THE FINISHING TOUCHES

Those small items of detail, so often overlooked by many modellers, can make all the difference to the appearance of a finished model

What is required of a model is entirely a matter for the builder. Some people are more than happy to build models and run them, whilst not bothering too much about the appearance. If the model works well then that is sufficient and nothing else is required. Others prefer to build models that look as near perfect as possible, and, whilst usually such models are capable of being used, that is not the prime purpose for which they were built.

Then there is the third section who like models both to run well and look good also. There is no reason why this cannot be, and many superb looking models run just as well as they look. There have been numerous such examples: The late Bill Carter built two locomotives, both capable of winning the highest possible awards at exhibitions and at the same time able to run as well as anyone could wish. Roy Amsbury also numbers amongst the models he has built, a compound Atlantic locomotive. The model won the International Efficiency Trials and also was a medal winner in its class at the Model Engineer Exhibition. There are plenty more examples that could be quoted!

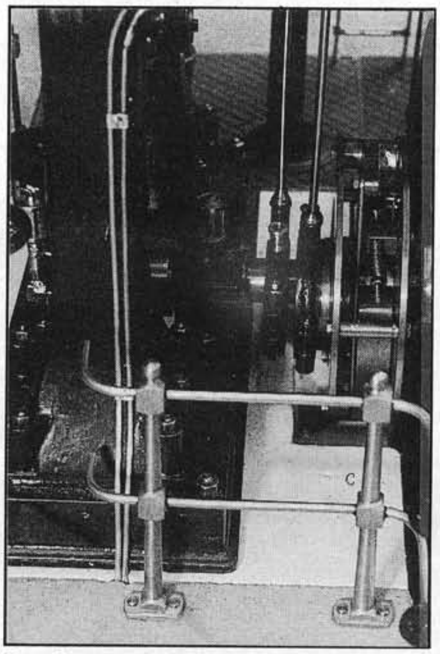
Ultimate accuracy

Of course, making a model of high quality appearance takes generally more time than making a simpler, purely working one. To some extent it also takes more expertise, not to mention patience, and it is necessary to have some knowledge of the original prototype so that reference can be made to it in order to get things right. This means either consulting photographs or, if the prototype is preserved, better still, going to see it as frequently as possible.

Coming back to the late Bill Carter, his last locomotive was a Great Western Railway 'Dukedog' and he decided to model one that was preserved on the Bluebell Railway. He made a number of visits, carefully measuring and noting details. When it came to the valve gear, which was underneath and inside the frames, Bill was still only going to be happy if that, too, followed the original as closely as possible. He got permission to get underneath, only to be astonished to find that there were distinct differences in the valve gear on each side of the engine. No doubt during the long course of its life parts had been cannibalized from other locomotives of the same or a similar type. Not in any way deterred, Bill made the valve gear on his model with identical variations. It is thus a *true* model of the original.

Attention to detail

Not all of us by any means can or would want to go that far, but some attention to detail and a few accessories can change a good model into a very fine one and there is not all that much involved in so doing. Builders of model ships already go a long way to completing the fine details, but rarely do we see this with locomotives, traction engines and stationary steam engines. There are many accessories that can be made and they do not take as long as one would think.



Rarely seen on model stationary engines are correctly formed handrail stantions such as these which are fabricated

If we take stationary steam engines, for example, it is rare to see the hand rails, which were always placed round them, on a model. It is not difficult to make these and they really do add to the appearance. Steam connections are all too frequently overscale nuts, whereas in full-size practice these were rarely used. Flanges would be more appropriate. The answer may be that many people, for some reason, prefer to buy a union nut than to make a flanged fitting. These do not take long to make and the appearance is much better. It is true that they are more fiddly to connect up to a steam plant, but they can be made in such a way that they can be changed when required. If the model is permanently fitted to a boiler, then a flanged fitting requires little more time to connect up than does a nut and nipple, yet the finished product is far superior.

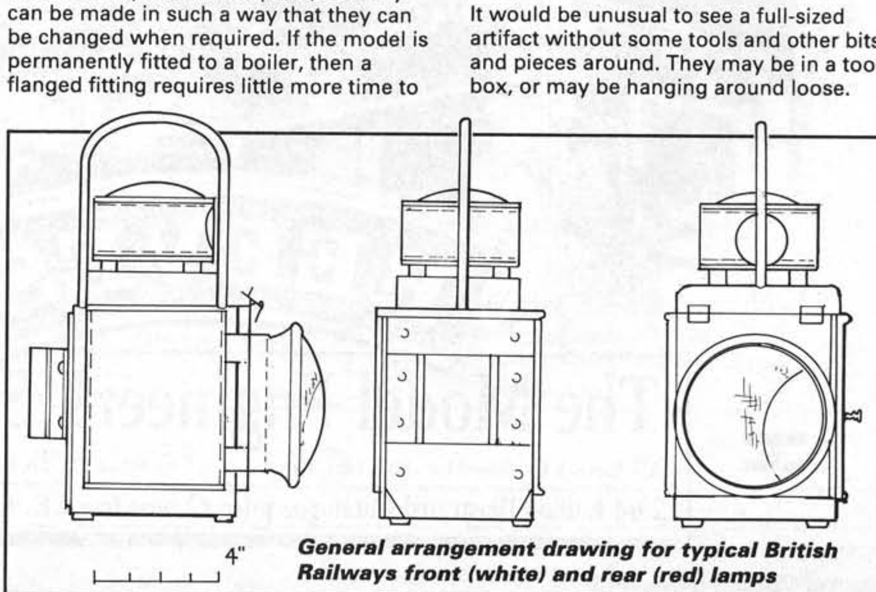
Likewise, many stationary engines were built on stone or brick bases. Louis Harling, whose work is featured elsewhere in this magazine, actually collects local stone which he cuts to size, and the effect is perfect. Not all of us can do this; we may live in the middle of a large town or in an area where there is no stone of the type needed. However, it is not too difficult to simulate the stone using plaster, or fire clay, and again the little effort involved is well worth while. It is also worth noting the little touches that the popular author Tubal Cain adds to his models...

Lamps for locomotives

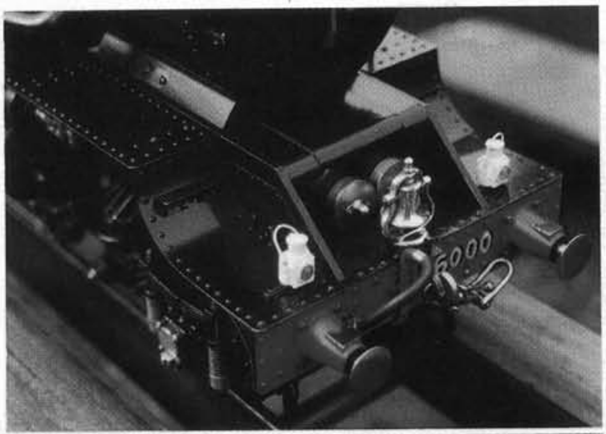
When we come to locomotives, how frequently do we see plain models with no attempt at what a cook would call 'garnishing'? A simple way to improve appearance is to fit lamps (many do not even fit lamp *brackets).* Again lamps are not difficult to make, and in fact they can be bought if that is what is preferred. They make a great deal of difference to the appearance of a model. Basically they can be folded from shim brass or tinplate with perspex used for lenses and they take little or no time to make. One reason people fight shy is believed to be because they are thought to be fiddly. This is because many of us are not used to making small items. Shim brass only a few thousandths of an inch thick is used which is easy to cut and bend. Once in shape such a structure is very strong indeed. Soldering can be done with a small iron as little heat is needed. Making them is a very satisfying exercise indeed. Lamps can also be made for traction engines and some drawings of different lamps are included. The scale of these can be altered to suit the individual by simple multiplication or division.

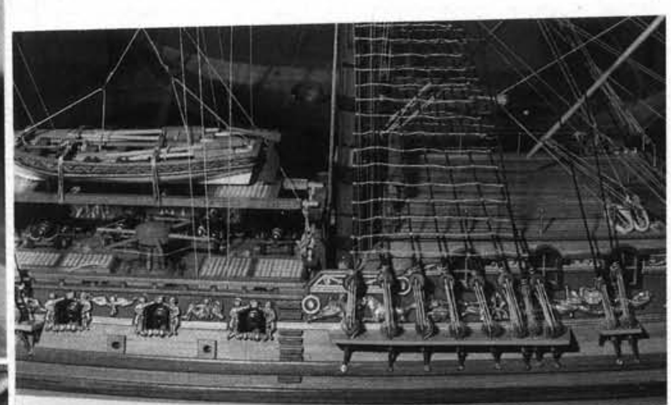
Other items

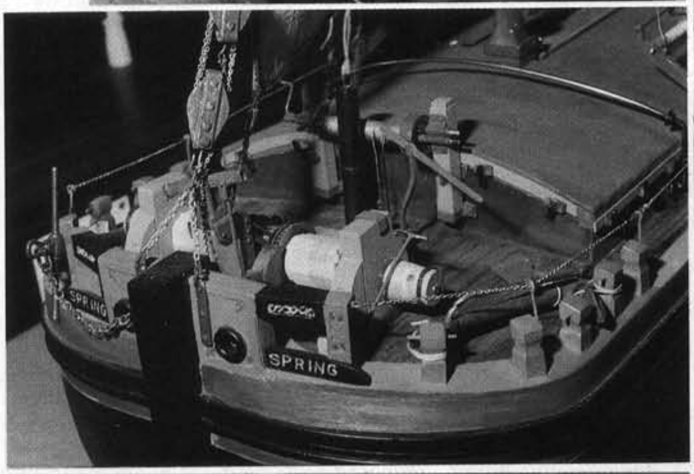
It would be unusual to see a full-sized artifact without some tools and other bits and pieces around. They may be in a tool box, or may be hanging around loose.

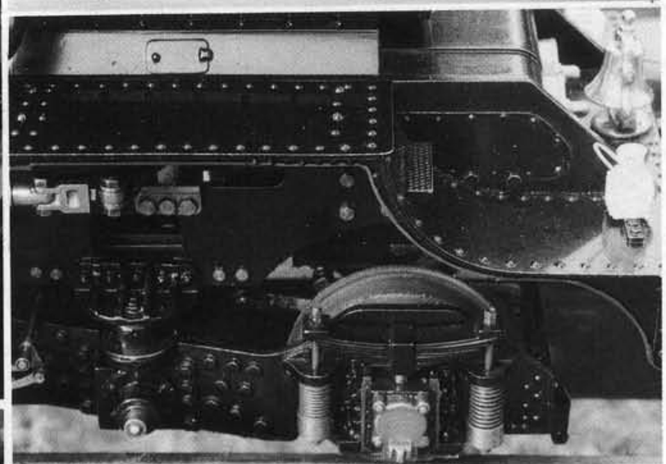


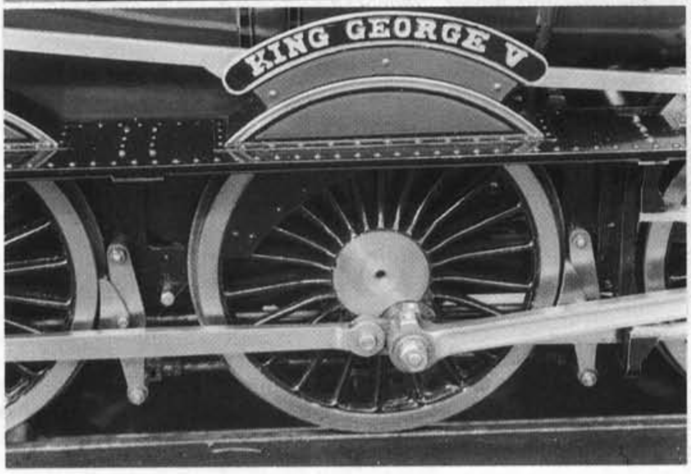
General arrangement drawing for typical British Railways front (white) and rear (red) lamps



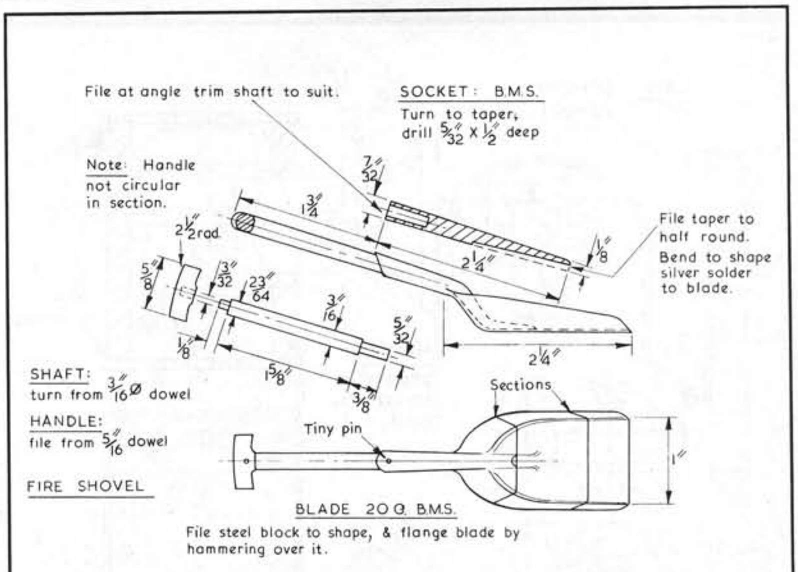


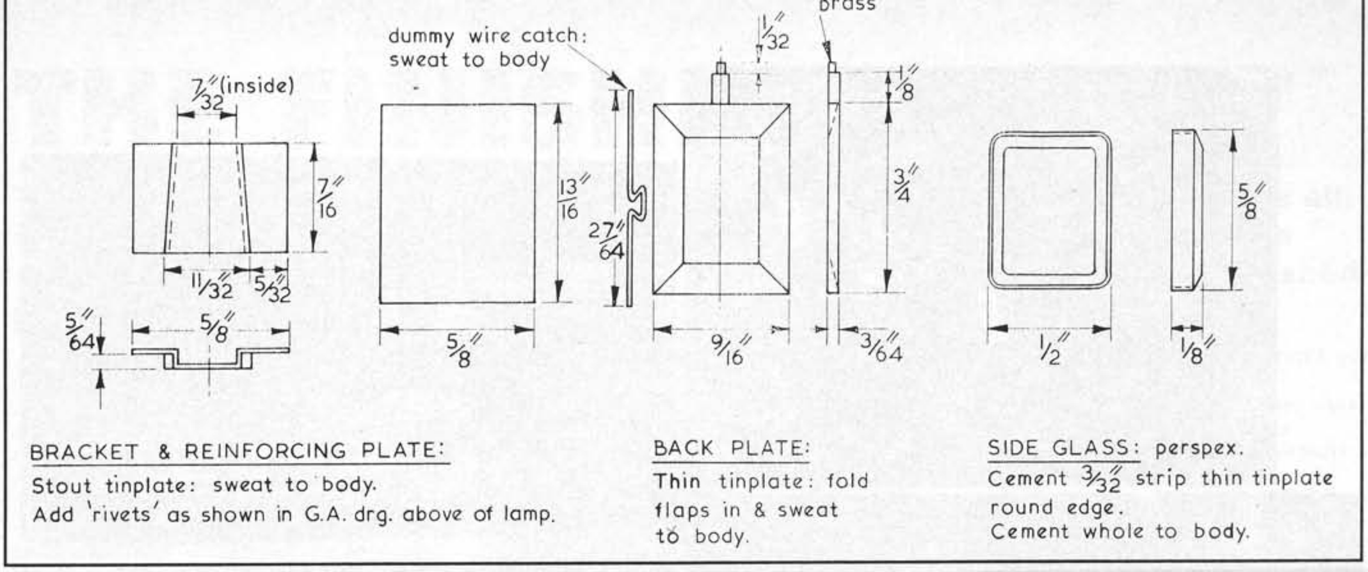


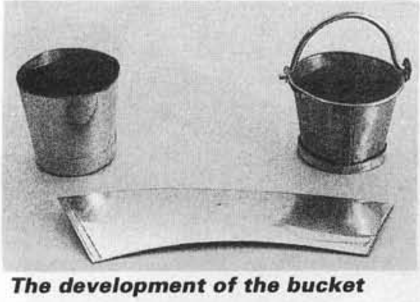




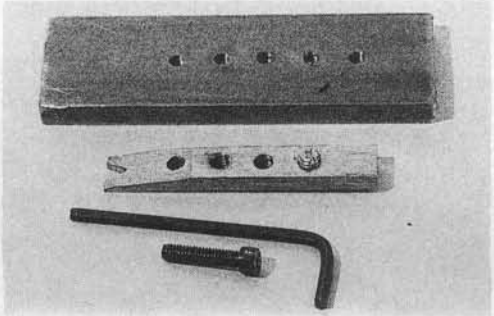
Top left; the finishing touches come with neatly made Great Western styled lamps and a brass bell as carried on the original, which even swings.
Top right and centre left; somehow we have come to expect these sorts of touches on model boats and here we see two excellent examples of attention to detail,
Centre right; scale sized bolts and rivets again show how reference has been made to the full-sized engine in order to get everything right.
Above left; carefully made coupling and connecting rods are fitted as per full-sized practice.
Above right; this excellent 3.1/2 inch gauge model of a Great Western Railway King Class Locomotive was seen at the National Locomotive Rally hosted by the Birmingham Society of Model Engineers. It reflects how much attention the builder, who unfortunately is not known, has given to details. The model runs as well as it looks!.

