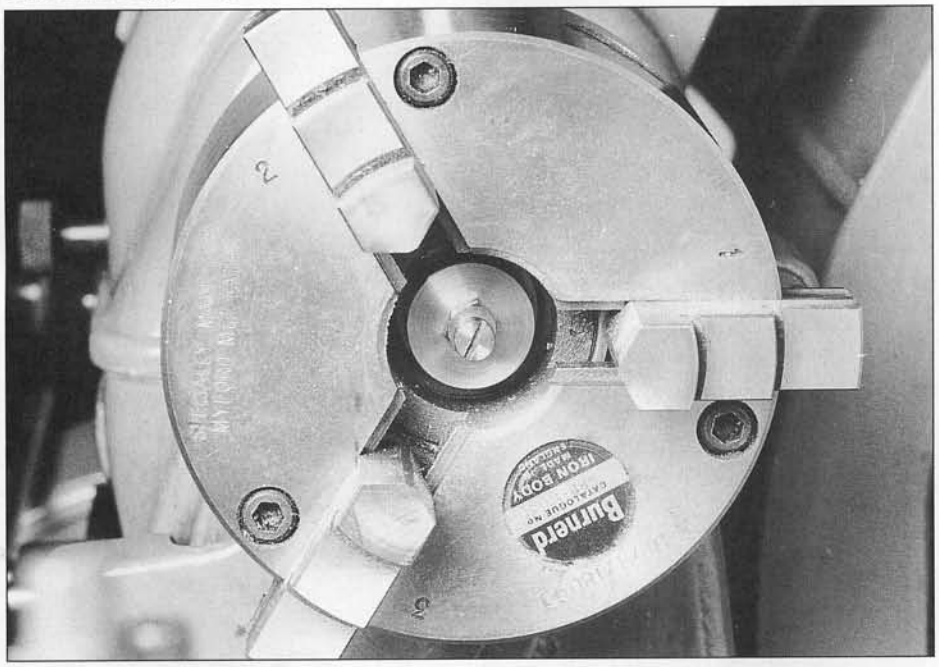
recommend the ones which have a screw thread for a drawbar. Prices at the time of writing range from £5 to £10 depending on the supplier. If you wish to make the whole thing from scratch it would be best to start by turning the taper first and then machining the boss with the workpiece mounted in the lathe spindle taper, this will enable clearance tests to be made easily by fitting the chuck over the workpiece. Assuming that you have purchased a ready made blank end arbor, the first thing to do is to make the *Drawbar* for it. This is very easy as all you need is a length of steel studding with a thread to match the thread in the arbor - this is usually $^{3}/_{8}$" BSW for No 2 Morse arbors. The length of the drawbar will need to be approximately the same as the length of lathe spindle; make it $^{3}/_{4}$" longer to start with and cut it down if necessary when the back stop body has been completed.The *Drawbar Collar* is made from mild steel. Grip a length of 1" dia. bar in the 3-jaw chuck with $^{3}/_{4}$" protruding from the jaws and face off the end. Centre the end and drill 9.9mm dia. (good clearance for $^{3}/_{8}$" dia.) to a depth of $^{3}/_{4}$". Now turn the end down to $^{5}/_{16}$" dia. for a length of $^{3}/_{16}$". (The $^{5}/_{16}$" dia. will allow the collar to locate in the bore of a Myford spindle at the gear train end. Adjust this dimension for other makes of lathe). Part off at $^{7}/_{16}$" from the end, reverse and, holding the collar carefully on the $^{5}/_{16}$" dia. with the shoulder against the chuck jaws, take a light facing cut just to clean up.

Now we can turn our attention to the *Body* of the back stop. Remove the chuck from the lathe and carefully clean the spindle taper making sure that no swarf remains inside. Wipe the taper on the blank end arbor and insert it in the lathe spindle. Insert the drawbar from the other end of the lathe spindle, screw it into the arbor thread until finger tight. Slip the drawbar collar over the drawbar and locate the smaller diameter in the end of the spindle and then secure with a nut and locknut. The locknut is needed to prevent the drawbar from working loose when the spindle is running.

Reduce the length of the boss end of the arbor to the $^{5}/_{16}$" width dimension by taking facing cuts or by parting off. Now turn the boss to 0.850" diameter. The width and diameter dimensions of the boss were arrived at by trial and error to allow the chuck jaws to close on small diameter workpieces, they may vary according to the particular chuck which is to be used. Check by fitting the chuck over the back stop and closing the jaws while observing the inside of the chuck. If all is well, use a $^{1}/_{16}$" wide parting tool to produce the undercut to a depth of $^{1}/_{32}$". Chamfer both sides of the boss to give a neat finish. With a drill chuck in the tailstock, centre the end of the boss and drill 4mm dia. (tapping size) x $^{7}/_{8}$" deep and tap 2BA for the stop screw.

The *Stop Screw* is made by modifying a 2BA cheese head screw. (If you are really keen you could make it from scratch but I am a great believer in doing things the easy





These photographs show the back stop in position with a 3-jaw chuck fitted on the lathe spindle. Note the clearance required between the front face of the back stop body and the rear faces of the chuck jaws (above) and the clearance between the outside diameter of the back stop body and the inside diameter of the chuck body (below).

way!). As we do not want to damage the thread it will be better to use a chucking piece to hold the screw.

If you are following these notes the back stop body will still be in the lathe spindle and this will make an excellent chucking piece. Put a 2BA locknut on the screw first and then screw it into the back stop leaving the head of the screw about $^{3}/_{8}$" from the face of the body and lock it in place with the locknut. Turn the head of the screw down to 0.265" diameter and take a very light facing cut across the head to make it square with the body. Again, the dimensions were found by trial and error so that the chuck jaws will close sufficiently to grip small diameter workpieces. Check this as described above.

This completes all the work needed to make the chuck back stop. It is now ready for use.

Instructions for Use

To set the back stop for use all that is required is to loosen the locknut and, using a screwdriver, position the head of the screw such that it will allow the workpiece to be held in the lathe chuck at the right position for the turning operation to be carried out. Lock the screw in position with the locknut and the set up is complete. It is just possible to get a thin 2BA spanner in between the chuck jaws in order to tighten the locknut but, with care, it is probably better to remove the chuck first. The actual position of the stop screw is not critical because its main function is to provide a datum point for the workpiece to rest on. All measurements for machining will then be taken from the workpiece as the job proceeds.

Footnote

I must confess that I managed quite well without a chuck back stop for many years, although I had often thought that a back stop would be a very useful addition for my lathe. However, I recently needed to make a batch of twelve steam manifolds for Gauge "1" locomotives so I set about making them using 'production' methods. As a further indication of how to use the chuck back stop, I offer the following description of the operations involved.

The bodies of the manifolds are made from $^{5}/_{16}$" hexagon brass bar and each one is $1^{7}/_{16}$" long with a $^{3}/_{32}$" dia. hole drilled through. In addition, they are threaded both internally and externally at both ends.

The thought of making twelve of these as 'one off' items was enough to convince me that I needed a back stop for my chuck! As I already had a spare blank end arbor in my toolmaker's cabinet, it only took an hour to 'design' and make the one described here.

Production of the steam manifolds was then quite easy to plan and I will describe the operations as an example of the use of the back stop.

Firstly, I cut off twelve blanks $1^{1}/_{2}$" long. The back stop was fitted to the lathe and the 3-jaw chuck put in place. Using one of the blanks, the stop screw was adjusted to allow the blank to be gripped with $^{3}/_{4}$" protruding from the chuck. This would allow for all machining to be carried out without altering the stop screw position. Each blank was put into the chuck in turn and one end was faced off to clean up.

One blank was then chucked with the unmachined face outwards and was faced accurately to finished length using the topslide to put on the depth of cut (the saddle was locked in place during this operation). The reading on the topslide dial was noted on the last cut. It was then easy to face all the other blanks to length until the same topslide reading was reached.

Each blank in turn was then drilled halfway from each end to produce the $^{3}/_{32}$" dia. through hole. Next, they were all drilled in turn at each end with the tapping drill for the internal thread, note being taken of the tailstock barrel position for the hole depth. Each one was then tapped at each end with the tailstock tapholder.

The external thread came next and each blank was chucked and turned to the thread diameter at each end with the cross slide reading taken for depth. Here the saddle stop described elsewhere in this issue came into its own - the turning tool was brought up to just touch the end face of the blank, the saddle was locked temporarily and the cross slide backed off to clear the workpiece. A $^{5}/_{32}$" dia. drill shank was held against the saddle face, the saddle stop rod was brought into contact with the other side of the drill shank and was then locked in position. After releasing the saddle lock it was simply a matter of turning each blank end to diameter in turn, up to the saddle stop, using the cross slide index for the final cut.