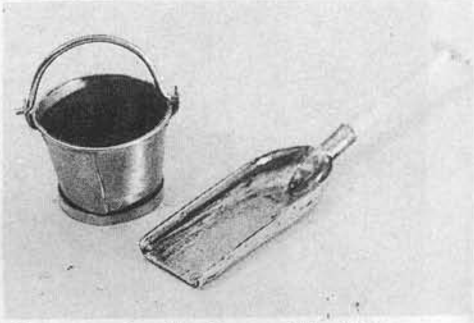




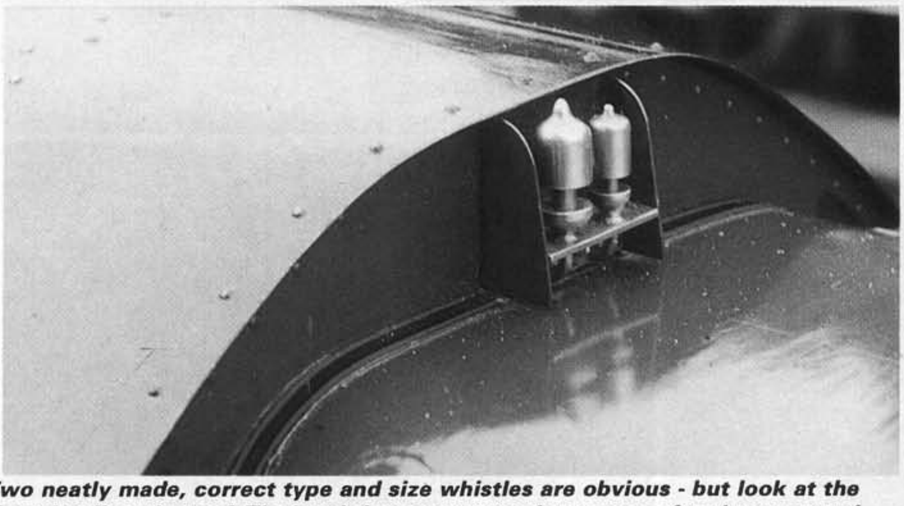


The development of the bucket

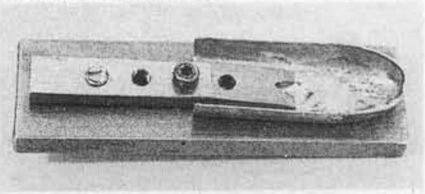




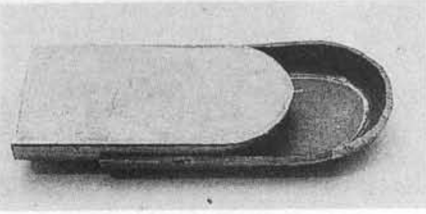
Above centre, the jig used for filing up the shovel; clamp holes are tapped 2BA, the base 4BA

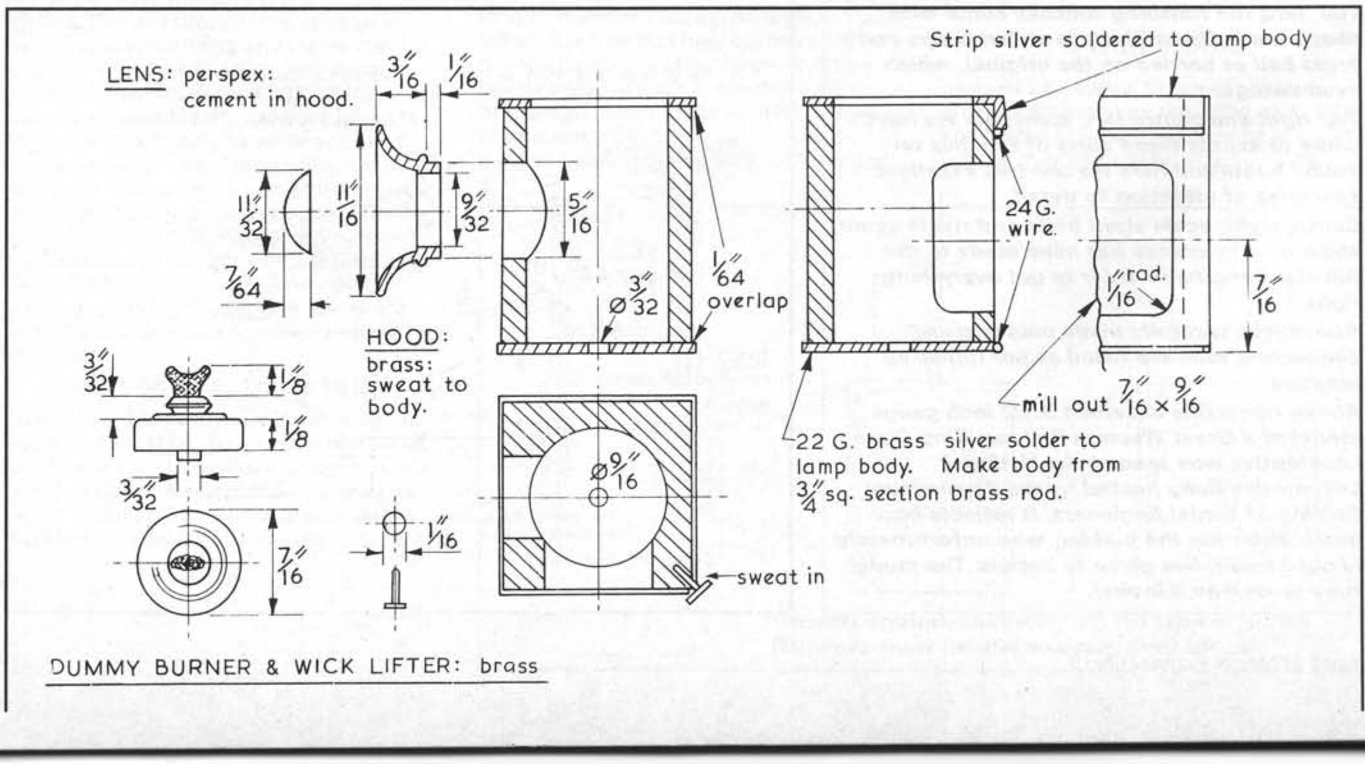


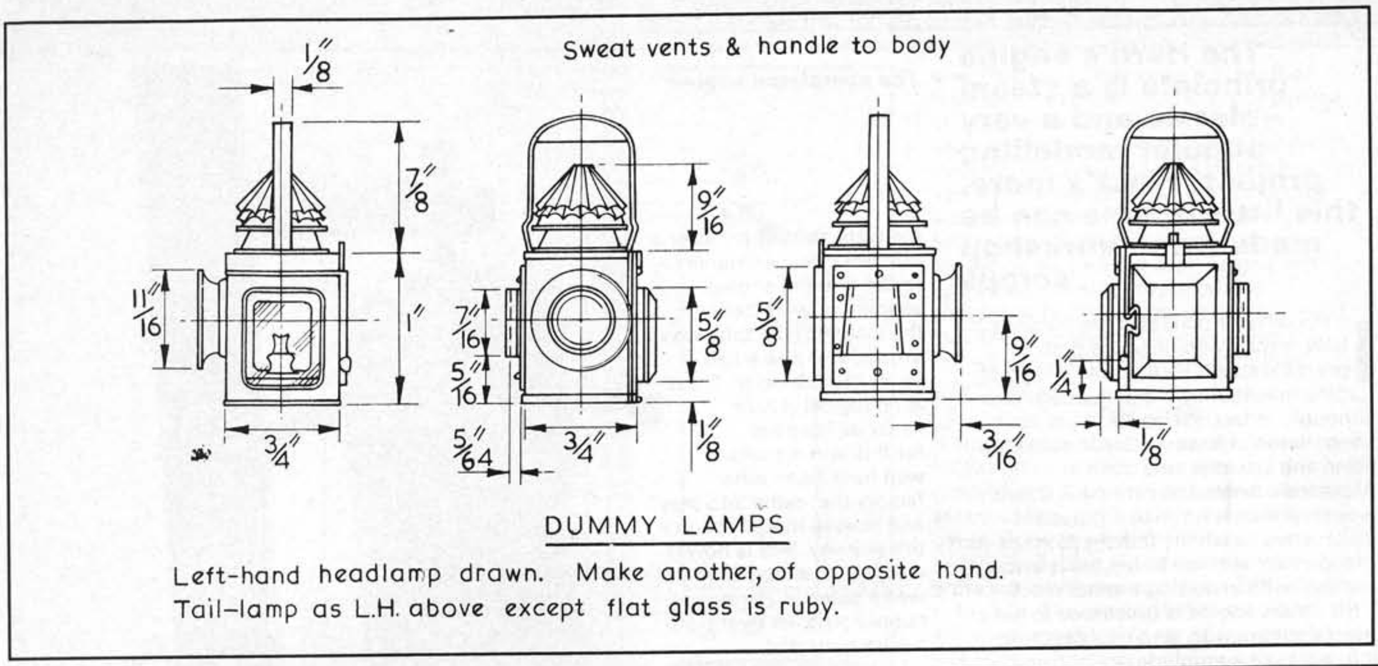
Two neatly made, correct type and size whistles are obvious - but look at the rivet detail on the roof. The head sizes are not too large as so often happens and they are correctly spaced



The shovel held for filing (above) and after forming (below)



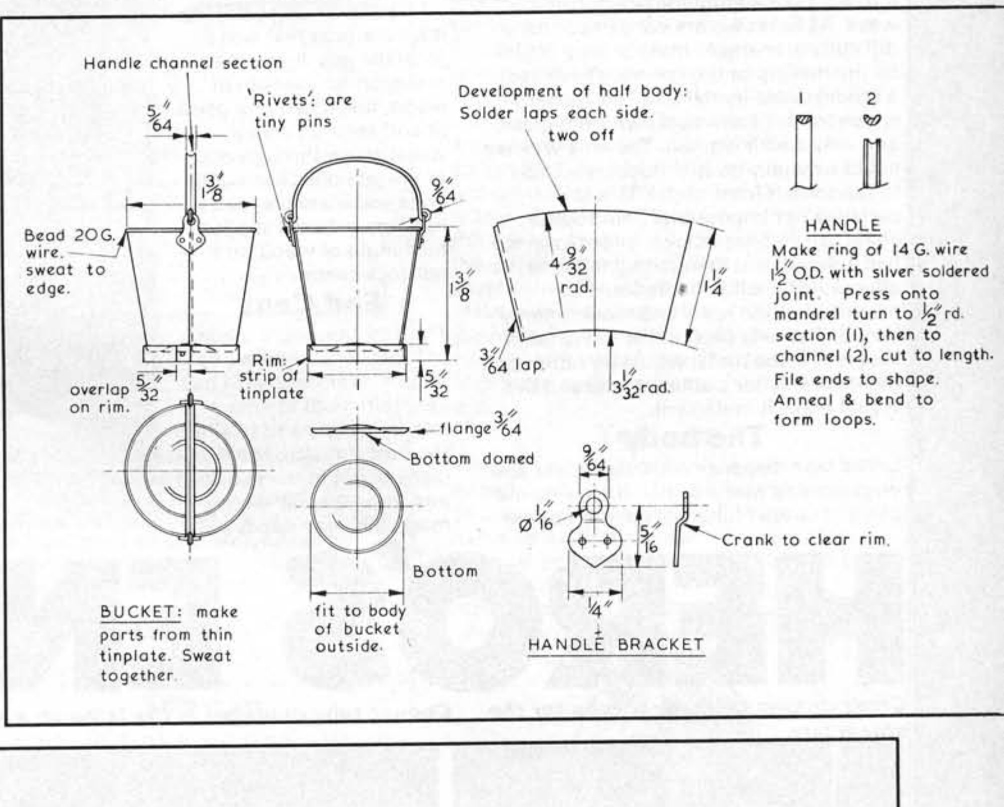


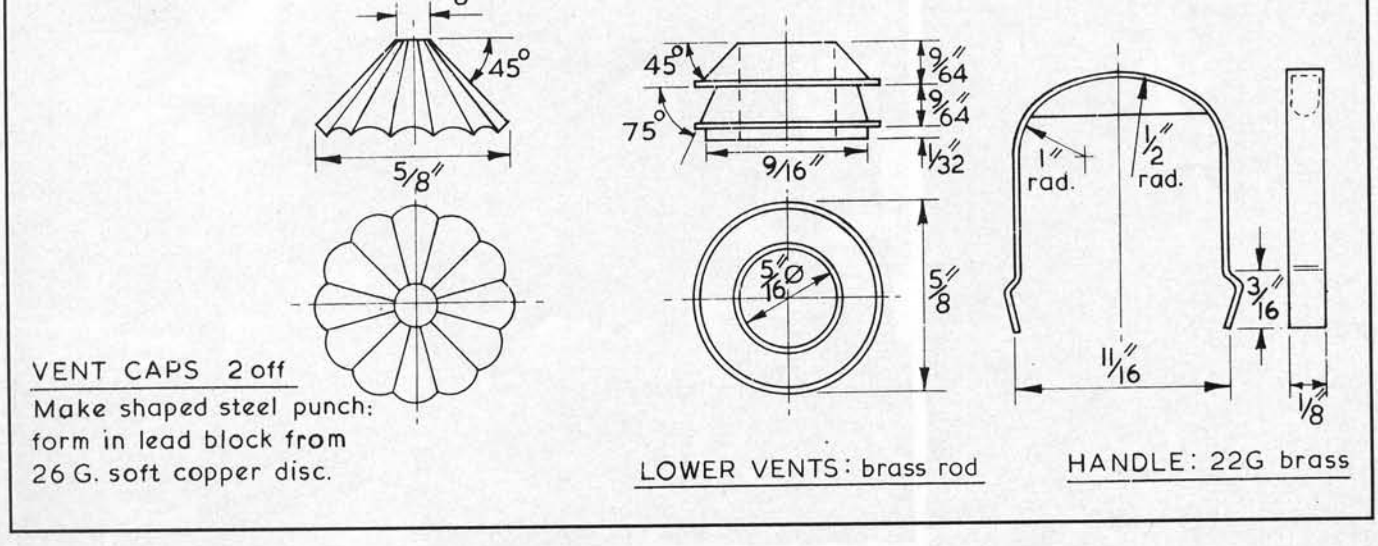


Spanners are easily filed from thin mild steel, shovels are fabricated by bending over a former, and buckets, etc., can again be fabricated easily from sheet metal. The best material to use for buckets and tool boxes is tinplate. We see less of this than we used to, and the tims that are made of it are frequently corrugated for strength as the material used is now so thin.

However, there are still some food cans which are made from it and the small round tins that hold salmon or tuna fish are an example. One such tin will make a couple of tool boxes and a couple of lamps. The metal is lacquered on the inside, as a precaution against lead poisoning, but a quick rub with a fine emery cloth soon removes this. The recovered material has great strength for its thickness, and soft solders particularly easily – it is well worth the little trouble needed to acquire it.

A number of drawings and photographs have been included to help readers with ideas on how to go about adding detail. Some are by the late Bill Hughes and they are of a scale of 1.1/2 inches to the foot but can easily be altered to suit whatever scale is being worked in.





HERO'S ENGINE

The Hero's engine principle is a steam classic and a very popular modelling project. What's more, this little engine can be made from workshop scraps

In the chapter on steam we discussed how, almost certainly, the first practical steam engine was a form of turbine invented by a man named Hero – although, in fact, the name could have been 'Heron'. He was a Greek mathematician and scientist who lived in Alexandria in the first century A.D. and was responsible for many important discoveries which include the formula for triangles we still use today. He is also credited with inventing a water clock.

His steam engine is presumed to have been a sphere with steam jets protruding, a simple enough device in some ways. As far as we are concerned the difficulty in trying to make a copy would be the making of the sphere. I have seen a model made by the late Ted Turner in which the sphere was blown from glass, and very well it worked. The only way we could normally do it, though, would be to fabricate it from metal. This is certainly not impossible. Thin copper sheet can be shaped over a former in to half spheres and then joined together, or alternatively half spheres could be machined in the lathe and subsequently joined. The only problem with the latter idea is that the metal would be rather on the thick side for a small model and this would make it inefficient.

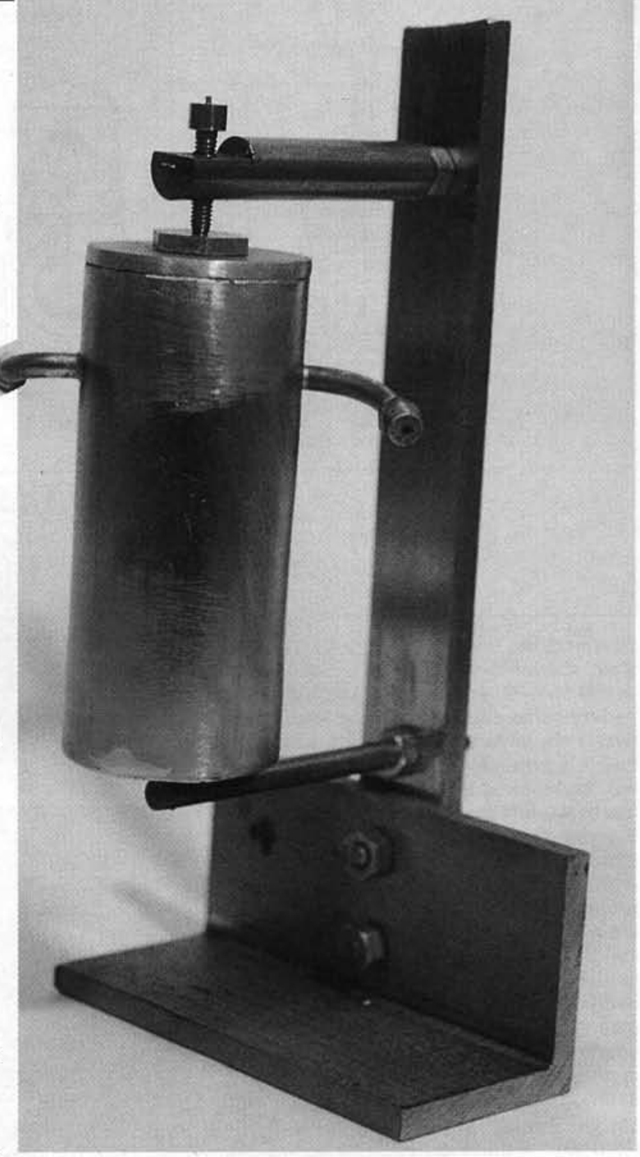
The body

Let us then dispense with the sphere and work instead with a sealed tube. Any old piece of copper tube will do, the thinner the walls the better. After a number of experiments I found that the engine seemed to work better if the length of the tube was around two and a half times the diameter. There is no logical reason as far as I can see for this and it could well have been other factors that came into play and caused more friction – but anyway, that is how it worked! The tube used was a piece of 25mm copper pipe left over from a plumbing job.

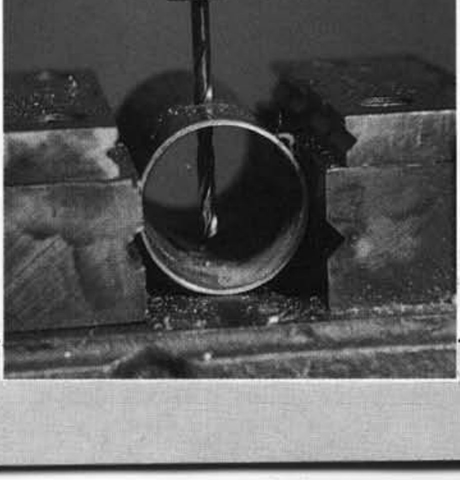
I started by cross-drilling it for the tube that was to form the jets. It was then mounted on a length of wood, machined to a good fit and secured with a wood screw through one of the jet holes. Facing the ends was a simple matter, but remember to support the length of wood on a tailstock centre.

End Caps

The end caps were made of brass. The bottom one in particular needed to be very thin, both to help reduce weight and to allow the heat through. Mount a piece of bar in the chuck and make a small centre mark; this only needs to be

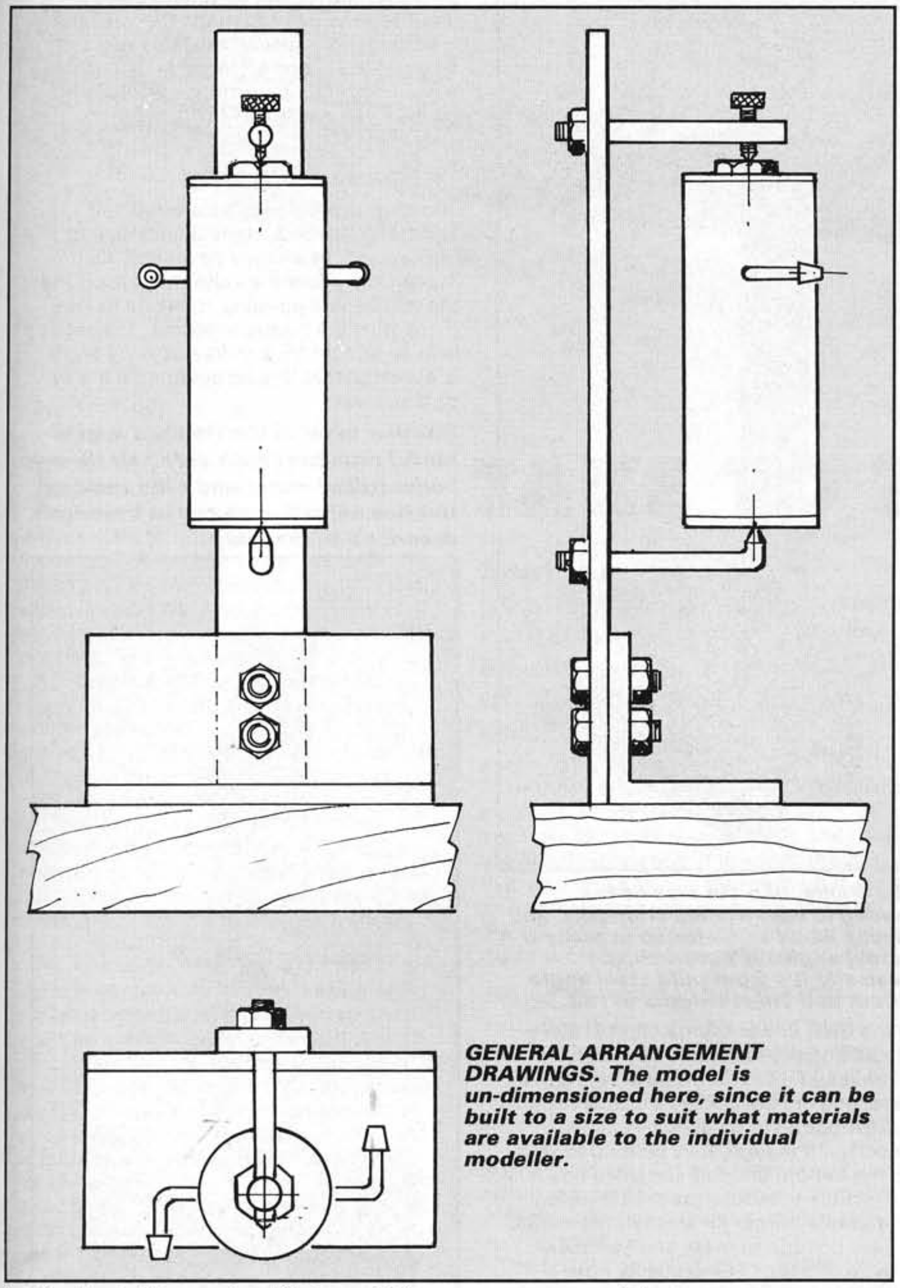


The completed engine.



Cross drilling the copper tube for the steam jets.

Copper tube mounted in the lathe on a wooden mandrel to face the ends.



GENERAL ARRANGEMENT DRAWINGS. The model is un-dimensioned here, since it can be built to a size to suit what materials are available to the individual modeller.

just touched with a centre drill since, if it is too deep, friction will be caused which will stop the machine from rotating easily. A lip can then be machined and this needs to be a good fit in the tube. The metal can be parted off at this point.

It is now necessary, for the sake of efficiency, to machine a recess in the base. If you have a good quality chuck or, better still, a suitable collet, then it will be possible to grip it by the tiny lip. If not, machine a recess in a piece of mild steel to accept the lip and drill a hole about a quarter inch diameter through the centre. Add just the tiniest touch of superglue and hold the cap with it. It should be possible to machine the recess and, with a smart tap from a rod bar, knock it off the holding piece. If too much glue has been used it might not come away, in which case heat the thing up and the glue will give way. Keep away from it as you do this, as a minute quantity of cyanide gas will be given off when it is heated. If time is not a problem leave it soaking in water for a day or so and again the glue will give way and the cap can be removed.

Top cap

The top cap is machined in a similar way to the bottom one but, in fact, has a hole right through it which is tapped whilst the work is still in the lathe, to ensure that the thread is square, as it must be. Machining a recess is not strictly necessary in this piece although it probably would help save weight. The matter is therefore left to the individual.

The filler

This is a simple screw to fit the cap and, although shown made of hexagon material, it could quite easily be made of round with a small knurl put on it. Having put on the thread, a centre is needed and again this has to be very tiny to avoid friction. Put a piece of scrap bar in the chuck, face it and then drill and tap to accept the filler screw which can be put in and centred.

Assembly

The next job is to silver solder the end caps in position. Start with the bottom one. Flux it well and push it in position then put it on a fire brick. Cut a tiny piece of silver solder and drop it inside the tube, making sure it is touching the wall. Heat the base up until the solder melts and flashes round the whole of the tube wall. The top one will have to be silver soldered from the outside and, again, should be well fluxed, then heated and just a touch of solder applied and allowed to run round the seat. It is almost inevitable that some will run where it is not wanted but try and keep it to the minimum.

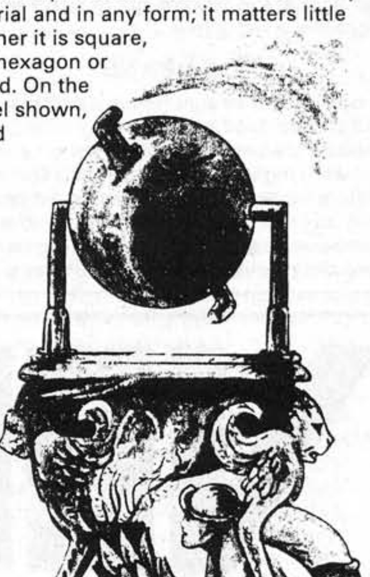
The jets

A single piece of tube is used as the arms for the jets and 3mm diameter will do nicely. File a vee notch around about the centre of the length to allow the steam to get in. Put it through the holes in the turbine body and adjust it so that the arms are evenly spaced. The notch is set to the top. The arms can then be silver soldered into place. In so doing the tube will soften. Put a piece of flexible wire in the bore and bend the arms to shape. I found that a slight angle down helped to give it a tiny lift and relieve what pressure there was on the bottom bearing.

The actual jets can be made from brass and are easy enough. Simply drill to accept the tube and then continue on for a short distance with a drill of about 0.3mm diameter or, say, a number 70. Put a fancy shape on if you wish although that is not important. Finally, silver solder the jets to the tube ends. Make sure the silver solder does not fill the hole; if you are in any doubt about this use soft solder, then if it does fill the hole it can easily be cleaned out with the drill.

Top arm

The top arm is a piece of bar with a screw thread on the end. This allows the bar to be adjusted as required to line the machine up. The arm can be made of any material and in any form; it matters little whether it is square, flat, hexagon or round. On the model shown, round



An ancient illustration of a version of Hero's engine; steam from the boiler (the animal on the left) passes to the spinning globe through its support pivots.

material was used for convenience and, where it is cross-drilled for the adjusting screw, was filed flat. Upon reflection there was absolutely no necessity for this and it could have been left in its original form.

The adjusting screw is simple enough. It is machined to a point of about sixty degrees and threaded to fit the arm. If one wished, the top could be knurled or slotted but, as little pressure is needed, there seems no reason to do so.

The bottom arm

The bottom arm can be made in the same way as the top one or the easier alternative is to machine a piece of thinner rod (which must be round) to a point and put a thread on the other end. Simply bend the pointed end at ninety degrees and the arm is finished. A third option would be to cross-drill the bar and insert a separate point made from steel about 3mm or 1/8th inch diameter. The bar can be cross-drilled and tapped for a grub screw to hold the pointed piece in position.

The frame

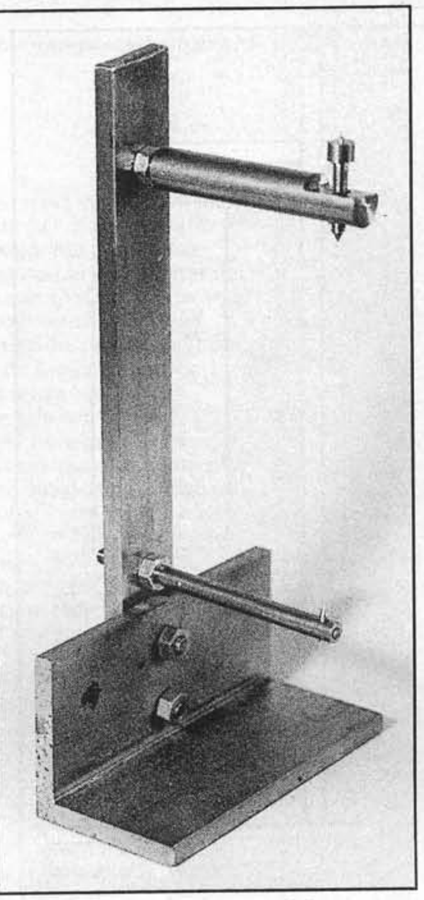
This hardly needs a description. Get a rough measurement of the distance the two arms will be apart when assembled and drill a piece of flat material on the centre line to accept them. Drill two holes for the screws to hold it to the angle which will support it. Clamp the strip to the angle and drill through, drill two further holes to accept the wood screws to hold it to the baseboard and that is it.

Adjustment

The adjustment of the contraption when it is to be steamed is all-important. Rest the turbine on the bottom point of the frame. Tighten the top screw until the turbine is stiff to rotate, loosen the screw half a turn and, hey presto, it is all set to go! Assuming, that is, you have thought to put in the water, which should roughly half fill it. If too much is put in it will work more like a water mill...

The heater

Making this is straightforward enough and should need no description. The engine I made will actually work on a standard night light but this soots the bottom up and it needs cleaning every time it is used. It will, however, generate some power and readers might like to consider making a model and entering it in the Gnat Power Competition at the Model Engineer Exhibition in 1994.



The frame, like the rest of the model, is constructed from bits and pieces likely to be found in many a model engineer's workshop. Basically it's from mild steel angle offcut and short lengths of rod.

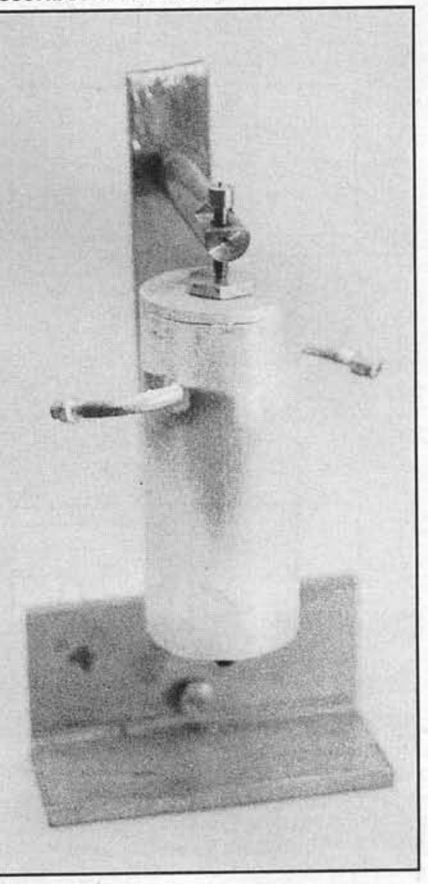
Tablets as used for picnic stoves can be used, and are advisable for safety reasons if the model is to be used by children. Once again though, they do tend to soot up the bottom and this can build up sufficiently to reduce the heat transfer. The simple burner for methylated spirits is easy enough to make and generally most workshops will probably have sufficient scrap material knocking about for the purpose. The canister can be a lozenge tin or something similar with a tight-fitting lid.