A die held in the tailstock dieholder soon finished the machining operations and a lot of time had been saved.

With the need to make the rest of the steam valves for the manifolds, the chuck back stop will certainly earn its keep and make life much easier for me! I hope you will find it just as useful in your own workshop. ■

BOILERMAKIN

by Geoff Sheppard

Geoff talks about boilermaking and testing and describes the sort of equipment needed ...

Apart from the usual tools for marking, cutting, forming and drilling sheet metal and tube, boiler making demands some additional kit, particularly for the silver soldering (or, more correctly, the low temperature brazing) process. The more obvious items are some form of heat source and some suitable place to do the heating.

Propane torch

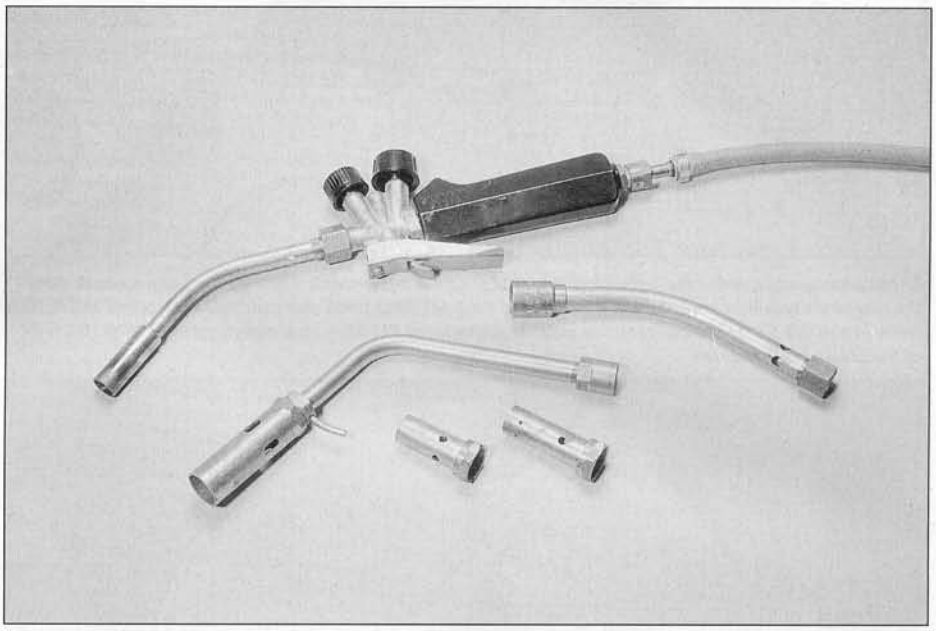
Short of having access to oxy-acetylene welding kit, plus having an understanding of the technique required for its use on copper, by far the best heat source is the self-blowing propane torch. These are listed by a number of manufacturers, of whom perhaps Bullfinch and Sievert are the most widely known. Full inventories of torches, regulators, valves, hoses and nozzles are available in ranges of sizes which will cope with the joints on components from the smallest fittings to hefty boilers. These devices are stocked by most of our supportive model engineering suppliers, who I know will give you sound advice on how to build up a kit to deal with the job in hand in the most economical manner.

Brazing hearth

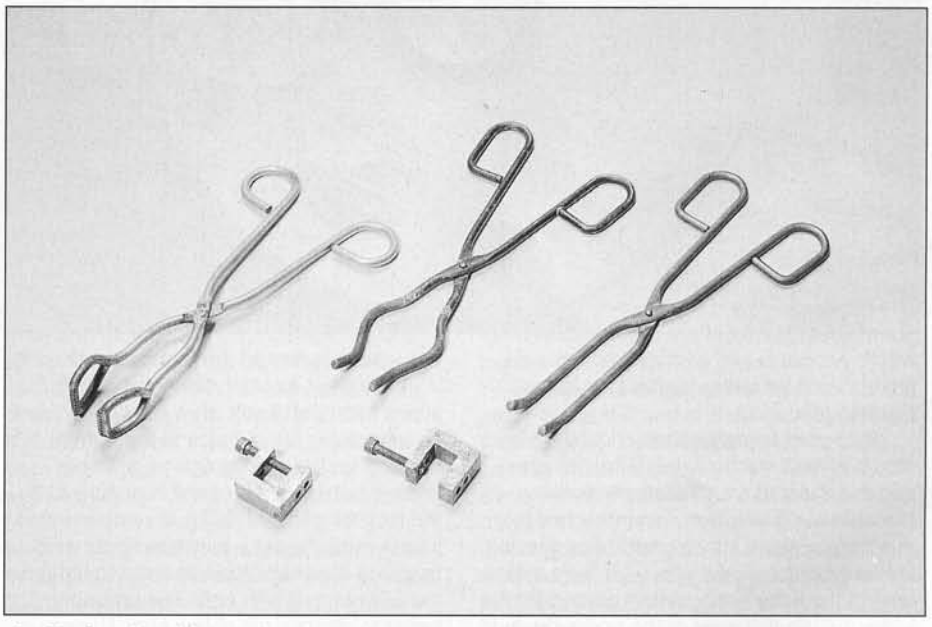
The other major piece of equipment required is a brazing hearth. This need not be a permanent structure as all it really consists of is a base and wall of firebricks built up on a non-flammable surface. To be successful, some of these bricks should be of the refractory type, as these reflect some of that heat which would otherwise go to waste. None of the bricks should be ordinary house bricks and, when stored, the bricks from your hearth must be kept dry. To heat up a damp brick can be dangerous.

Silver solder holder

One other tool which I have found invaluable is a simple silver solder holder/heat shield. This allows me to keep the flame pointed at the job at the same time as I am applying the silver solder stick. Mine is no more than a handle made from 3/8 in. diameter steel bar bent into a `U' shape, with one leg longer than the other. This longer leg has a hole drilled in the end to accommodate the solder stick, while a cross drilling is tapped 4BA for a clamp screw. A piece of thin aluminium sheet, just big enough to form a shield for the hand, has one hole large enough for the long leg of the `U' to pass through, while a small hole clears another 4BA screw which enters a thread in the end face of the shorter `U' leg. With a washer under the head, this screw clamps the heat shield into position. Recent years have seen the description of much more elaborate devices, which include gadgets for feeding the solder through, but my old crude version still works well enough.



A suitable range of Sievert propane burners and handle.

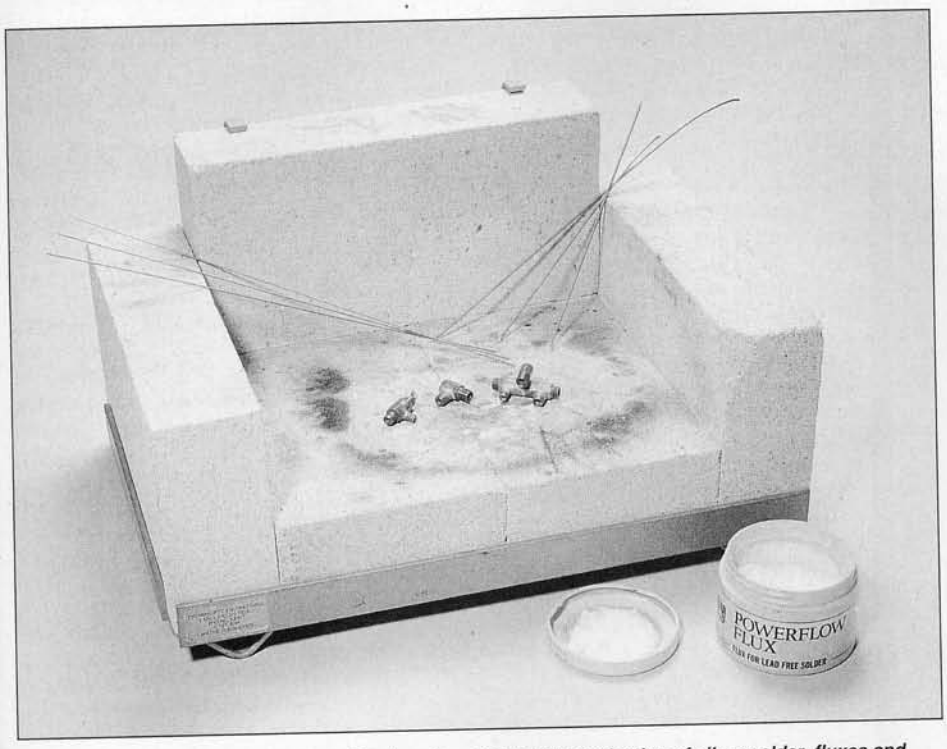


A collection of useful tongs from Proops and clamps for handling hot components.