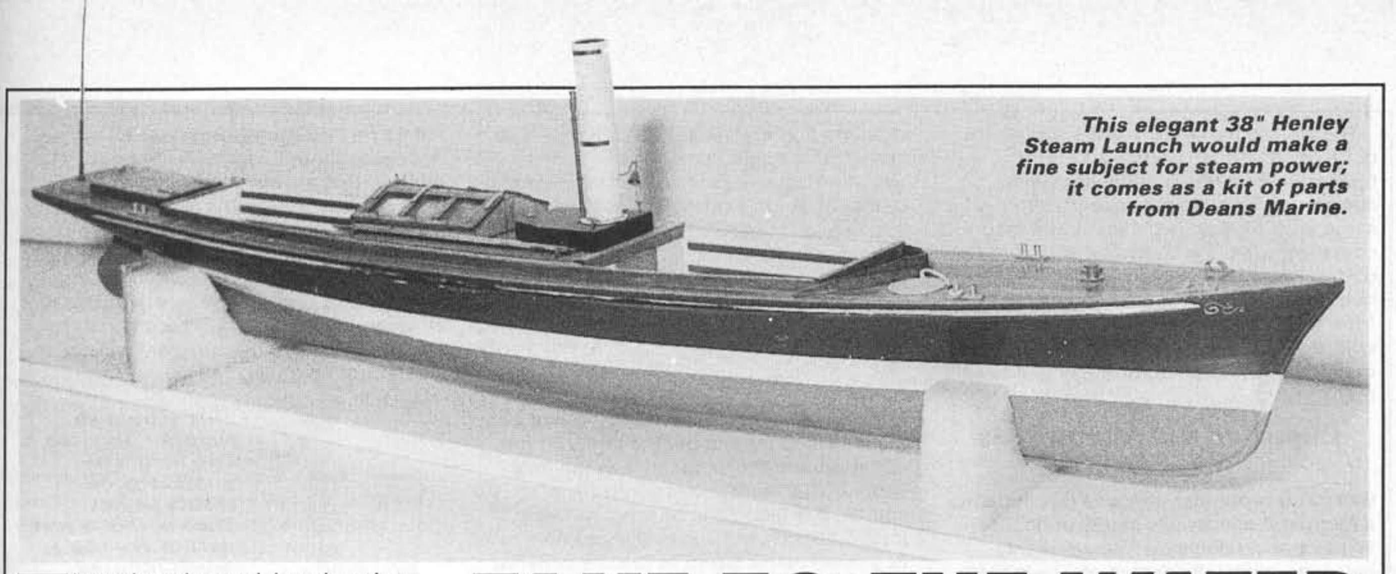
The tube for the spirit can be soldered in position as close to the base as possible. A wick will be required and I find bandage as used in the first aid box is quite good – special asbestos wicks can be purchase if one so requires. If a suitable lozenge tin cannot be obtained a canister can easily be fabricated from sheet brass.

Running

The engine must only be around half filled with water, and the adjustment to the bearing, as already described, then made. Just allow the water to heat up and the engine will possibly rotate on its own; if not, give it a nudge to start it. The secret is in an almost friction-free bearing and it is essential that this be obtained if it is to be a success.

Another view of the finished engine. Model runs best with only half the boiler full of water and after making the fine adjustments to the bearings described in the text.





This elegant 38" Henley Steam Launch would make a fine subject for steam power; it comes as a kit of parts from Deans Marine.

TAKE TO THE WATER

Boat modelling is a popular pusuit in its own right, but, for the model engineer, the application of steam power enhances the pleasure...

These days the model engineering interest in model boating appears to be limited largely to that of making steam plants to drive the vessels. For many years now the market has been flooded with a tremendous variety of kits which account for a large proportion of model boats made. These kits are usually of a very high standard.

If a complete kit is not purchased then, more often than not, a ready-made hull, either a styrene or fibre glass moulding, is generally available thus allowing would-be builders to dispense with much of the hard work. This does not mean that there are not still many very fine models made either directly from published drawings or from the builders' own observations, and, fortunately for the hobby, there are plenty of models made in this way each year.

Power plants

The use of steam to drive models has shown a remarkable increase in recent years and, whilst electrically operated models are still the most popular, there is sufficient interest in steam for there to be specially organised events for models so powered. This has also led to an increase in interest in model engineers making steam engines large enough to drive a full-sized boat – after all, such an engine is not all that big and can easily be managed in home workshops with the larger sized lathes.

Boilers for large engines can present problems and they would almost inevitably need to be of steel, if only because of the cost. To build a steel boiler it is essential to employ a qualified welder, known as a 'coded welder', and unless this is done it would be very difficult to obtain insurance.

The interest in petrol and diesel powered boats seems to have really plummeted. Probably it would be fair to say that not many enthusiasts built their own internal combustion engines anyway, but there have been some nice designs published. Making an engine is a most interesting project and there is a dedicated band of enthusiasts who enjoy doing so. It is possible to make the engines water-cooled and allow the water to syphon round the engine without the need for a pump.

One of the main reasons for the demise of the internal combustion engine in model boats has been the noise associated with it, as well as the exhaust and oil discharge. Some of this has been due to bad maintenance and carelessness for it *is* possible to run an internal combustion engine quite quietly if one wishes.

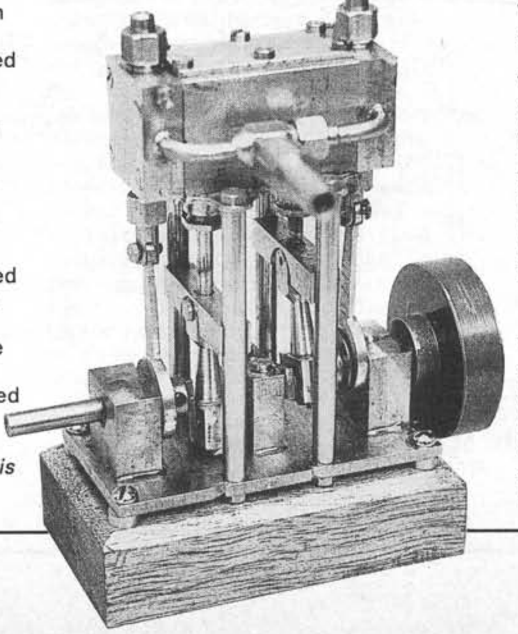
For those driving their boats with electric motors a whole range of gadgets are available to create sound effects and they are remarkably good. It is ironic, though, that with noise as one reason for *not* using an internal combustion engine, the quiet electric motor powered model should be made to create a noise electronically . . .

Power plant design

Assuming that we are not going to get involved in this issue in building a diesel or petrol engine for a boat, let us have a look at what we need to aim for with a steam plant. The engine, of course, needs to be large enough to provide the boat with a good amount of power. In fact, the power required to drive a boat is remarkably small and so engines need not take up a lot of space.

The boiler size will depend on two things – the amount of steam the engine consumes and the length of sailing time required. If we take the first point it means that the engine should be made to the minimum size practical for the size of hull and should be as free running and efficient as it can possibly be made. The second requirement is that the engine must be self-starting if the boat is to be radio controlled. In general this will rule out a single cylinder engine except where it is to be used for straight running.

A simple two-cylinder launch engine designed and built by the late Ted Turner.



Boilers

The larger the boiler the longer the period it will run without re-filling but, for obvious reasons, it cannot be made too large as it will spoil the appearance of the model. A compromise must be sought. The design of the boiler is also important. A simple tube sealed at each end with holes for safety valve and steam take off will work but it is far from ideal and certainly not the most efficient thing to use.

Again, to some extent, the material from which the boiler is made will have an effect. If the copper used (and *only* copper is recommended for model boilers) is too thick then heat will be lost and there will be a lack of efficiency. This means that the shell of the boiler must be as thin as possible WITHIN THE LIMITS OF SAFETY.

One way to increase the efficiency of the boiler is to allow the heat source to work on smaller diameter tubes containing water, known, for obvious reasons, as 'water tubes'. These will heat up quicker and more efficiently than the larger barrel with the result that heat will be saved and a longer running time can be expected.

There are several ways of using water tubes, the easiest being simply to run two or three along the base of the boiler. Another way to increase heat, although not quite as great an increase as the water tube, is to have flue tubes. This simple means tubes along which the heat can pass and give a greater overall area of heating than the shell alone. Probably better still is a combination of the two.

Heat

The heat for a boiler can come from a variety of sources. Methylated spirits is a popular form and is without doubt easy to use as well as being quite efficient. Unfortunately, burners for this type of fuel are now not available commercially because of the danger of spillage.

The alternative is fuel tablets. These are quite good and are particularly to be recommended where youngsters are concerned. They do not seem to supply the same level of heat as the spirit and tend to coat the surface being heated with a form of dirty wax. This in itself will insulate the boiler from heat and so it must be removed from time to time. Unlike methylated spirits where a special burner must be designed, the tablets will burn quite safely in a simple tray.

Liquified petroleum gas (LPG)

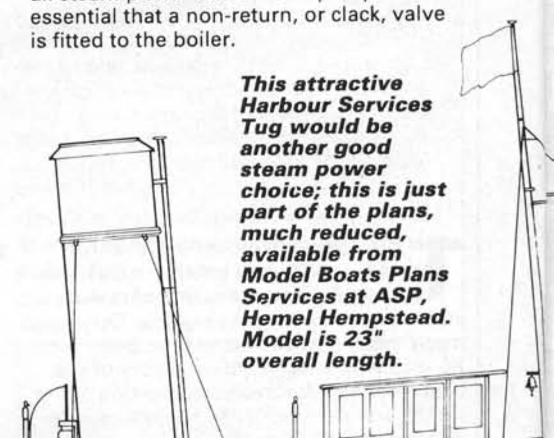
Gas firing is popular now and it is certainly a method that supplies plenty of heat. When making one's own steam plant, however, whilst the design of a burner for liquid petroleum gas is easy to make and design, a suitable container for the gas is another proposition. It must be designed to hold the pressure of the gas and needs also to be tested to ensure safety.

The method of filling it also needs to be safe as well. Needle type fillers as used on cigarette lighters are available and can be used, this probably being the best method. The alternative is to adapt a standard small cylinder but, unless one really knows what it is all about, there is a high degree of danger involved. The gas is heavier than air in its liquid form and if it leaks it will lie in the bottom of a boat for a white and could ignite with pretty disastrous results . . .

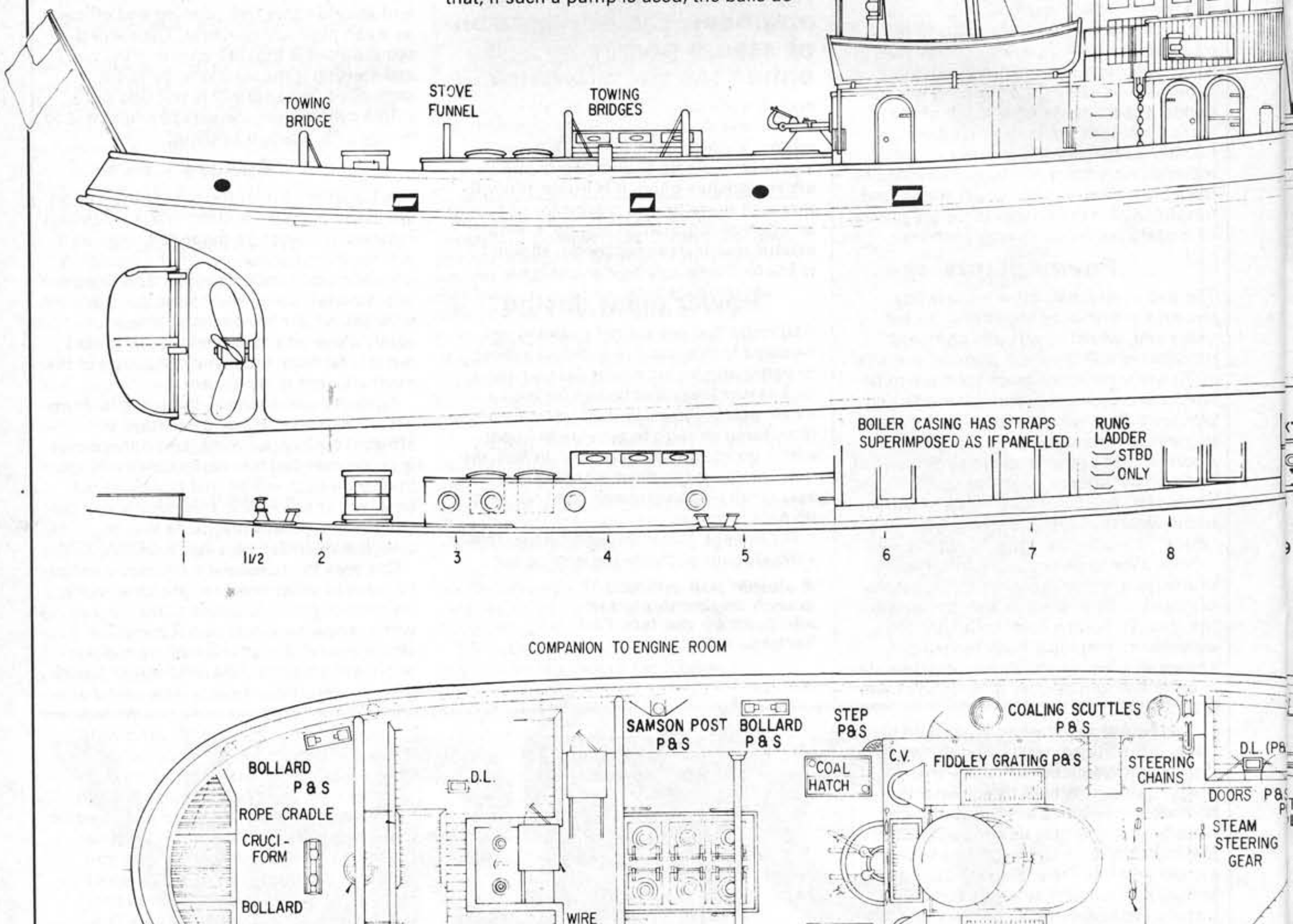
Water supply

Most boats work off one fill of a boiler and the idea is to try and get the boiler to run out at around the same time as the heat supply. This works quite well and, of course, it is best if the heat is finished a fraction before the water. It is possible to fit a small water pump to top the boiler up as the boat is in use. Such a pump will normally be mechanically driven via the engine, although on larger boats it could be steam operated, such as a Duplex.

Most mechanical pumps will work with a ram and two non-return valves which are sealed with ball bearings. It is essential that, if such a pump is used, the balls do not come into contact with any oil as this will cause them to stick. It is not generally realised that a simple water pump for a boat can be made in the form of an oscillating engine. Simply drive the piston rod from the engine and connect one side to a water supply. The water will pump through and keep the boiler supplied. On all steam plants fitted with a pump it is essential that a non-return, or clack, valve is fitted to the boiler.



This attractive Harbour Services Tug would be another good steam power choice; this is just part of the plans, much reduced, available from Model Boats Plans Services at ASP, Hemel Hempstead. Model is 23" overall length.

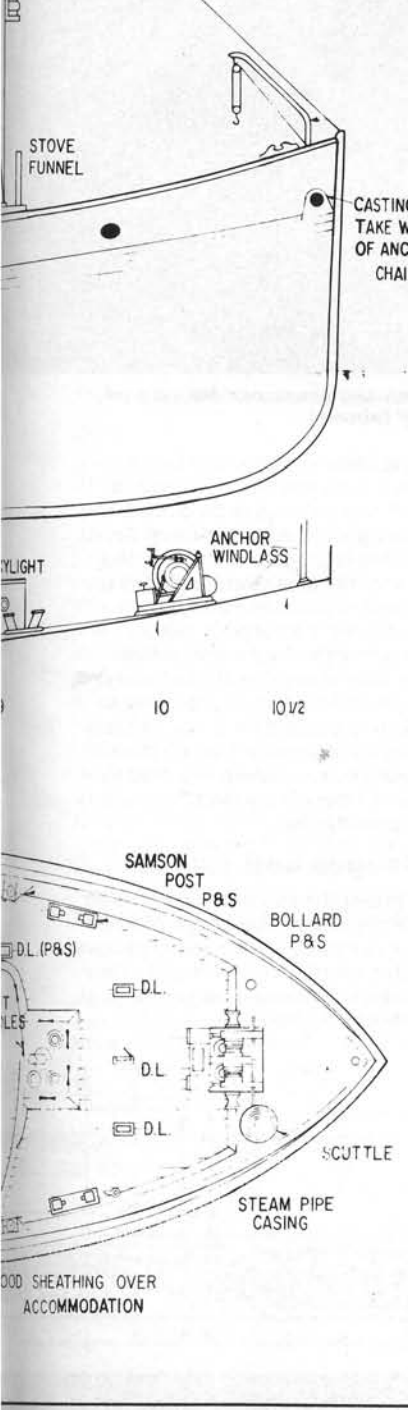


Engine design

The simple oscillating engine is probably as good as anything when it comes to driving a boat. Properly designed it is quite efficient, needs virtually no maintenance and is fascinating to watch. It can be made in various forms, from a single to multi-cylinder engine. Much will depend on the type of boat in which the engine is to fit; if it is a tug or similar vessel with a superstructure, then the appearance of the engine will matter little and the oscillating engine is ideal.

For an open boat things need to be a little different. A well-designed two cylinder oscillating engine will not look at all wrong but for those seeking more realism something a bit more authentic is needed. True, older boats in full-size had oscillating engines but these worked on a different principle to those we generally associate with models, a twin cylinder slide valve engine or a similar piston valved one being the ideal thing.

Two more from the popular Deans Marine range of kits. At top is their 28" RAF Pinnace and above their 27.5" SS Furie tug. The latter would be a good subject for steam power while the former would be best as an electric-powered model. There are many similar kits available and scores of plans...



For larger boats there is no reason why the engine should not be a three cylinder version. It may be possible to use a form of compounding – this means using the exhaust steam from the high pressure cylinder to drive a second cylinder. The idea works well and saves steam.

Boiler-making

The design of boilers has been touched on but consideration should be given to the actual construction. The copper must be of sufficient thickness to provide the strength needed. Joints should be silver soldered, and all bushes and fittings should be made of bronze. Brass will literally disintegrate after a period of use, this being caused by the leaching out of the zinc which is one of its components.

A safety valve must be fitted and either a water gauge or two cocks to allow the height of the water to be gauged. If possible, fit a pressure gauge as well. Pressure gauges should always be fitted via a syphon to avoid damage to the gauge. The boiler when made must be pressure tested, not to find leaks but to see if it is safe. A leak in a boiler matters little as regards safety, although it will not help when it comes to maintaining pressure.

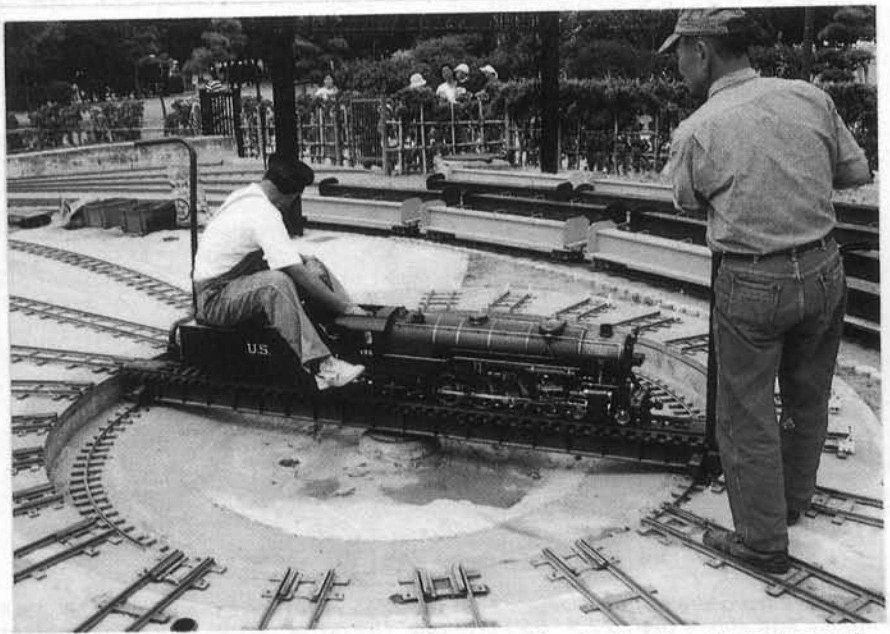
The boiler should be maintained for at least half an hour. Pumping may be used to keep the pressure up if need be. At the end of this time the boiler should be examined to see if it has bulged at all. If it has then it should be discarded as dangerous. If a seam has opened (as sometimes happens) then there is no reason why this should not be re-sealed with silver solder and the boiler re-tested.

When you are satisfied with the strength of the boiler half fill it with water. Use a blow lamp or similar flame to heat it and maintain it again at twice the working pressure. Take care not to overdo it as it is all too easy to get the pressure too high. If it has not bulged or had seams open up then it can be considered as being right.

It is at this stage that leaks are most likely to appear. Whilst they do not affect safety the boiler will not be very efficient unless they are sealed, using the same grade of silver solder as was used originally. The safety valve should be put on and adjusted against the gauge to release pressure as required. If possible it is always advisable to fit two safety valves in case one should fail. Boilers in model boats do not need excessively high pressure for successful working – indeed, if a very high pressure is used it is doubtful if any great advantage will be obtained and around forty or fifty pounds per square inch should be about the maximum to aim for.

There is no reason why a steam plant cannot be radio controlled, one servo fitted to the steam supply regulator and one to the reversing mechanism is enough. In the case of oscillating and piston valve engines it is possible to combine reverser and regulator and then only one servo will be required for the driving of the boat, the second being available for steering.

STEAMING ALONG



A scene from Japan where people are just as enthusiastic about building and running model steam locomotives as they are in the UK.

And much the same can be said of Germany (above).

The perennial joys of steam locomotives are as much in evidence in small scale as they are in full-size and it's not hard to understand why they make such popular models

The building of model locomotives would seem to be by far the most popular aspect of model engineering, if surveys taken in *Model Engineer* are an accurate reflection of readers' interests. The figures shown in those surveys are amply borne out by the number of castings and drawings sold by the model engineering suppliers. Let us therefore take a look at what is involved in the building of such models and what makes them such firm favourites.

It would be impossible to give readers a comprehensive list of how many different designs are available - many suppliers market designs specifically prepared for themselves and it would thus be inevitable that some models would be missed out. There are however a number of designs that are available from a variety of sources and, undoubtedly, these are the ones most frequently made.

Generally speaking if one wishes to build a model locomotive then a set of drawings will be required, a certain amount of basic metal and some castings. How many castings will depend on several things. Firstly the design chosen, secondly the skill of the builder, who may feel that certain parts can be fabricated rather than cast, and thirdly on the money available to buy what is required. Generally, castings work out more expensive than fabrications and a considerable amount of money can be saved if items are fabricated.

Designs

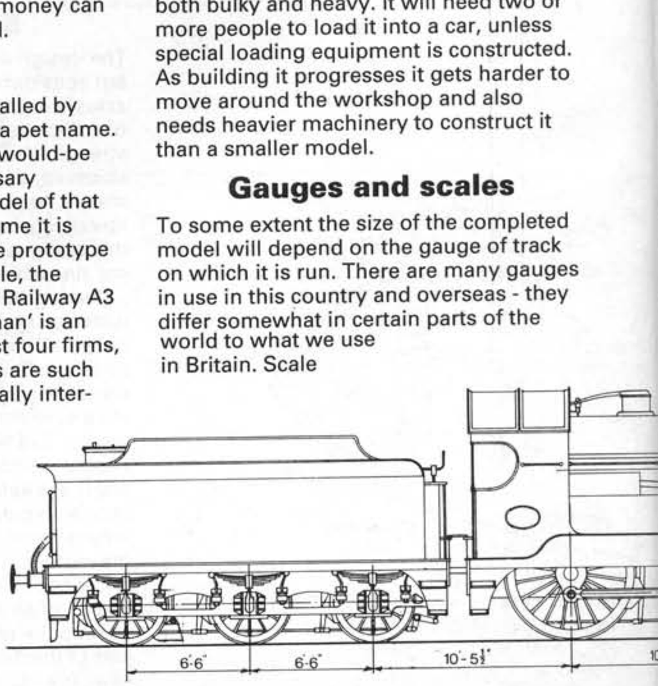
Many model locomotives are called by what can only be described as a pet name. This has its advantages as the would-be purchaser can order the necessary material appropriate to the model of that name. If instead of having a name it is called by the designation of the prototype it can be confusing. For example, the popular London North Eastern Railway A3 pacific of which 'Flying Scotsman' is an example is marketed by at least four firms, in various gauges. The designs are such that the castings are not generally interchangeable.

It is therefore essential that potential builders obtain the castings and drawings from the same supplier in order to make the model. Where we get named models such as 'Rob Roy', 'Simplex', 'Titch\, etc., then, generally speaking, suitable castings will be obtainable from a number of suppliers.

There are many things to be considered when building a model locomotive. An important one is the size of the finished model. If a lot of passenger hauling is to be done there is much to be said for a large size. It must be borne in mind, though, that the finished model will be both bulky and heavy. It will need two or more people to load it into a car, unless special loading equipment is constructed. As building it progresses it gets harder to move around the workshop and also needs heavier machinery to construct it than a smaller model.

Gauges and scales

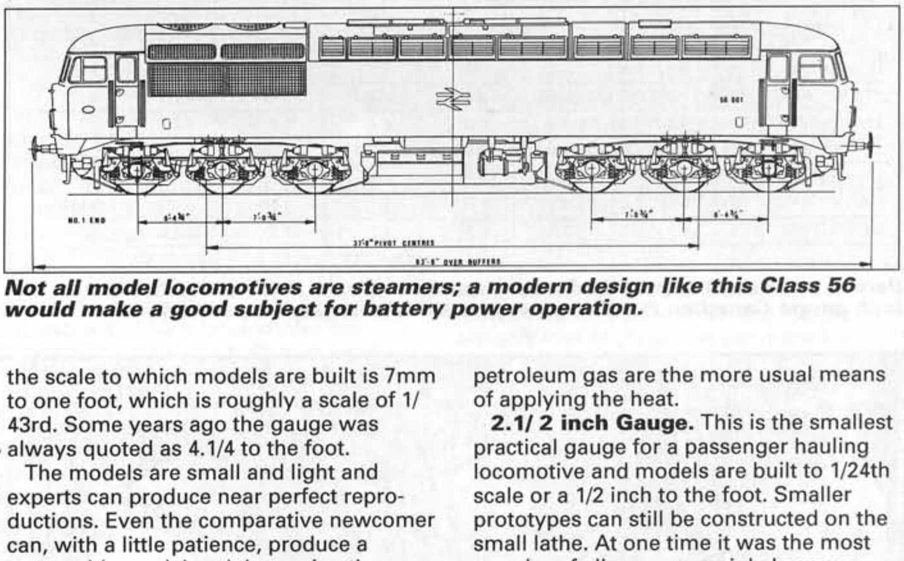
To some extent the size of the completed model will depend on the gauge of track on which it is run. There are many gauges in use in this country and overseas - they differ somewhat in certain parts of the world to what we use in Britain. Scale



French model engineer Francois Laluque driving his 7.1/4 gauge locomotive with a happy load of young passengers.

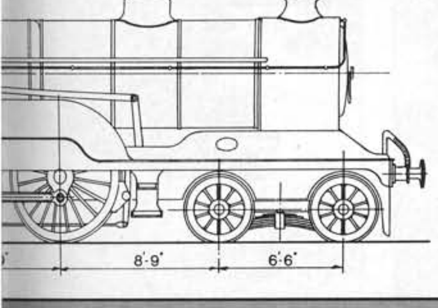
goes with the gauge but these days people do build narrow gauge models and these work out considerably larger for a given gauge than would the standard locomotive - this in spite of the fact that the original prototypes were smaller than standard gauge engines. Some of the smaller gauges are used only for scenic railways where the problem of bulk and weight does not arise. It is also, of course, very much cheaper to build these small models.

Let us have a look at how the gauges work out. **'0' gauge** is usually normally used only for scenic railways and, although some years back successful attempts were made to build locomotives that would haul a passenger, this is hardly a practical proposition. The gauge (distance between the rails) is 32mm, and



Not all model locomotives are steamers; a modern design like this Class 56 would make a good subject for battery power operation.

Ideal for miniaturisation; this neat outline locomotive would make a very pleasing model.



the scale to which models are built is 7mm to one foot, which is roughly a scale of 1/43rd. Some years ago the gauge was always quoted as 4.1/4 to the foot.

The models are small and light and experts can produce near perfect reproductions. Even the comparative newcomer can, with a little patience, produce a reasonable model and they enjoy the added advantage of being able to be constructed on the smaller lathes. Usually steam driven models will be fired with methylated spirits or liquid petroleum gas, but there are a number which are coal fired.

Gauge 1 relates to models running on a gauge of 45mm or 1.3/4 inches and built to a scale of 10mm to the foot, or approximately 1/30th. The gauge is invariably used for scenic railways and is highly suitable for the model engineer with a small workshop. Steam models are often coal fired, but methylated spirits or liquid petroleum gas are the more usual means of applying the heat.

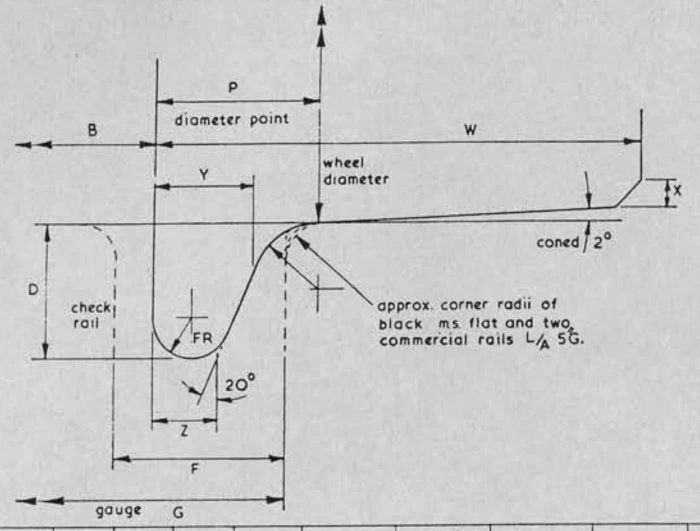
2.1/ 2 inch Gauge. This is the smallest practical gauge for a passenger hauling locomotive and models are built to 1/24th scale or a 1/2 inch to the foot. Smaller prototypes can still be constructed on the small lathe. At one time it was the most popular of all gauges, mainly because models could be transported easily to a track, and there is still a considerable interest in the gauge.

Gauge 3. This is another name for 2.1/2 inch gauge and is used when the railway is entirely for scenic purposes.

3.1/2inch Gauge. In this class, locomotives are modelled to a scale of 3/4 inch to the foot, are almost invariably steam models and are coal fired. Smaller prototypes are still compact enough to handle easily but larger ones are quite bulky. The gauge is quite suitable for passenger hauling and even the smallest

TABLE OF GAUGES AND SCALES						
Gauge		Scale			Conversion Factor	
Ins.	m/m	Ins. per foot	m/m per foot	m/m per 100 m/m	A.	B.
2½	63.5	17/32	13.50	4.43	1.124	22.59
3½	89.0	3/4	19.05	6.25	1.587	16.00
5	127.0	1 1/16	26.99	8.85	2.250	11.29
7¼	184.0	1½	38.10	12.50	3.175	8.00
9½	241.0	2	50.80	16.67	4.233	6.00
10½	260.0	2¼	57.15	18.75	4.763	5.33

The S.M.&.E.E. Recommendations för Model Railway Gauges and Scales.