Pickle bath

To complete the inventory of equipment, we'll prepare the pickle bath. The successful cleaning of oxides and other contaminants from the copper prior to silver soldering requires some form of acid bath. Traditionally this was a sulphuric acid mix at a dilution of about 20:1 with water. Evolving Health and Safety legislation, culminating in the Control of Substances Hazardous to Health (COSHH) regulations have made the purchase (and subsequent disposal) of this chemical less easy. I have now switched to the use of citric acid, which is widely available as a wine-making ingredient and quite inexpensive. About 150 grams dissolved in a large bucket of water seems to give about the right strength. To

G EQUIPMENT



Small brazing hearth from Crowhurst Engineering shown with a selection of silver solder, fluxes and silver soldered boiler fittings.

A small propane gas cylinder with regulator and non-return valve, high pressure hose and Sievert torch.

accompany this, a similar bucket of clean water for swilling the job off should also be to hand.

Pressure testing

All pressure vessels must be hydraulically tested on a regular basis. The normal procedure with copper boilers is to test a new boiler to twice its normal working pressure and then to re-test it every two years to one and a half times its normal working pressure. A large pressure gauge of known accuracy should be used for test purposes (not the small model gauge) and the model's own small gauge should also be tested for accuracy against the larger gauge. A written record should be kept of all boiler tests carried out and the next re-test date should be noted. Insurance cover must be taken out if the boiler is to be used under pressure at any public event.

It should be noted that several governments around the world are looking at the question of pressure vessel safety and new legislation is likely to come in force in the near future. As this will affect model engineers as well, it would worth keeping an eye on local regulations concerning boiler design and construction. Joining a local model engineering club would have the benefit of keeping you in touch, as well as providing the proper boiler testing procedures. Developments in the new regulations will be reported in *Model Engineer* magazine.

The first steaming

When steaming for the first time it will be better to 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 designated working pressure. Always make sure that any boiler in steam always has at least half a glass of water showing in the water gauge glass. If you are in any doubt about the amount of water in the boiler it is much safer to extinguish the fire and let the boiler cool down until ALL pressure is released. Then you may investigate matters further.

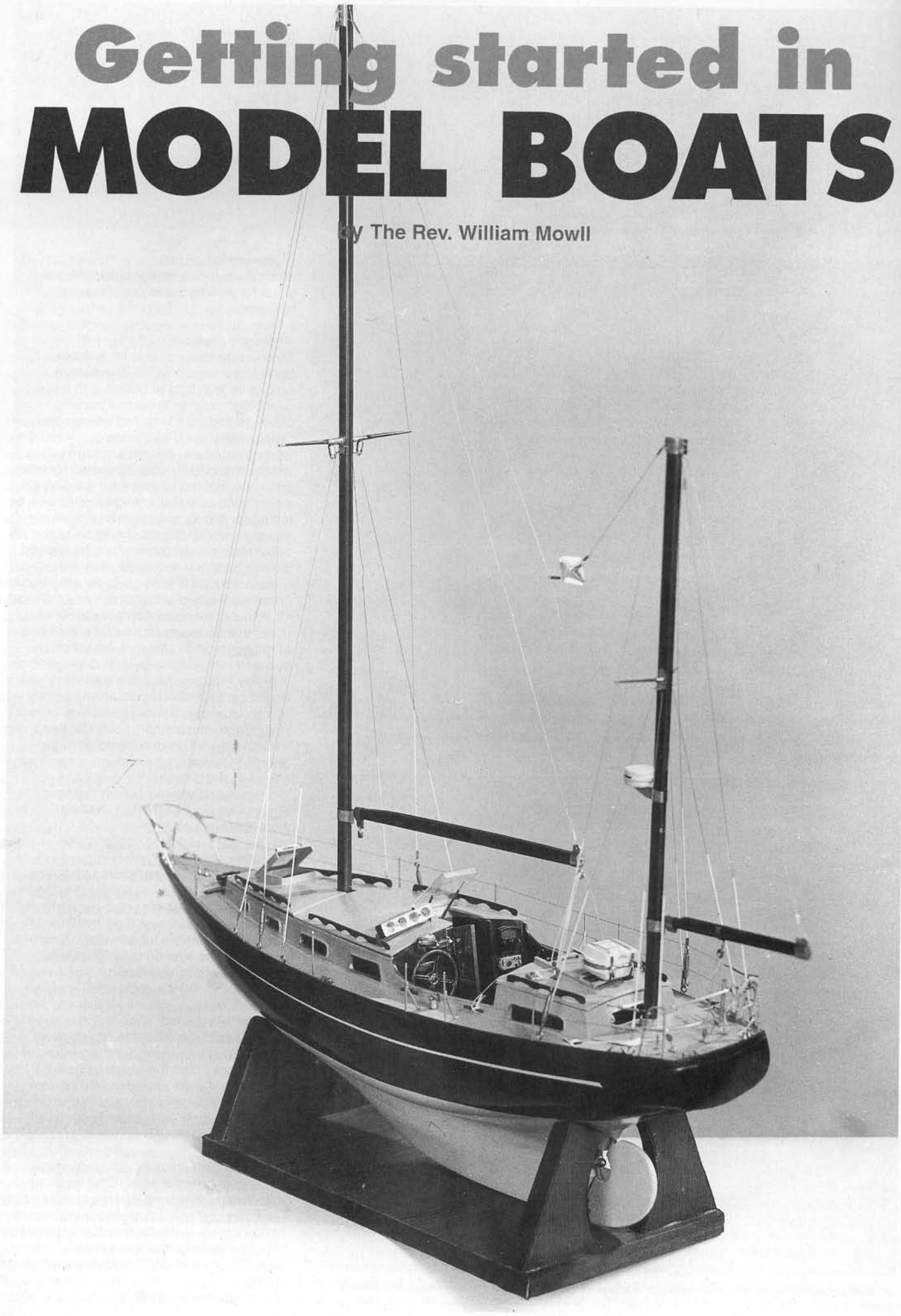
Safety

A model boiler under pressure can be a very dangerous thing but with proper care and common sense in making and steaming the boiler you should be able to enjoy your hobby in safety without fear of any potential disasters. Remember this advice - "IF IN DOUBT - PUT IT OUT" and you won't go far wrong.

Happy steaming! ■

Getting started in MODEL BOATS

by The Rev. William Mowll



Judging by the sizes of the boxes in the average model shop, it's likely that those tempted to enter the world of model ships and boats will do so through the doors of their local model shop. It is a good place to begin, because these shops are invariably run by enthusiasts who are just as interested in what's inside the box as the potential buyer. It is a totally different kind of shopping, and the only sort that I really enjoy.

The importance of the Model Shop

The local 'Mecca' has two other advantages as a starting point, in that they are not only prepared to help and advise, but they are also in touch with the rest of the world in terms of knowing which publications will help you most in your quest. Secondly, they are in touch with the local club, which has permission to use the nearest pond suited to the needs of the model you are about to purchase. If you are about to spend out on a whizzbang DeepVee with a l5cc motor, then make sure there's a place where there is permission to run it.

"Big ones, small ones, some as big as your head..."

Kits come in all shapes and sizes; the larger the box, the more likely it is to be almost ready to run, particularly if the hull has been preformed.

If you are a pondsider, and want to get the vessel on the water as quickly as possible, you'll find that quite a few packages are directly aimed at you, and most will have facilities for radio control, though many of them make good straight runners. There are also kits which, when you have built them, allow you to enter into a 'sailing class' rather like the local Yacht Club; you thus 'buy into' a ready-made group of fellow enthusiasts, against whom you can compete, and with whom you will very quickly learn a whole lot of things you'll never read in books.

More serious kits

Then there is a completely different sort of kit, which is half way between the genuine scratchbuilder, and the state where much of the work and difficulty has been removed by the manufacturer. Some of these kits are extremely sophisticated, and expect you to have command of the many skills demanded of the model shipwright, and could take a long time to bring to completion. As indicated by the prices - and some rise towards the £500.00 mark - they are for adults pursuing dreams, rather than children enjoying themselves. Even these kits divide off into 'glass case' models, known as 'static', and working models which demand a slightly different approach in terms of waterproofing and strength.

Tugboats and Tea-clippers

Pretty well all subjects are now covered by the kit manufacturers, and it is quite a contest to come up with something original and new. Tugboats, like tank engines, have always been popular because they're short and beamy and they don't stick out in awkward places. One always has to remember that model boats start innocently enough, in their hull length, but they grow upwards and outwards like trees, particularly if there are masts involved. The problem is that some (most?) modelmakers are dreamers, and one day it is going to be a working model of the Cutty Sark; and when you get into this area you're probably beyond any help known to medical science.

Scratchbuilding

Then there are the scratchbuilders. These are the people who found that they had so much left over from the last two kits they built, that they have enough raw material to begin a third model, simply by using plans. This is not a joke; this is exactly where I came back into the world of model ships and boats as a scratchbuilder in the wake of two Billing kits. The kits gave me the experience and the confidence to tackle a dockyard plan, and without their introduction to the perils of planking and so forth I would never have contemplated making the break. Scratch-building is the equivalent of exploring the jungle rather than using the paths normally taken by sensible people.

It likely that when you start to scratch-build in earnest, you will, at the same time, begin a collection of strange articles which convert readily into a miniature role quite different from what the manufacturer intended. I refer to things like toothpaste tube tops, which change so well into miniature windlasses; I have even converted a brass bath tap into a four bladed propeller, so nothing is really safe any more.

Other disciplines

The scratchbuilder also cross-fertilises with many other disciplines and is very liable to get caught up in a spiral where the desire for true scale means investment in some fairly sophisticated machine tooling. It is no longer the happy-go-lucky world of 'pop it into the nearest water'; it becomes a serious business with a micrometer and a pillar drill, and it can get worse than that as well. Books begin to play a significant part in the scratchbuilder's life, there being more than a dozen standard works on different aspects of the hobby, to say nothing of a the particular vessel with which you become involved.

The pleasures of ownership

Nothing will ever come up to your childhood memories of seeing either the real thing, or a miniature of it in the hands of a favourite uncle or friend. 'Pooh sticks', as a game, takes a lot of beating when your stick wins. It occurs to me though, that the building and ownership of a model brings a deep and satisfying pleasure whether the hull is in or out of the water. Model ships and boats are pieces of three dimensional sculpture, and they are the prettiest shapes imaginable wherever you are sitting in the room. Whatever shape the top hamper may be, the science of hydrodynamics always demands that the hull is as pretty as a fish. ■

My first scratchbuilt model. A Camper & Nicholson 38' ketch rigged yacht, made from dockyard plans in 1976 at a scale of 1:16. Constructed from timber, it includes several items of interest to the scratch-builder; the forward head basin is made from an old razor blade dispenser; the head itself (not visible) from a hinged Smartie tube cap. The engine is a 'Tick Tack' sweet box, over-laid with electrical condensers; and the working steering gear uses the machine head worm gear from a guitar tuner, ratio approx. 50:1. Whereas it is not a true working model, the keel is ballasted so that she is quite at home in the water.

MODEL LOCOMOTIVES

by Kevin West

Kevin gives an insight into one of the more popular model engineering fields - that of model railway locomotive construction ...

This is a fine example of "Rob Roy", the Caledonian Railway 0-6-0T in 3½" gauge designed by Martin Evans.

LBSC's "Juliet" design is an ideal beginner's loco which is quite easy to build. This unpainted example seen at the recent Model Engineer Exhibition is built to Gauge '1' standards to run on 45mm (1¾") gauge track.

So you've decided you want to build a working model locomotive, but what a choice! Not only do you have to decide what type of locomotive to build, but in what scale, on what gauge and powered by what type of energy? That last statement may seem a little strange - but steam locomotives are no longer the sole type of motive power now being built by the model engineer, an increasing number of 'modern image' locomotives powered either electrically or by an i.c. engine are appearing, helped by increasing support from our trade suppliers. For this article, however, we will concentrate on the traditional steam scene with its bewilderingly large range of types on offer to confuse the beginner.

If we return to our leading questions of what locomotive and what scale, we will probably find that there will be about 20 other problems to be solved before we can make a sensible judgement. But if we take it all too seriously we would probably never start a model locomotive at all - the problems would be weighed too heavily against us! A lot depends on our personal engineering skills and background. You may be an experienced professional engineer or toolmaker, working with machinery and metals all day, in which case the building of a working steam locomotive will not present too many problems. But on the other hand you may be an office worker handling nothing more than paper all day with little or no "hands on" engineering experience. Then there is the question of what equipment you have to hand to aid the construction of your chosen model.

Workshop facilities

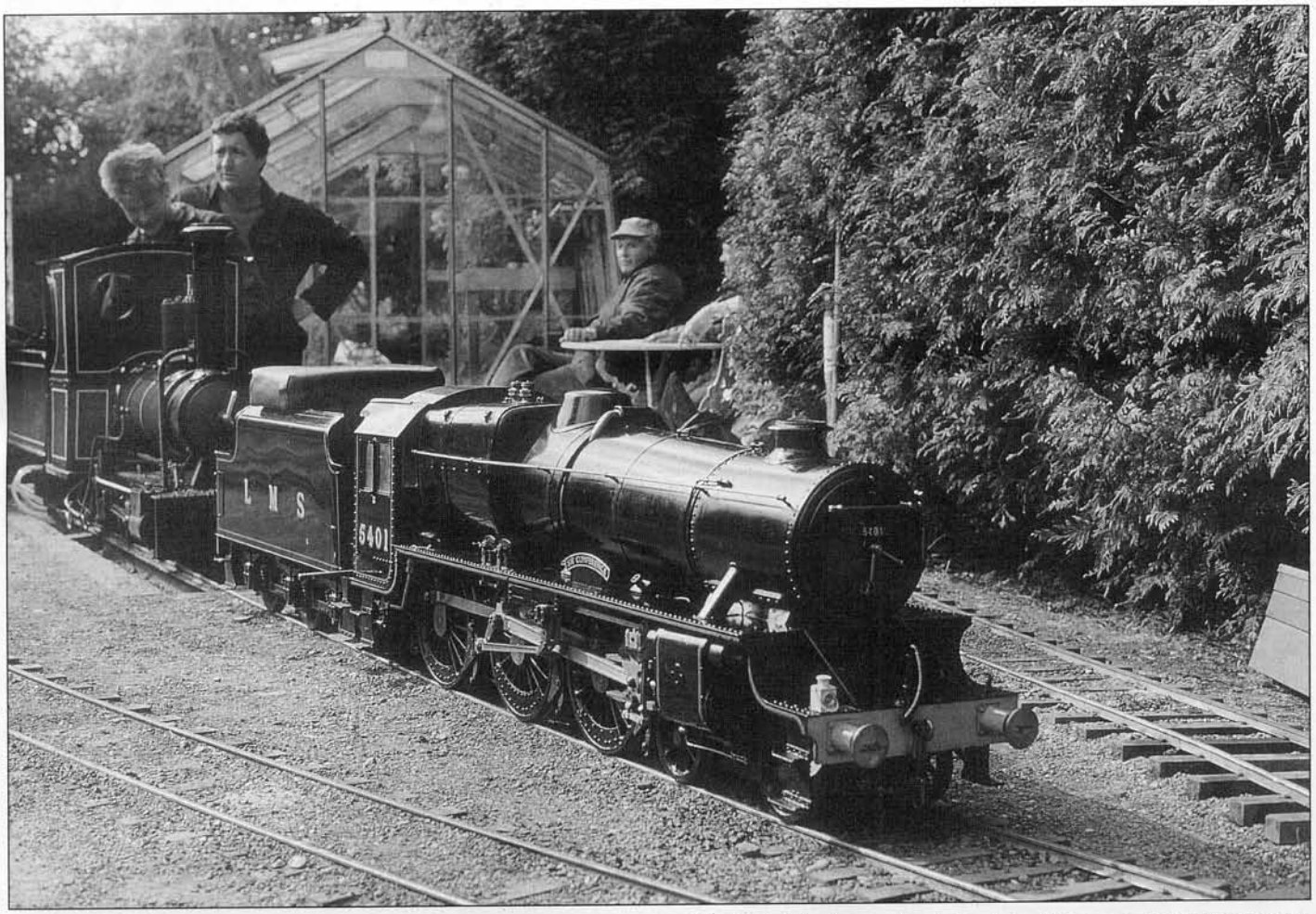
As a professional engineer you may have access to machine tools at your place of work to help in the construction of parts, but the amateur engineer will have at best a home workshop or if no home workshop is available perhaps the facilities provided by a model engineering class at a local night school.