Gauge	Back to Back	Tyre Width	Flange Depth	Root Radius	Flange Radius	Chamfer	Tread Diameter Point	M/c[g] Dimension	M/c[g] Dimension	Flange Way
G	B	W	D	RR	FR	X	P	Y	Z	F
2½in	2.281	0.268	0.085	0.035	0.020	0.015	0.090	0.055	0.034	0.125
63.5m m	58	6.8	2.2	0.9	.50	.40	2.3	1.4	0.90	3.2
3½in	3.281	0.375	0.110	0.050	0.030	0.020	0.126	0.076	0.051	0.130
89m/m	83	9.5	2.8	1.3	.75	.50	3.2	1.9	1.3	3.3
5in	4.687	0.535	0.140	0.070	0.045	0.030	0.176	0.106	0.077	0.190
127m/m	19	13.6	3.6	1.8	1.2	.80	4.5	2.7	1.95	4.8
7¼in	6.800	0.776	0.203	0.100	0.065	0.040	0.245	0.154	0.110	0.270
184m/m	172	19.7	5.2	2.5	1.7	1.00	6.4	3.9	2.8	6.9
9½in	8.900	1.017	0.266	0.133	0.086	0.050	0.336	0.203	0.146	0.350
241m/m	225	25.8	6.8	3.4	2.2	1.30	8.5	5.15	3.7	8.9
10¼	9.600	1.097	0.287	0.144	0.093	0.060	0.363	0.219	0.158	0.380
260m/m	244	27.8	8.0	3.7	2.4	1.50	9.2	5.55	4.0	9.7

Below, a scene at a track in Canada; model engineer Bob Pare with a 3.1/2 inch gauge Canadian Pacific railways 4-8-4. Photograph by Noel Tyler.

models will usually pull at least two adults.

4.3/4 inch Gauge. This gauge is usually used on the North American continent. Models are made to a scale of 1 inch to the foot or 1/12th. All models are on the bulky side and can be quite powerful; most are coal fired but the use of oil and liquid petroleum gas is also quite common.

5 inch Gauge. Originally models for this gauge were built to a scale of 1 inch to the foot. More recently they are 1.1/16th inch to the foot which works out at a rather odd eleven and a bit scale. The models are good passenger haulers and the gauge is very popular. Most steam models are coal fired.

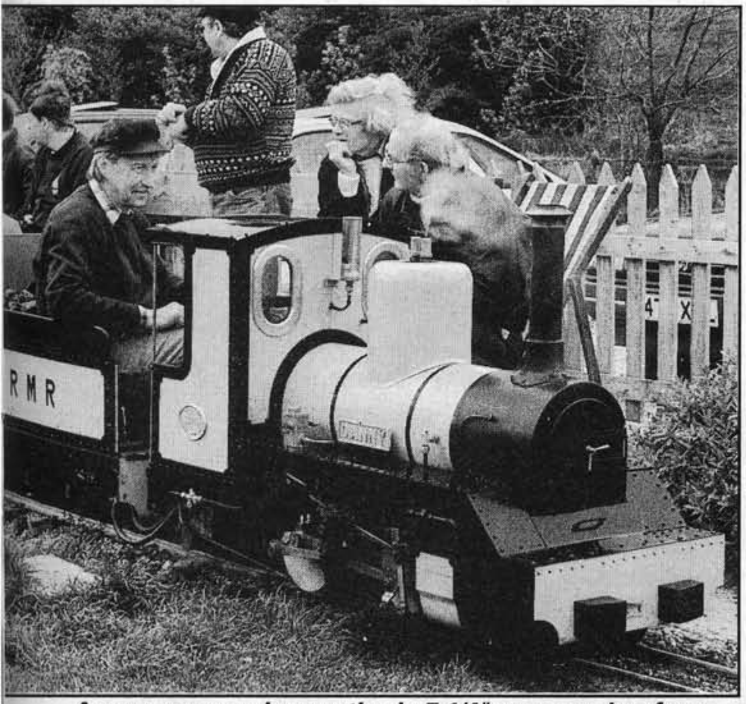
7.1/4 inch Gauge. Models are built to a scale of 1/8th or 1.1/2 inches to the foot, and are big and bulky, usually requiring at least two people to handle them. It is a popular scale amongst the enthusiast who likes hauling passengers and steam powered models, in Britain at least, are usually coal fired.

7.1/2 inch Gauge. Again, a gauge usually found in North America. Models are built to the same scale as those running on 7.1/4 inch gauge track.

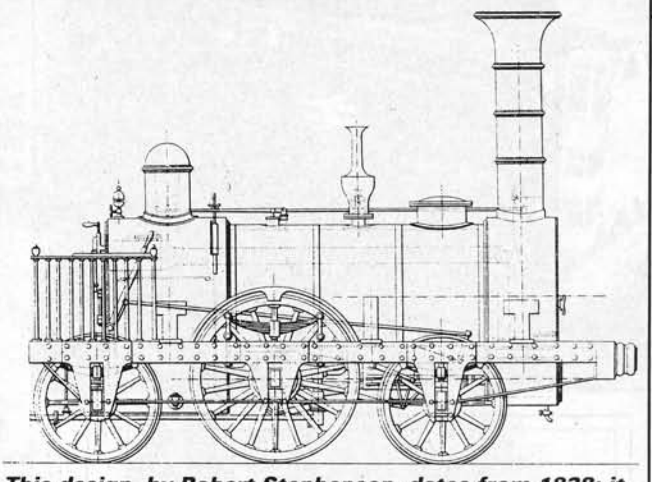
Narrow Gauge models

It is somewhat difficult to deal precisely with scales when it comes to narrow gauges. The originals ran on a variety of gauges from 15 inches upwards to 3 feet 6 inches. If we accept the fact that generally the models will run on one of the gauges listed above, then it becomes obvious that a model of a locomotive for, say, a 2 foot gauge railway will have to be of a different scale to one of a 3 feet 6 inches gauge track, assuming both are to have the same model gauge.

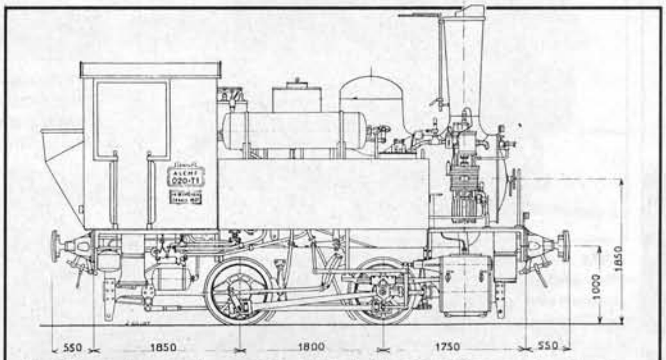
It is possible to offer a degree of generalisation though, and, in the smaller scenic or garden railways, set standards of scale are available. **SM 32** relates to models built to a scale of 16mm to the foot running on "0' gauge track. This more or less assumes the original prototype to have been a 2 foot gauge locomotive, which is the most common narrow gauge in this country. However, if a model was made of a prototype of a larger gauge engine, still to run on '0' gauge track, then it might be desirable to change the scale



A narrow gauge locomotive in 7.1/4" gauge makes for a very large model.



This design, by Robert Stephenson, dates from 1838; it would make an unusual model subject.



And here's another; this delightful 0-4-0 is typical of the sort of locomotive found on rural tramways in France and Belgium between the wars.

to which the modelling is done.

SM 45 relates to models made in a scale of 16mm to the foot but now running on gauge 1 track. This allows for, say, a three feet gauge original to be built and use a suitable track whilst keeping the 16mm scale. Again readers wishing to be more correct to scale might like to make some alteration from the 16mm.

Narrow gauge models on the gauges from **2.1/2 inch** to **7.1/4 inch** will again vary in scale according to the prototype. For example, a two foot gauge original to run on 2.1/2 inch gauge track would be to a scale of just under 1/10th, as against the 1/24th of a standard gauge model. A model running on 3.1/2 inch gauge track could well be to a scale of around 1/7th as against 1/12th.

So we are looking at near enough double the size of locomotive for a given gauge when using narrow gauge prototypes. This means that, when we get to 7.1/4 inch gauge, the models work out at nearly a third full-size on occasions. This sounds very large and indeed it is and such models usually have sufficient room for the driver to be able to sit in them! However, it must be kept in mind that the original locomotives were smaller overall than standard gauge prototypes and so things are not quite as bad as they seem

A typical scene in the United States where a very fine model 'Big Boy' cruises round the extensive track.

Foreign prototypes

The modelling of foreign prototypes is rightly popular but here again we come up against difference in sizes of finished models. Most overseas railways had a larger loading gauge than this country which means, basically, that tunnels, bridges, etc., were higher and wider, allowing both locomotives and rolling stock to be built larger than those in the U.K. Models of such locomotives will therefore, even though built to the same scale as a British type, be quite a bit larger.

Then there were differences in gauges with overseas railways. The British gauge was 4 feet 8.1/2 inches; this applied to many countries but some (and only a few examples can be given) differed. Ireland, for example, had a wider gauge than we did on the mainland. South Africa had a gauge of 3 feet six inches and Russia at one stage operated a number of different gauges. These facts must all be taken into account when deciding on which model to build.

The prototype

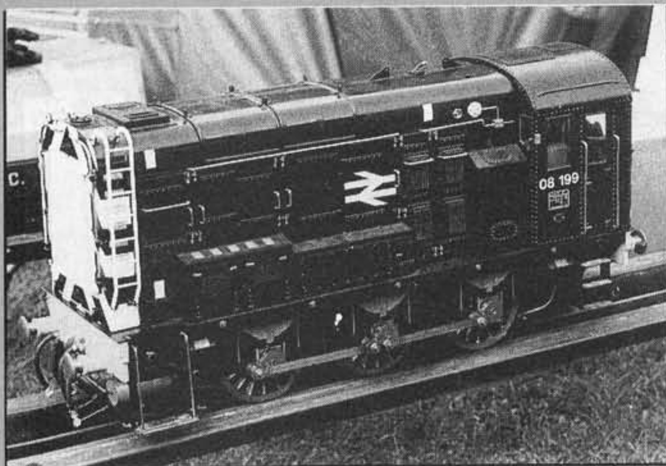
The prototype chosen for our model will have a bearing on the final size of the completed model, a fact that is quite obvious to all readers, I am sure! What then are the advantages of building a certain type of model. Undoubtedly, most readers will be familiar with the way that we in Britain classify the steam locomotive - we use the wheel arrangement. The small wheels supporting the front end are counted first, the larger driving wheels next, and then the trailing wheels.

If we take a locomotive with four wheels at the front, six driving wheels and two trailing it is classed as 4-6-2. If there are no wheels at the rear it is a 4-6-0, and if there are no wheels at the front or rear an 0-6-0.

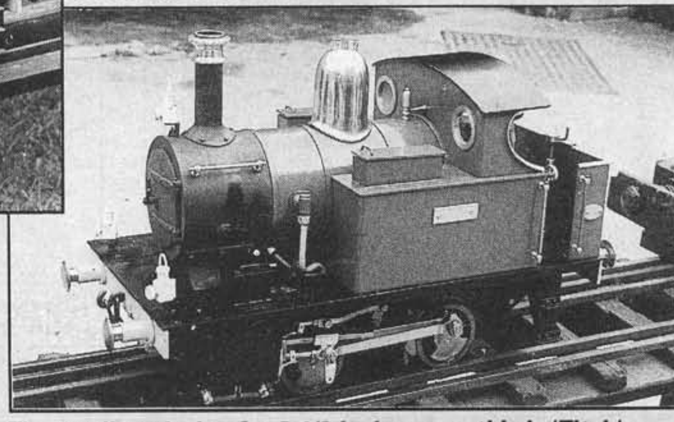
On the continent things work differently and the classification is by the number of axles. For example, the 4-6-2 becomes a 2-3-1 and the 0-6-0 an 0-3-0. The more wheels, then almost invariably the longer the locomotive will be. So if we are looking for something small and not too complicated the answer is to select a model with only driving wheels. If there are only four of these that will make life easier still!

A model built with just four or six driving wheels will work perfectly well and quite possibly pull as many passengers as one with the smaller carrying wheels. The small wheels at the front and rear are mainly used to support the ends of the locomotive and stop it running with a pitching movement when speed is increased. The front wheels are also a means of guiding the engine into curves; they are carried in a separate truck known as a bogie if it has four or more wheels and a ponie if there are just two. They support the front end as well as preventing the pitching motion referred to - they swivel and move sideways as a unit and so make a smoother ride.

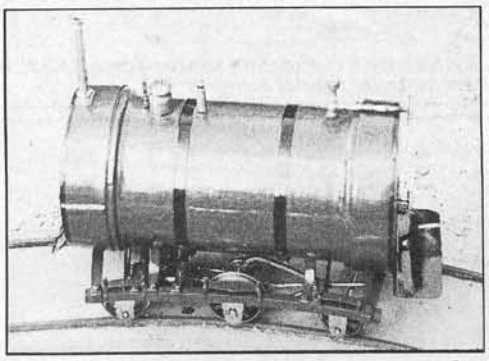
The small wheels at the rear on the full-sized engines would probably not have had a great deal of sideways movement, although there would have been some. Their main job was to support the rear of the engine and again prevent it pitching - particularly when the throttle is opened



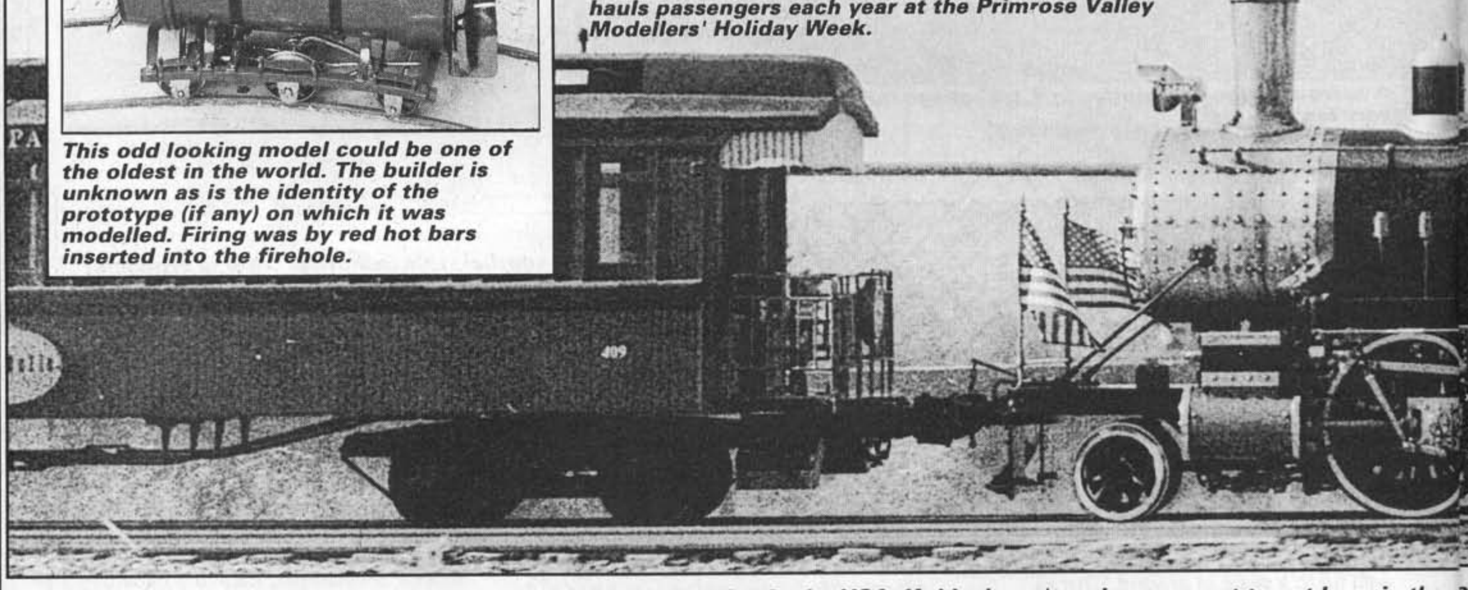
Built to a design by Blackgates Engineering, this 5 inch gauge model of a BR 08 type diesel shunter (left) has had a considerable amount of extra detail added by the builder.



The smallest design for 3.1/2 inch gauge, this is 'Titch', a very popular model, especially with beginners. This one hauls passengers each year at the Primrose Valley Modellers' Holiday Week.



This odd looking model could be one of the oldest in the world. The builder is unknown as is the identity of the prototype (if any) on which it was modelled. Firing was by red hot bars inserted into the firehole.



A lovely study of model steam locomotive building and operating in the USA. If this doesn't make you want to get busy in the wor

particularly when the throttle is opened the front of the engine is inclined to lift and the rear wheels smooth out some of this effect.

The action of these wheels is fairly faithfully reproduced on a model and, so apart from the desire to reproduce an actual prototype, the number of wheels needs to be considered. With front and rear carrying wheels the locomotive will ride smoother and on a long continuous track this can be an asset. Our simple engine with just driving wheels will, however, behave perfectly well and is quite suitable in model form for most tracks. It is a sensible choice if the potential builder is looking for simplicity of construction.