In my own case I have a workshop situated at the bottom of my garden. The ground falls away from the house so the workshop is about 7 feet below the level of the house. I have a 5" gauge 2-6-0 under construction, and having completed the engine, how do I get it up 8 steps into the garage without dismantling it into manageable parts! That's a problem I will have to solve later by possibly doing the final assembly in the garage. But I think it illustrates a point, such as can you build a 10' long model in an 8' shed?

So when these and the other answers have been found to these questions and you go to pick up the hacksaw for the first time, what locomotive have you chosen? Again it will depend a lot on your personal choice and also what you want your labours to provide you with at the end of the building process. Do you want to be able to pull just yourself and maybe a couple of others around a track, or would you like something a little more powerful to handle 10 or 12 adults. Or maybe you would prefer to haul a train of scale carriages or wagons on a scenic layout? This is where scale and gauge comes into the equation.

Scales and Gauges

For passenger hauling the gauges from 2½" upwards should be considered, whilst the smaller scales of Gauge '1' and '0' are

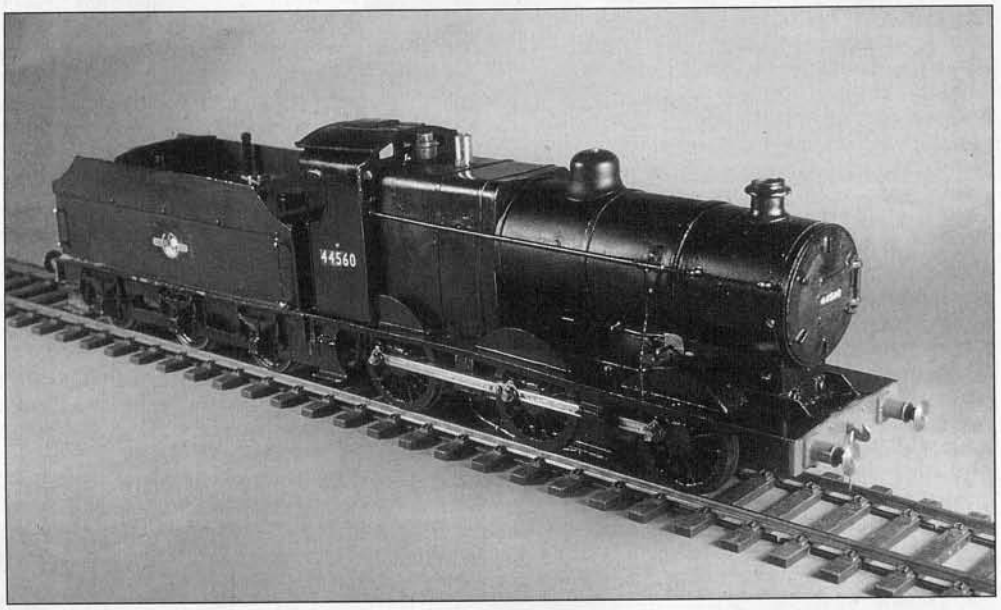


An interesting comparison of sizes - Peter Beale's 7¼" gauge Black Five to the "Highlander" design is seen here in front of a 7¼" narrow gauge "Romulus" at the Hemsby ground level track. (photo Kevin West)

the most common for live steam 'scenic' locomotives. It cannot be stated that a 3½" gauge loco will pull, say, 3 people because there are so many types of locomotive designs available. The diminutive *Tich* 0-4-0T will haul 2 adults, whilst the larger 3½" gauge designs such as *Mountaineer*, a narrow gauge 2-6-2T based on the Festinoig Railway locomotive of the same name, could possibly take up to 10 on a good track. Generally, the larger the locomotive the more pulling power you will have. The same rules apply in our models that do in full size practice, that smaller wheels give more power and larger wheels give more speed.

Choice of design

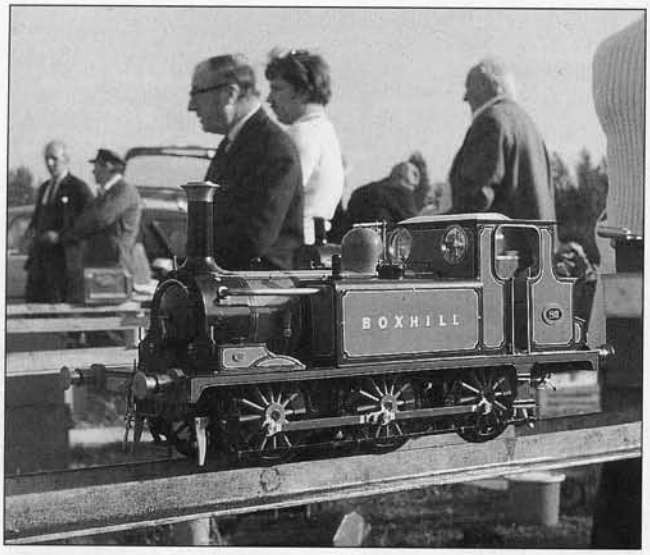
So then we come to the choice of specific design to be built. The express passenger classes such as the Great Western King and Castle 4-6-0's, the LMS Royal Scot 4-6-0's and Duchess 4-6-2's, the LNER A3 and A4 4-6-2's and the Southern Railway Bullied Pacifics or Lord Nelson 4-6-0's would probably be some of the most popular locomotives on a 'build list'. But the construction of such a large and complicated locomotive in any scale will take considerable time and expense, so the beginner is recommended to look at one of the smaller designs as a first effort. The shorter construction time will give a 'quick' result and provide you with both a check on your efforts and a locomotive to run while the 'big' project is under way.



Designed by Ron Poulter and Bob Hines as a starter loco for beginner , the "Project" is a model of the LMS 4F 0-6-0 goods engine. This one was built by Kevin West as his first loco and has since spent many years hauling rakes of scale wagons and carriages. (photo Kevin West)

There are a number of recognised "starter" designs in most of the popular gauges which should be considered. For passenger hauling some of the more popular are the freelance 0-4-0T *Tich*, available in 3½" 5" and 7¼" gauge variants - *Rob Roy*, a 3½" gauge 0-6-0T based on a Caledonian Railway prototype - *Juliet*, a freelance 3" gauge 0-4-0T, which can be fitted with either outside Baker valve gear, inside Stephenson's or slip eccentric gear to choice - *Sweet Pea*, a narrow gauge 0-4-0ST with the simple Hackworth valve gear and circular marine type boiler is available in 3½", 5" and 7¼" versions - and at the top of the size range, *Romulus*, a simple and rugged 7¼" gauge 0-4-0WT capable of hauling a dozen or more adults. All these coal fired designs will provide the builder with a reliable locomotive at the end of construction and are simple to build using normally available workshop equipment.

An immaculate example of LBSC's "Pansy" in 5" gauge painted in London Transport livery. (photo Kevin West)



"Boxhill" in 5" gauge is a model of the LBSCR Terrier class 0-6-0 and makes a good looking passenger hauler. (photo Kevin West)

Many locomotive designs have been described in the Model Engineering press over the years and reading the writings of the designer will greatly aid the newcomer. The late LBSC who designed many locomotives from Gauge '0' up to 5" gauge, including *Tich* and *Juliet* mentioned earlier, was famous for his 'words and music' writings which, far from being too technical, guide the reader through the construction.

The Smaller Scales

On the smaller scales the advantages of being able to easily handle a complete locomotive should not be discounted, and the finished locomotive will give much pleasure and provide as much of an engineering challenge to build as a larger model. In Gauge '1' a range of designs suitable for the beginner includes the very popular Gauge "1" Model Railway Association *'Project'* design, an LMS 4F 0-6-0 tender goods engine with a single cylinder, slip eccentric valve gear and spirit fired boiler. With only one cylinder and one set of associated valve gear and motion work, the construction time is reduced but the finished locomotive will pull a realistic load of scale coaches or wagons. Also several of the late LBSC's 3½" gauge designs were also described as half sized simplified versions in Gauge '1' including *Juliet*, mentioned above, and *Dot*, based on the 3½" gauge model *Doris*, which is an LMS Black 5 4-6-0. All these models make a very good introduction into the art of model locomotive construction. The skill and precision required to build a successful working Gauge '1' live steam model will provide useful training and experience for the construction of a larger model at a later stage. Gauge '0' is considered by many as a little small for the beginner to live steam. The economies of scale also dictate that a small scale locomotive can be built using smaller equipment, many Gauge '1' locomotives have been built on a Unimat or Cowells lathe and at less cost for materials and castings than a larger model.

One item that I feel is often overlooked, but should be considered, is how the finished model is going to be moved from its place of construction and storage to where it will be run. A Gauge '1' pacific can be carried in a wooden box complete with tools with relative ease, but a 7¼" gauge Duchess will require something a little more than the back seat of a Ford Escort! Trailers are commonly used but you then require a car that can not only pull it but also has sufficient braking power to stop it fully laden with the weight of the locomotive. Some form of safe storage is required at home as well, so that the engine can be easily off loaded onto a stand at a convienient height without having to be lifted.

Trade supplies

The services and parts obtainable from our trade suppliers look after the needs of the locomotive builder of all skills, from raw materials and castings for the scratch-builder, to complete fully machined kits ready to assemble, such as those from Maxitrak. Boiler kits or completed boilers can be had from several sources, laser cut main frames can be supplied and there are others able to offer machining services to customers requirements so that there is help for those who maybe question their own ability to produce certain parts or assemblies. See the Suppliers Listing in this magazine for more details.

Reading through the catalogues of our suppliers will show that most will supply not only all the castings required for a particular design but also material for items such as the main frames, buffer beams, etc. as well as being stockists for all the other materials of differing sizes required to finish a particular engine.

Progression

Once we have built our first locomotive and wish to move onto something either larger or more complicated what designs are on offer? Again it is very much a case of personal choice. In Gauge '1' the options include one of the coal fired designs such as *'Southern Belle'*, an LBSCR 4-4-2, or *'Green Arrow'* an LNER V2 2-6-2. Both these designs use techniques common in the larger models and require the challenge of preparing and maintaining the coal fire for a run. Or perhaps a twin inside cylinder design with the problems of getting all the motion work into such a constricted space.

In the larger scales the range is bewildering, covering all types of locomotive from shunters to express passenger classes. In fact some classes of prototype such as the LMS 'Black Five' 4-6-0 have published designs in all scales from Gauge '1' up to 7¼"!

There are some unusual, but interesting, prototypes including *'Rainhill'* and *'Canterbury Lamb'* both early style 4 wheel locomotives from the early 1800's for 3½" gauge, *'Petrolea'* a GER 2-4-0 tender engine from the late 1800's also for 3½" gauge. For 5" gauge there are *'Titfield Thunderbolt'* - a Liverpool & Manchester Railway 0-4-2 from 1830, *'Metro'* - a GWR 2-4-0T, 'Asia' - a 2-4-0 late 1800 design, and *'Princess of Wales'* a Midland Railway 4-2-2 from the late 1800's when single wheeler express passenger locomotives where at their height.

On the narrow gauge

Generally, the narrow gauge locos are of simpler outline than their standard gauge counterparts - many of the most popular are 0-4-0's with simplified valve gear and very simple plate work as used on 2 foot gauge contractor's locomotives. Several designs which fall into this catagory are *'Conway'* and *'Sweet Violet'* for 3½" gauge, *'Sweet Pea'* and *'Edward Thomas'* for 5" gauge and *'Lilla', 'Romulus' and 'Elidir'* for 7¼" gauge. More complicated and pehaps more characterful designs include 'Spencer' - a 4-6-0T for 3½" gauge, *'Mountaineer'* - a 2-6-2T again for 3½" gauge and for 7" gauge a *'Rio Grande'* 2-8-0.

So from all this bewildering list you have chosen your design and started work. Where do you go if you come across any problems. Your local club will probably be your best bet as you will probably find someone who has already built the same design or come across a similar problem, so don't be afraid to ask. But most of all have fun and have a go. ■

CLUBS and CLASSES

Help and advice is readily available from club members and evening classes. They can also be enjoyable places to meet new friends ...

For the newcomer to the model engineering hobby there will be many questions to which he or she will need answers as they progress. How do I set up a workshop? What equipment will I need? Where can I get drawings and materials for my chosen model? How do I go about making a particular part? The answers to these questions may be found in many different places but there is one place where most of them can be answered very easily and this is within a model engineering club or society.

Clubs and societies

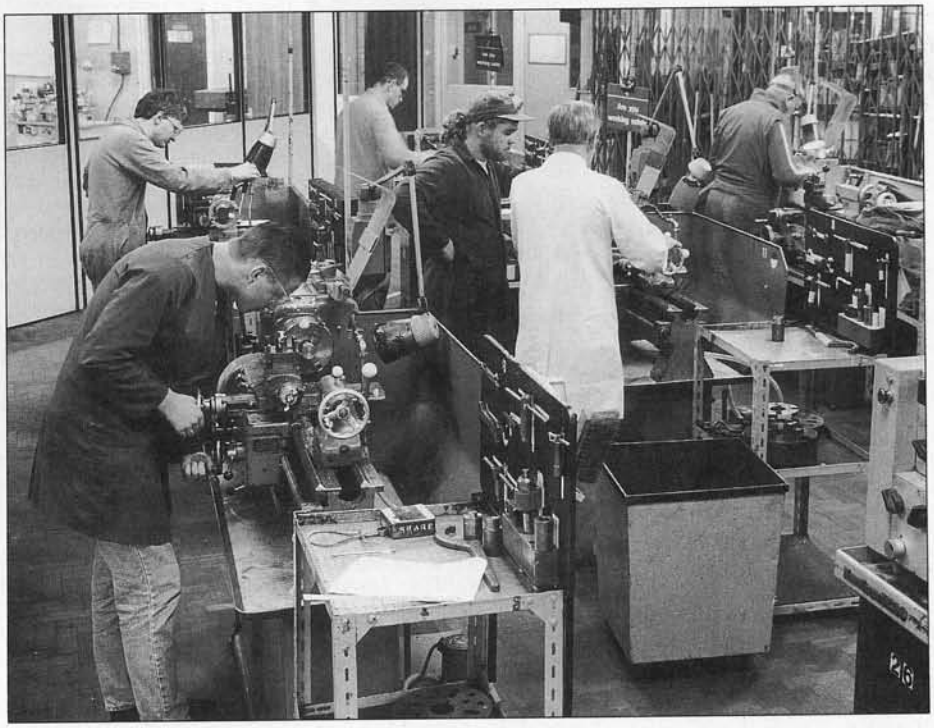
There are a great many clubs around the world, and in the UK there is bound to be a local club in most towns. Model engineering clubs are usually formed and run by a dedicated band of modellers who enjoy the opportunity to share their knowledge and experience with other like-minded individuals. Very often, the clubs will have a place to meet socially on a regular basis and many of them are lucky enough to have some sort of workshop facility where the members can use tools and equipment that they may not have access to on their own.

A lot of clubs will have some form of railway track where members can run locomotives of various scales and haul loads made up of members of the public. This is often seen as a good way of generating funds for the club as well as being an enjoyable way to use the models. Sometimes the club may have a portable track which can be taken out to local fetes and the like where rides are given to children (and many adults as well!). Model traction engines are also popular for giving rides at club events and fetes etc.

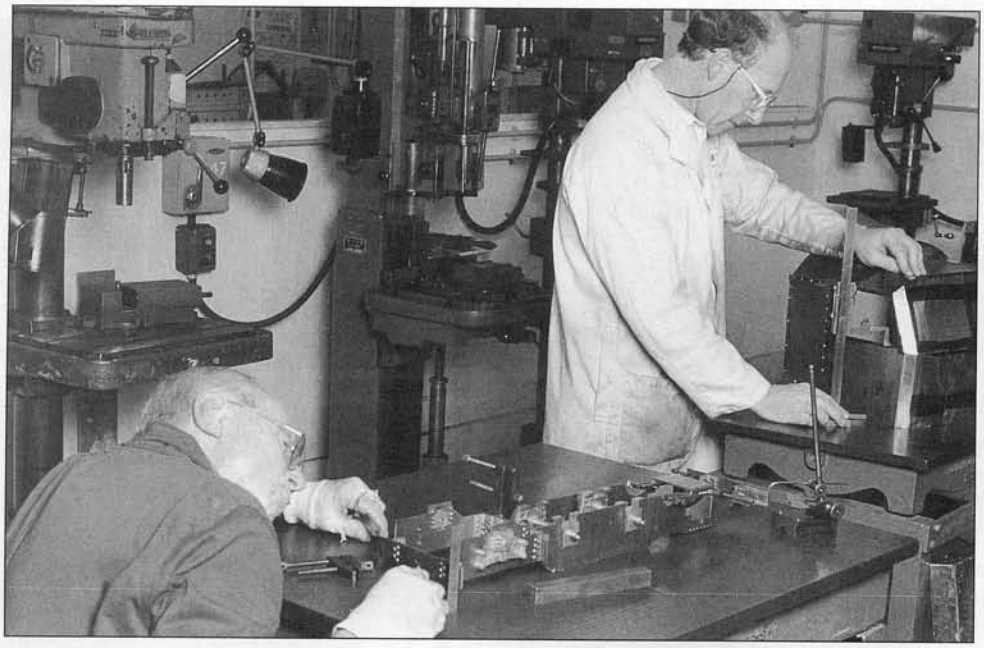
In return for a little bit of help in setting up the track or whatever is needed, newcomers to the club will be encouraged to learn to drive the locomotives or traction engines and plenty of free tuition will be available. This is a much better, and certainly more enjoyable, way of "learning the ropes" than trying to do it on your own. Most of the club members will already have learnt from their own mistakes and will help you to avoid the problems and pitfalls which you may come across as you go along.