There are one or two other points worth considering - like whether, for example, to build a tank or a tender locomotive. There is little doubt that there is less work in making a model of a tank locomotive. In fact, when the locomotive has been constructed and a tender still needs to be built, it can be an especially daunting project!

As far as driving is concerned then it will depend largely on the size of the model chosen and the type of track it is to be used on. If the track is raised on pillars it can be difficult to lean across the tender of a 5 inch gauge model in order to get at the controls; leaning on the tender can cause derailments. With a 3.1/2 inch gauge model the reach is not so great. This is not a consideration in the case of a tank locomotive.

If a ground level track is in use then it is possible to construct the tender for a five inch gauge model strong enough for the driver to sit on it, and with 7.1/4 inch gauge models this is invariably done. Getting at the controls of a 3.1/2 inch gauge model on a ground level track can be, to say the least, a little tricky but many manage it quite well.

The larger the model the easier it is to drive and a tender locomotive can usually be driven further without stopping for re-fuelling than a tank engine. The smaller models, such as those of 2.1/2 and 3.1/2 inch gauges, need much more attention whilst being driven; to some this is seen as an advantage since part of the pleasure is in overcoming the difficulty of keeping a little model going.

The final factor influencing the choice of model to be built will inevitably be a matter of personal preference. The locomotive that appears good looking to one person may seem entirely different to someone else; the points set out above at least give the reader something to consider when making that choice. But let us progress a little further by thinking of the construction of the model.

Construction of locomotives

Whatever the scale the locomotive will need a frame. This is usually cut from sheet steel and supported at each end with a buffer beam held in place with small pieces of angle iron. More often than not a support is placed somewhere along the centre of the frames in the form of a spacer. Some Continental and North American prototypes have what are called 'bar frames'. These are much heavier than the plate type being several times thicker.

Whatever the type chosen, except on small models, the axles run in axle boxes

A scene near Toronto in Canada where locomotives await the chance to operate on the track of the Richmond Live Steamers. Photograph by Noel Tyler.

rkshop, nothing will! Photo: Angus Davis.

which slide up and down gaps in the frame supported by horn blocks, and controlled by springs. These horn blocks are either castings or fabrications from steel. The front end of the frames hold the cylinders which may be inside or outside the frames depending on the type of locomotive modelled. The wheels are keyed on to the axles in such a way that the crankpins will be at ninety degrees to each other with a two cylinder locomotive. Connected to the pins will be the rods which couple the driving wheels together and, if it is an outside cylinder engine, one will also carry the rod connecting the crank to the cylinder.

If the cylinders are inside then this will be fitted to a crank axle. The valve gear to drive the cylinders may be outside or inside the frames depending on the type of gear chosen.

The boiler sits on top of the frames and is connected to the cylinders via a regulator valve, and at the front of the boiler is the smokebox which contains the exhaust pipe and an opening for the chimney. The boiler also carries the safety valves and a steam dome from which the steam is collected to go via the regulator to the cylinders.

The superstructure depends on the prototype but will, in the case of a tank engine, include the tanks. These in turn will probably house a hand pump for putting water in the boiler. A mechanical pump is frequently fitted between the chassis, driven by one axle. The cab is just cut to shape as per the design and purely acts as a cover for the back end of the boiler.

On most models the practice is to make part of the cab removable to enable the driver to get to the controls. If a tender is required, this will hold water and fuel and will almost certainly house a hand pump.

There are, of course, more bit and pieces but at least the foregoing gives some idea of what making a model is all about. There is no doubt that modelling a locomotive is a highly satisfactory occupation no matter what size replica will be.

Of course, all the foregoing relates to model steam locomotives. Many younger people do not wish to make models of machines which they have only seen in museums and prefer to build models of diesel or electric engines. Construction of such models is usually considerably simpler than making a steam locomotive. As a general rule the motive power will consist of an electric motor running on a battery or perhaps a small internal combustion engine taken from a lawn mower or something similar. Only very rarely do we see models where the actual power unit itself is made by the builder.

The building of these models can have its own problems. Suitable gearing and control units are required for the electric motor and fitting the internal combustion engine also involves sorting out a fuel tank, etc. Many models do not have a frame as does the steam engine, but run instead on a girder frame fitted with two bogies.

For whatever reason, be it one of relative simplicity when compared to the live steamer or the fact that the full-size are familiar sights on the railways of today, there is little doubt that the building of such models is increasing in popularity.

A SIMPLE BOILER

Boiler making need not be a black art but it does require special techniques. The advice which follows should offer encouragement for beginners...

Perhaps the heading of this chapter is a little misleading; whilst boilermaking is not difficult it does require a little knowledge and a certain amount of equipment. IT IS ESSENTIAL THAT A BOILER IS SOUNDLY MADE – a poorly made boiler can be dangerous.

Materials

The material specified should be used and under no circumstances use brass. Whilst at one time boilers were riveted and soft soldered and there is nothing wrong with a properly constructed one, the making of such a boiler requires considerable skill and so the use of silver solder is suggested. Johnson Mathey Easy Flo No 2 is ideal as it does not require too much heat and flows well.

It should be possible to make the boiler with two decent DIY type blowlamps providing the thing is well packed. For packing it is essential to use a refractory type firebrick. These can be obtained from dealers in jewellery making equipment or telephone your nearest brickworks and explain what is required. They will be able to give the name of your nearest stockist.

A refractory brick is one which glows when heated and reflects the heat back; do not be tempted to use ordinary firebrick as this just absorbs the heat and will prevent proper temperatures being reached. A solution of citric acid will also be needed. Get a small tub from your local wine making supplier, put a handful in a bucket of water and allow it to dissolve.

Flange plates

A start should be made with the flange plates that fit in the ends. This gets the less experienced user to the temperatures involved. Make a former in the lathe from a piece of round bar, radius the edges and make sure that it is sufficiently undersize for the tube to allow the plate to fit in when completed. Cut two pieces of copper sheet allowing a flange of about 10mm. Heat the sheet to a bright red colour and quench it in a bucket of water.

Put it and the former in a vice giving some protection to the copper from the serrated jaws. Tap round and start off the bend. Do not try to get one part right over, just do a little at a time right round the circumference. It will not go very far before it gets hard. Don't try to force it – heat it again and carry on. It will probably take at least four heatings to get it right round and for the less experienced might take six. File the edges round when the hammering is finished and drill the holes for the bushes.

The chimney

This can be put anywhere along the boiler to suit the job it is being made for. There is no point in putting it at one end if it is for a boat and will only match up in the middle. Drill the cross holes and cut the cross tubes to length, about 4mm longer than the diameter of the chimney tube. Soak the lot for a couple of hours in the acid, rinse and dry them. Put the tubes in the chimney, and flux round them. Mix the flux with water or methylated spirit to enable it to run down the minute gaps. Heat the assembly up until it turns a dull red or perhaps even a bright red. Then, and only then, apply the silver solder. Quench it and put it in the acid.

Testing the chimney

It is now necessary to test the chimney, as once it is in the boiler it is too late to plug any holes. Make up two brass stepped plugs to fit in the ends, drill and tap a hole in one to accept a cycle valve, or if you have a hand pump for water to accept a pipe from that. Clamp the brass plugs to the ends of the chimney and, if you have a water pump, put water in until you can feel a good resistance on the pump.

If you also have a pressure gauge stick that in the other end and pump to about 50 p.s.i.. If you only have a cycle pump then pump air in until the resistance is so great you cannot pump any more. Without releasing the air put the chimney in a bucket of water. Whichever test is being used any leaks will have to be sealed before going any further. Next, file the ends of the cross tubes perfectly flush with the chimney tube and repeat the testing operating.

Making a start on the soldering.

Drill the boiler barrel to accept the chimney and the safety valve bush and half a dozen holes round the edges for rivets. The holes for the water tubes at the bottom should also be drilled. File off all the burrs made by the drilling. Heat the barrel to a nice bright red and quench it, then put everything in the acid to get it clean.

Put the blank flange plate in the end of the boiler and drill through the flange plate for the rivets. Slip the rivets in and support the thing on a long heavy bar held in the vice, using this to just lightly tap over the rivets. Don't go mad as they are not going to give any support. With a pin hammer and the assembly still supported on the bar, tap the edges of the boiler tube to ensure it is in contact with the flangeplate - that is why you softened it in the first place.

When you are happy that contact is made all round, stand the assembly on a brick and put others round it to ensure that heat is driven back to the copper. There should be no more than half an inch or 12mm of the boiler showing. Flux well round the seam and round the rivet heads. Heat to a bright red and then touch the silver solder to it. It is essential that the solder is not applied until the assembly is hot enough to ensure it will run right round. Quench it and put it in the acid to clean up.

When it is thoroughly clean examine it, in particular inside, and make sure that the solder has penetrated right through. If not, repeat the operation. It should be possible to get the copper hot enough for the solder to flash round it but at the same time the original solder will not melt; it requires a higher temperature to melt it second time round.

The second end can be dealt with in the same way, although some readers might prefer to put in the bottom of the chimney and the water tubes first as they will then have a chance to examine the inside. Obviously the rivets cannot be closed over but this does not matter. Anyone who really wants to make a first class job can substitute bronze screws for rivets. The pinning over of the boiler end to contact the flange plates can be carried out easily enough as the copper should be soft for soldering the other end. At the same time as soldering the flange plate put in the bronze bushes.

The water tubes

The bottom of the chimney and the water tubes can be soldered in. Get a piece of mild steel the same diameter as the water tubes, put it in one of the holes for the water tubes and pull it roughly to the line the tubes will take. Repeat in the other holes. Soften the water tubes and bend to the required shape, then insert them in the holes leaving about 3mm inside the boiler. Pack the assembly with brick and, again getting it really hot, solder in both the tubes and the bottom of the chimney.

Finishing and testing

Finally the chimney and the top bushes can be put in; this should be possible at a single heating. After this, small plugs will need to be screwed into the boiler for testing. The procedure for this can be the same as for the chimney. The cycle pump is not the ideal test but if there are no other means then it is Hobson's Choice, and it will do.

It is possible to put in about fifty pounds of pressure in that way and so the boiler should only be used at around thirty p.s.i. The pressure must be maintained for at least half an hour. Do not worry about very tiny leaks as long as pressure can be maintained by pumping. After half an hour the boiler must be examined for signs of distortion. Those who have to resort to an air test might well consider taking the boiler along to the local garage and asking to use the air line. Do not however take the boiler straight up to full pressure on an air line. Raise it in steps of about 5 p.s.i. and check after each one for potential weak spots.

The ideal pressure to test a boiler such as this is around eighty p.s.i. and this should be aimed for whichever test is used. The boiler is designed to work at no more than fifty p.s.i.

Fittings

The number of fittings needed has been left as a minimum. The steam pipe can be attached to one of the top bushes, the other takes a safety valve adjusted to go off at the correct pressure. A stop cock can be incorporated in the steam pipe. If a water gauge is to be fitted then use the two bushes in the end, one above the other. Alternatively, use two plugs and take the top one out when filling the boiler – when the water comes out consider it full. Filling can be done via the safety valve hole. The other bush can be used for a pressure gauge if one is to be fitted. With this type of burner a pressure gauge is not strictly necessary as the boiler will never raise enough pressure to come to any harm. The bush should be incorporated, however, in case gas firing is considered at some stage.

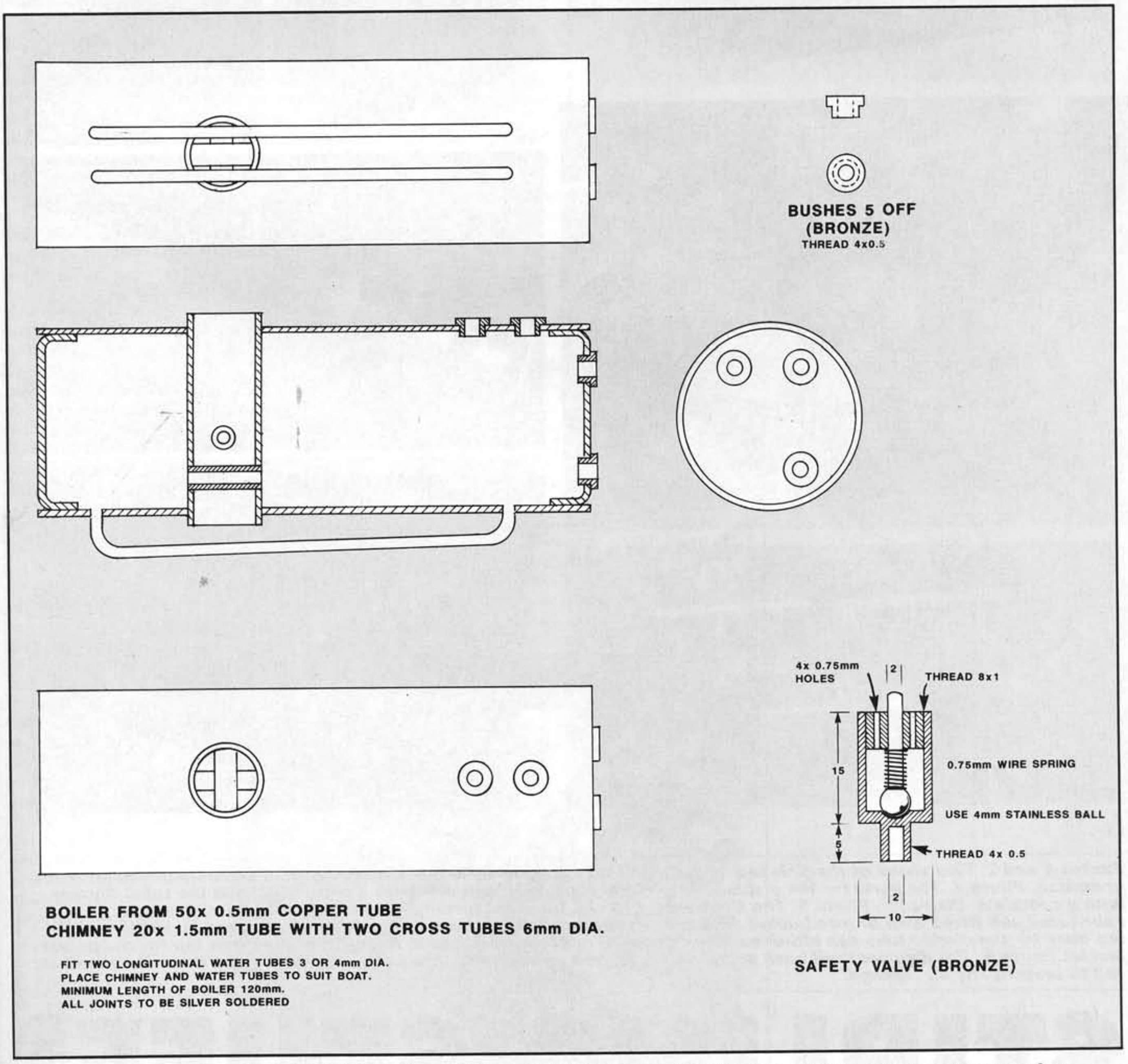
Boiler support

The type of support used for the boiler will depend to some extent on the use it will be put to. The base will need to be a minimum of 35mm from the standing surface. There should be no need to supply air holes at the sides of the support if this is made from sheet metal. There is much to be said from making an adjustable support so that the height of the boiler can be adjusted to find the best position in relation to the burner.

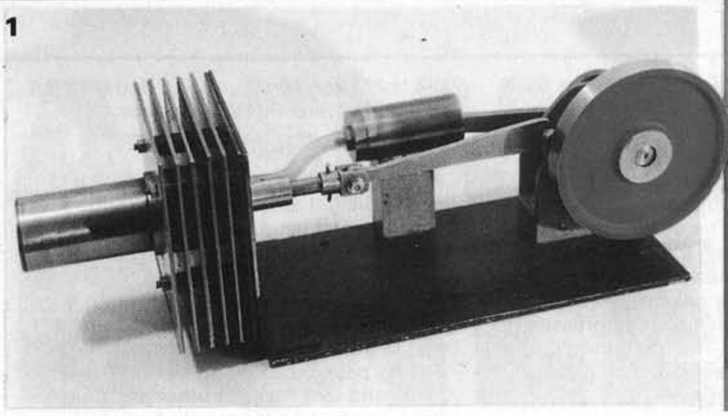
The burner

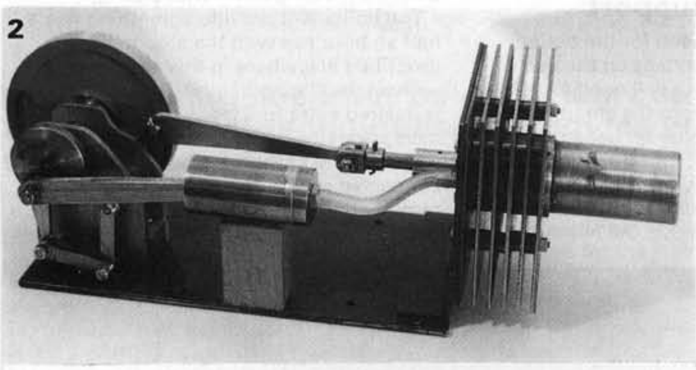
A simple flat tray is specified in order to reduce height and to allow the flame to cover a good length of the boiler and give a good heat. It may well be that, if the plant is being used in a boat, this arrangement will need modifying to suit the hull. One trouble is getting enough fuel in the burner for a decent run. It is always possible to put in separate fuel tanks and tuck these in other parts of the boat, connecting them with piping.