Another advantage of joining a club is that there are often financial benefits whereby the club may have an arrangement with a local supplier who gives a discount to

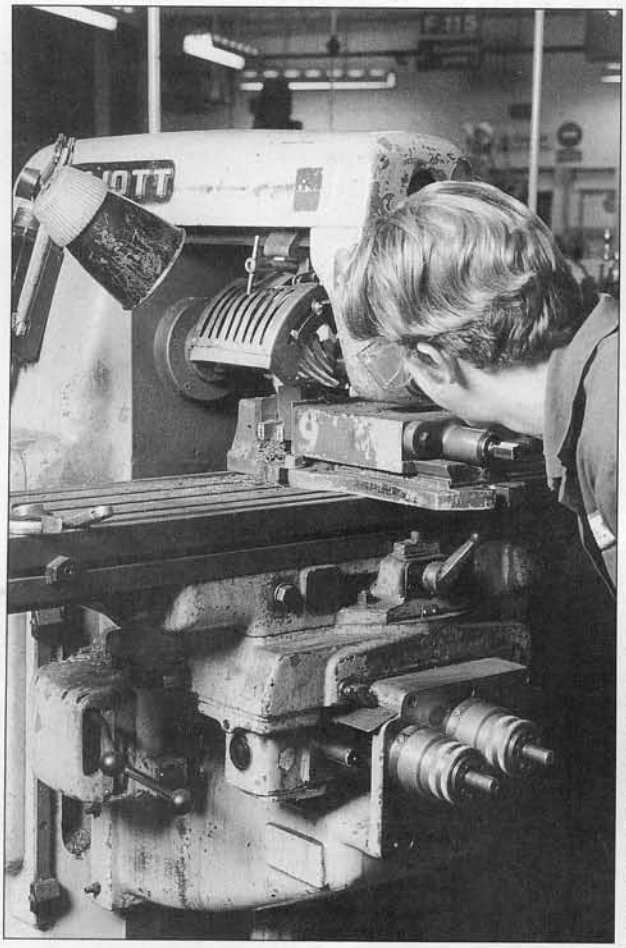
Typical scene at a club track - a 7¼" gauge "Midge" pulling away from the station with a train of passengers.



Part of the engineering workshops at Dunstable College with a group of model engineering "students" working at the lathes.



Squaring up a locomotive frame assembly and marking out the sides of a diesel loco cab on the large surface tables at a college evening class.



A model engineer at work on a horizontal milling machine during an evening class session.

club members. Sometimes the club may purchase materials in bulk and pass on the savings to the members. I remember, some years ago, that the club I was a member of joined forces with another club and all the members who needed to make boilers got together. When the price of copper reached a low level, we purchased all the material at one time and got a huge quantity discount which we all shared. In addition to this, one of the members enjoyed making boilers and he made all the boilers for us. The social side of club life can also be very enjoyable. Talks and lectures, slide, film or video shows, visits to other clubs or places of interest etc. are often organised and these all help in the quest for further knowledge about the hobby. Bring and buy sales or club auctions are a good place to pick up useful items for the workshop etc. - or even to get rid of things which you no longer need. "Bits and pieces" evenings, where members are invited to take along an item they are working on, are good for exchange of ideas and often result in discussions which may solve a particular problem with how to make a part and so on.

Although the majority of model engineers are of the male gender, there are a great many ladies who are actively involved in the hobby, whether it be making models, helping out in general with running the club, or - the most important job - making endless cups of tea! Ladies are always welcome at the model engineering clubs and, indeed, are actively encouraged to take part in all the activities. In fact, there is one lady in particular who regularly enters her models in the competition section of The Model Engineer Exhibition and usually gains a Gold Medal and the supreme prize of The Duke of Edinburgh Trophy. So, come on ladies, you are more than welcome to join us and take part - we might even make the tea for you!

Evening classes

Many colleges and schools with engineering workshop facilities run evening classes in engineering and these classes are very often based around model engineering subjects. The usual sort of arrangement is that the "student" is allowed access to all the facilities and may just get on with making his model but, if he needs help or instruction, the lecturer is on hand to advise and teach as required. Very often these classes are quite informal and have a very nice social atmosphere about them. I would recommend any beginner to the hobby to join a local evening class because the benefits to be gained in terms of instruction and access to equipment are well worth the course fees. From my own experience, it pays to plan in advance what you want to do each evening and make sure you have all the necessary drawings, materials and tools to hand as soon as you arrive. This will enable you to get the most work done in the couple of hours or so of each session.

Most colleges will have larger lathes than the model engineer is likely to have at home. Usually college lathes are of 7" to 10" centre-height (whereas model engineers have 3½" to 5" lathes) and this may seem a bit daunting at first but if you ask the lecturer to show you how to operate the larger lathe you will soon find that it is quite easy to use. There is also the added advantage of being able to handle bigger jobs on the larger machines. If you have a smaller lathe at home, plan things out so that you do the smaller, more delicate, jobs at home and use the college facilities for the jobs which your own lathe is not quite big enough.

You will also have access to milling machines and shapers at the college and, even if you do not plan to get a milling machine at home, it is well worth while learning how to use these machines. The experience will definitely be invaluable later on in your model engineering "career".

Another very useful aspect of going to a college evening class is the fact that good brazing facilities will be available. In fact, many model engineers build their boilers at college because the sheet metal work is easier to undertake with large guillotines and bending rolls, as well as having access to the more specialised sheet metal working tools etc. A large brazing hearth with gas-air or self-blowing l.p.g. torches certainly makes the final assembly of the boiler much easier. The college will also have a reasonable size of pickle bath for cleaning the components before and after brazing operations.

In summary

Many model engineers prefer to "go-it-alone" and have no wish to join a club or go to evening classes. There is nothing at all wrong with that approach to the hobby and I know of several people who are happy to work on their own and they do produce some really excellent models. However, there also a great many modellers who like the company of other people and get a lot of enjoyment from being involved in club activities and sharing other peoples' experiences. I would certainly recommend the beginner to join a club and attend evening classes as the help and advice on hand will be invaluable in the pursuit of this most rewarding hobby. ■

SUPPLIERS LISTING

Whilst every care has been taken in compiling this list of suppliers of model engineering equipment etc., it is almost inevitable that mistakes will creep in. Apologies are therefore made to anyone who is not included.

ACORN MACHINE TOOL CO. (1936) LTD.
The Causeway, Egham, Surrey, TW20 9AN.
Tel: 01784 434226
All types of machining facilities including gear cutting to order. Also stock a large range of spares for Atlas Lathes.

S.S. ADAMS,
12 Queensbury Terrace, Cummertrees, Annan,
Dumfries DG12 5QF. Tel: 01461 700215
Precision engineering of all types carried out to the order of customers.

ADAMSON AND HEATH,
P.O. Box 74, Paddock Wood, Kent TN12 6DW.
Tool for adapting an off-hand grinder into a belt sander.
3 Laurel Close, Furnace Green, Crawley, West Sussex RH10 6QE. High quality measuring equipment, (micrometers Verniers etc) available by post.

M. J. ALLEN FOUNDERS,
Hilton Road, Cobbs Wood Industrial Estate, Ashford, Kent.
TN23 1EW Tel:-01233 622214
Foundry who is prepared to do work for model engineers in iron, light alloy and gunmetal.

ALLSPEEDS LTD,
Royal Works, Clayton Le Moors, Accrington,
BB5 5LP. Tel: 0254 235441
State of the art inverter drives for three phase machinery allowing it to work on single phase electricity. The range includes speed controllers.

AKRON TOOLS,
46 Rickmansworth Road, Pinner,
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Small high quality accessories for machining purposes. Also diamond dressers for dressing grinding wheels.

A.R. ENGINEERING
Unit 5, Haigh Road, Parkgate Industrial Estate, Knutsford, Cheshire.
Perspex cases for models made to order or material supplied for home use.

ARRAND ENGINEERING
The Forge, Knossington, Leicestershire LE15 8LN.
Tel: 01664 454586
Specialists in high quality lathe tooling particularly boring equipment of which they have a particularly wide range.

ARIAN SERVICES,
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SA14 7RW. Tel: 0269 844987
Can supply ready made or self assembly track for small passenger carrying railways.

ASSET OPTICS
Coventry Point, Market Way, Coventry CV1 1EA.
Half eye magnifying spectacles for close up work.

R.A. ATKINS LTD.,
Normandy, Guildford, Surrey. Tel: 0483 811146
Stocks of machines and tools of use to the model engineer, including the Myford range of lathes and milling machines.

AXMINSTER POWER TOOL CENTRE
Chard Street, Axminster, Devon. EX13 5DZ
Tel: 01297 33656
Stockists of the most comprehensive range of machine tools and accessories. Apart from supplying machinery they also have a large range of spare parts. A mail order service is offered on all equipment.

T.E. BARRU
161 Park Road, Teddington, Middlesex TW11 0BP.
Model locomotives made to order, also kits of parts for some popular models.

BASSETT LOWKE,
Augusta Centre, 99 Sanders Road,
Wellingborough NN8 4NL.
Stocks of high quality plans for construction of model ships.

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BLACKGATES ENGINEERING,
209 Wakefield Road, Drighlington, Near Bradford, West Yorkshire BD11 1EB. Tel: 01132 853652
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Three phase converters and other electrical equipment suitable for use in the workshop.

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A wide range of engineering supplies and models including boilers for all interests particularly to the marine modeller. Stockist of the Stuart range of stationary engine kits. Specialities are some particularly well engineered finished models and a range of cylinder hones.

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Maple Works, Northgate, White Lund Industrial Estate,
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G AND M TOOLS,
The Mill, Mill Lane, Ashington, Sussex. RH20 3BX
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Full range of second hand machinery, accessories and tools. The stock is constantly changing and a visit is recommended.

GRAHAM ENGINEERING (MIDLANDS) LTD.,
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The firm stocks a most extensive range of machinery and small engineering tools as well as woodworking equipment. It is probably fair to say that as far as tooling is concerned there is little that cannot be obtained from Graham Engineering, including spare parts for many makes of machines. They market the famous "Alpine" range of equipment as their own line.

GRAHAMS MACHINERY SALES,
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17 Uplands Way, Springwell Village,
Gateshead, NE9 7NQ Tel:- 0191 416 3626
Narrow gauge garden railway specialist, supplying models and equipment.

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10 Park Lane, Earls Colne, Colchester,
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The above address is the head office. The firm has retail outlets in most major cities. They stock a large range of tooling of various kinds, a great deal of which is useful to model engineers. Prices are very competitive and some of the equipment is not easily available elsewhere.

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All types of supplies suitable for model engineering including a range of castings, books, drawings, nuts, bolts, rivets, transfers for both locomotives and traction engines etc.

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A range of workshop equipment for the model engineer including the Dore Westbury Vertical Milling Machine and the Quorn Tool and Cutter Grinder. Sold as kits with heavy machining already completed, as are technical items such as the protractor heads for the cutter grinder.

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A full range of model engineering supplies including some machinery, castings, metal and tooling. A mail order service is available.

N. MOLE, Tel:- 01923 896597
The firm carries a large range of new and used machinery as well as stocks of tools.

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The range of traction engines and steam rollers originally marketed by H.R. Plastow are now supplied by this company. Scales are from 1½ inches to 4½ inches to the foot and include showman's engines, road locomotives and agricultural engines.

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Wide range of tools, materials and machinery for the model engineer and also manufacturers of copper boilers. Machining services undertaken to customers requirments.

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Range of drawings and castings for stationary steam engines based on those of Robey of Lincoln, as well as a range of steam boiler feed pumps. Also Silicone 'O' rings, a tapping tool casting kit.

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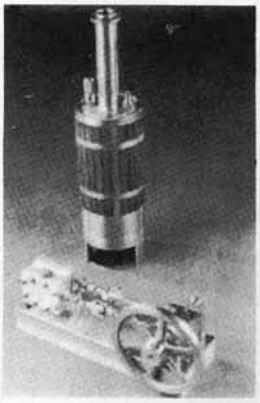

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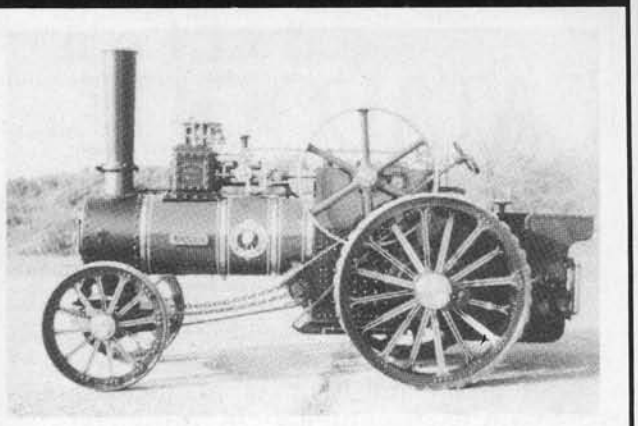

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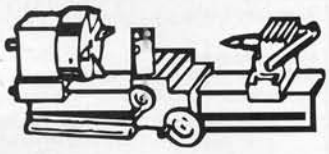

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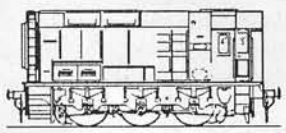

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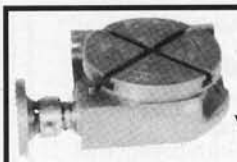

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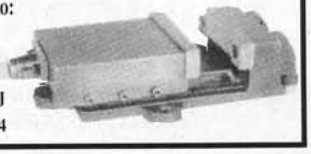

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Editor : Mike Wade
Designer : Jeff Hamblin
Advertisement sales : Ben Adwole and Paul Skinner
Advertisement copy control: Louise Jones
Managing Editor : Stuart Cooke
Group Advertisement Manager : Claire Jenkinson
Production Manager : Tony Dowdeswell
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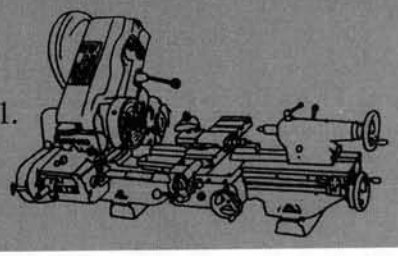

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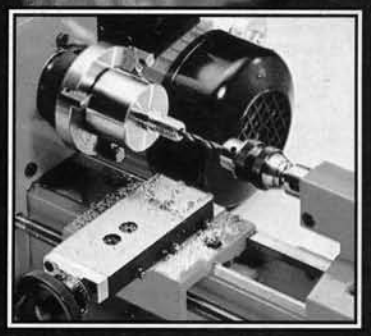

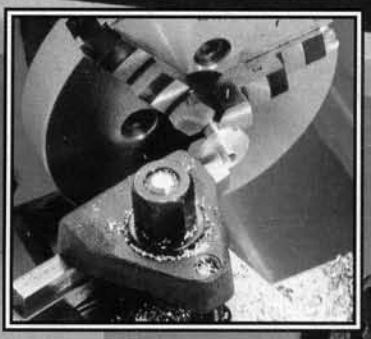

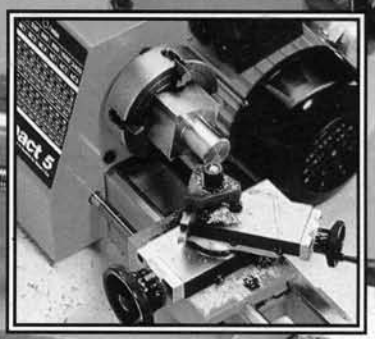

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