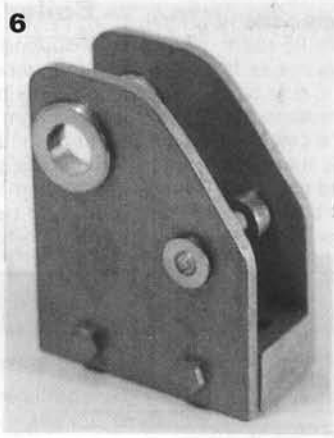
The boiler will provide something like a half an hour run with the steam plant described elsewhere in this magazine or with an oscillating engine. If a longer run is desired extra fuel tanks can be incorporated and the boiler should be fitted on one side with a non-return valve connected in turn to a small pump with a ram of about 5mm diameter.

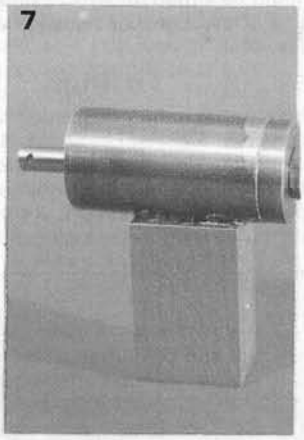


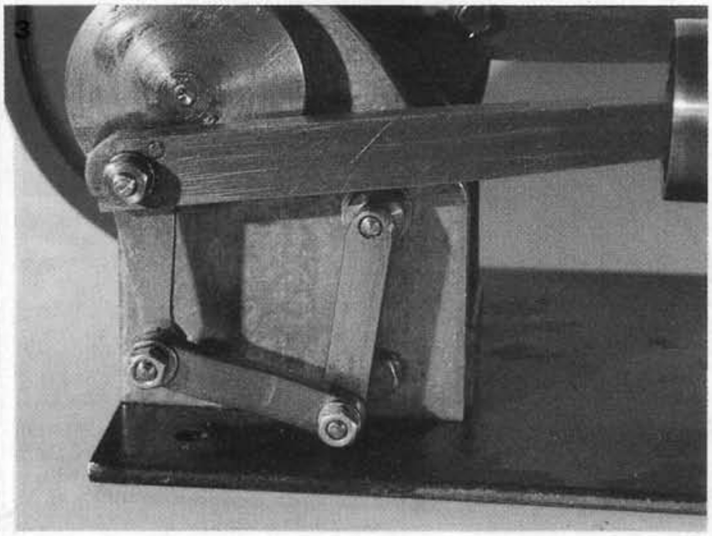
Drawings for a simple boiler; this little unit would be suitable for powering the twin cylinder marine steam engine described elsewhere to provide a compact steam plant for a scale model tug or launch.

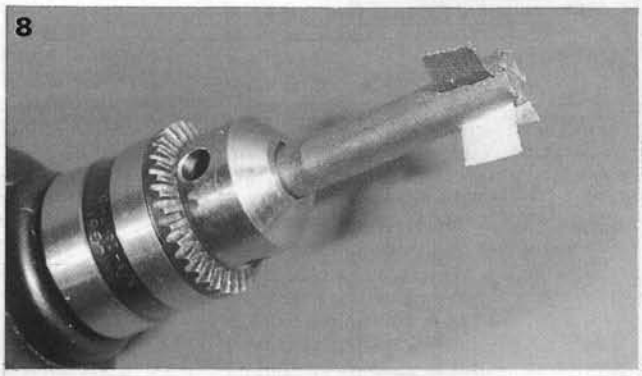


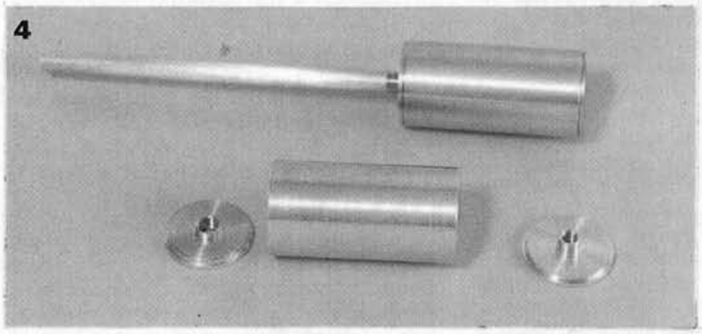


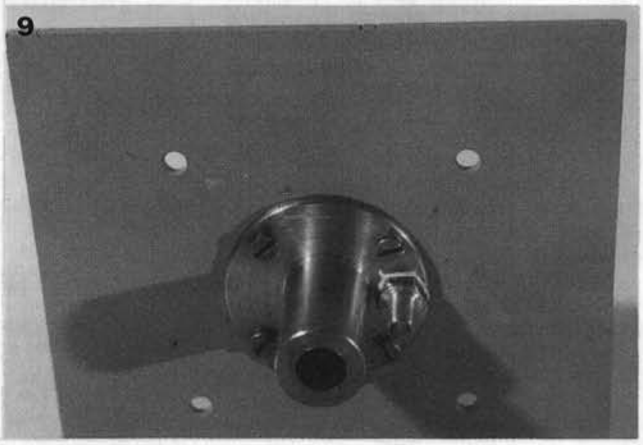












Photos 1 and 2. Two views of the finished model – quite an elegant little machine.Photo 3. A close-up of the lever operation. Photo 4. The parts for the displacer – two end caps (the front one with a blind bore) and the tube. Shown with a complete displacer. Photo 5. The flywheel – a straightforward turning job.Photo 6. The bearing support. Fabricated and fitted with bronze bushes. Photo 7. The power piston. The end cap is silver soldered in position and the boss for the plastic tube can either be silver soldered or screwed.Photo 8. A simple home-made lap for the power piston. Photo 9. The displacer rod bush and the boss for the plastic tube. The bush must be a good fit on the displacer rod to prevent any air leakage.

STIRLING STUFF!

We told you earlier how easy they were to make – now's your chance to try one. This elegant little engine can be built from scrap bits and pieces

It has been pointed out how hot air engines can be made, as a rule, from any handy material. The one about to be described was, in fact, made from odd bits around the workshop, and, with one small exception where an alteration in design can easily be made, all the material used is likely to be fairly easily available if not actually already to hand, for those wishing to construct an engine to a set design rather than design their own. Even if the specified metal is not to hand it will not be difficult to substitute something else in order to make a particular component.

The engine about to be described differs from most made nowadays in as much as the movement is by a series of cranks and levers.

At one time most engines had such an arrangement, now it is not often seen since there is a loss of power involved and the engine runs much more slowly. However, it may be that some readers will find it far more fascinating to watch the levers operating than to watch a normal type of engine which just has two cranks set at ninety degrees to each other...

The displacer cylinder

This was made from a piece of steel tubing of unknown origin. It was, in fact, seamed but of course seamless would be an improvement. It was just over one and quarter inches in diameter outside and about one eighth of an inch wall thickness. Any tubing around this size will do as the actual displacer will have to be made to fit it and so measurements are not important at all. The tubing was machined to length and then the bore just skimmed to erase the mound left by the weld – also such tubing frequently is far from even in thickness. One half of the outside was then turned down so the wall was around a thirty second of an inch thick. The other end was left as it was.

The end cap was made of brass, the idea being to give a quick heat up. It was made very thin and stepped to fit inside the cylinder. However there is no reason why sheet brass or copper should not be used as, after fitting, it was silver soldered into position and this could just as easily have been done with a piece of sheet, which could then be filed to shape. The end that will secure the cylinder in place was not made at that point as the fins were used as a template.

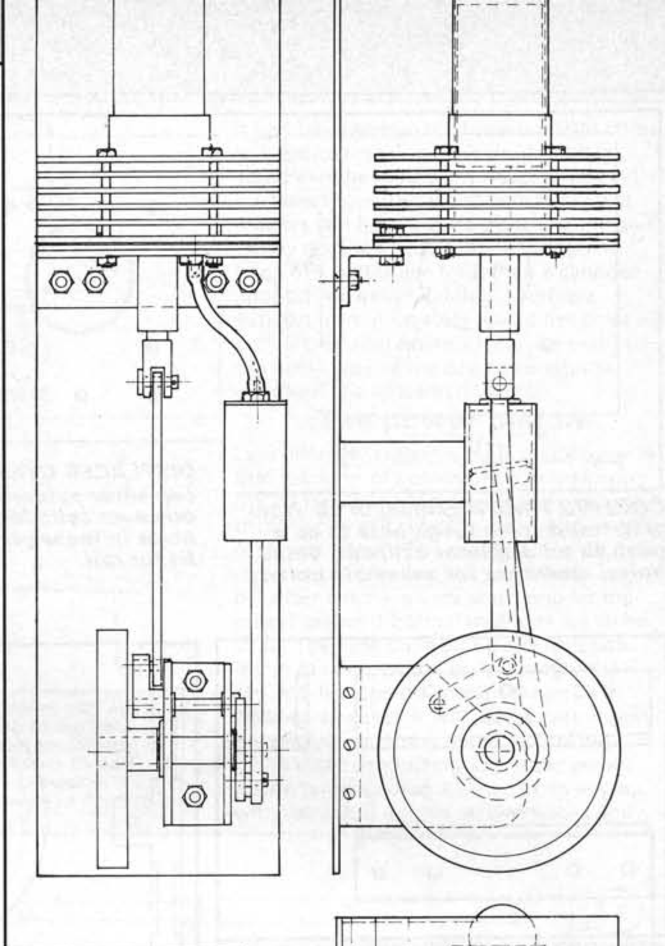
The displacer

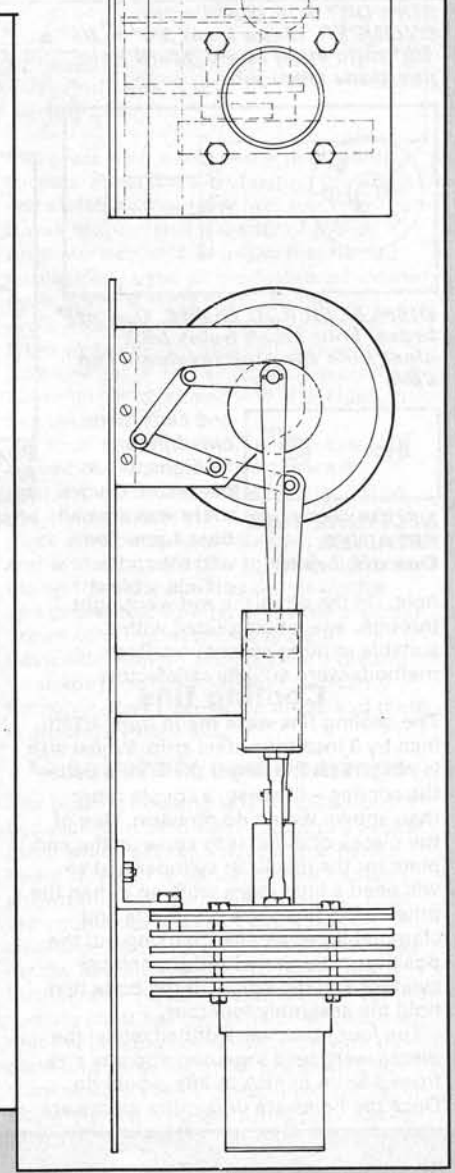
The displacer was tackled next and here a piece of aluminium tubing was used – not the best of materials in some ways but it does have the advantage of not rusting. Although tube was used because it was available, a piece of solid could have been bored to do the job. The finished tubing needs to be one thirty second smaller in diameter than the inside of the cylinder, and the wall of the tubing no more than this in thickness when finished. This involved machining the outside of the piece used, but some people may have to thin down from the bore. If a piece of this thickness is gripped in the chuck there is a distinct danger of its collapsing. The length used was there fore longer than needed and the work carried out whilst a more solid portion remained in the chuck. When finished it was simply parted off.

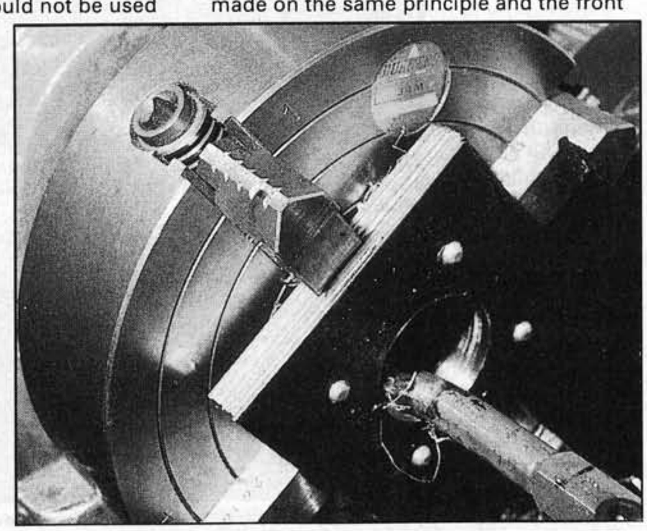
Displacer end caps

These too were made from aluminium, but steel could have been used. Both were drilled and tapped to take the rod and a well-fitting step machined to fit inside the displacer tube. IT IS ESSENTIAL THAT THIS IS WELL-FITTING AS THE FINISHED DISPLACER HAS GOT TO BE AIRTIGHT. When time comes for assembly, the displacer rod – which is an ordinary mild steel rod suitably threaded – is screwed in to both caps after applying a little gasket compound to get the joints airtight.

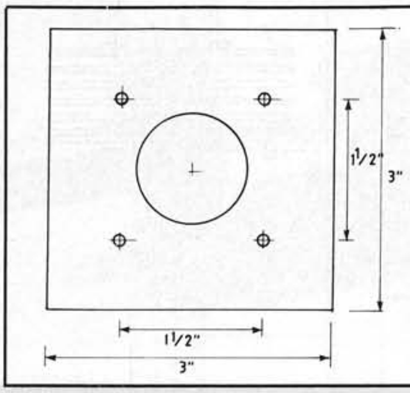
The result is a very thin displacer that is nice and light. Actually two engines were made on the same principle and the front



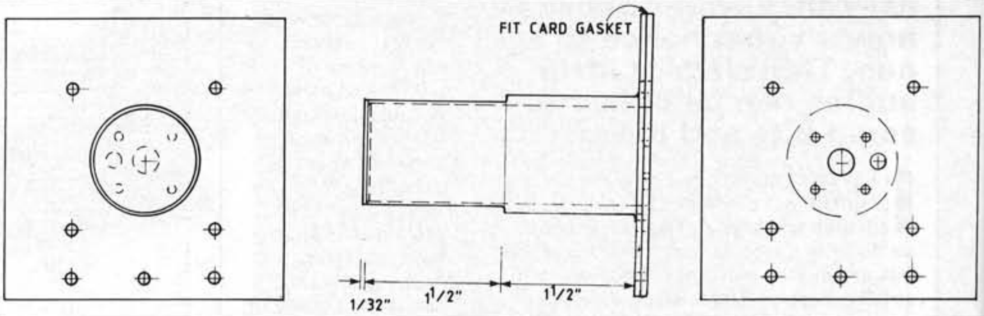




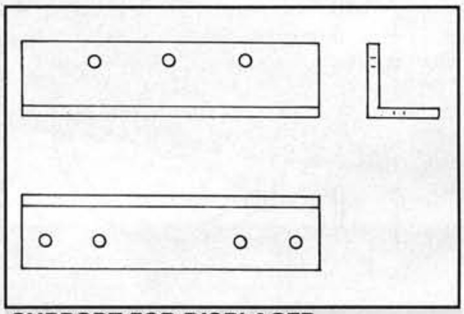
Finish the fins by boring accurately so that they are a good push fit on the displacer cylinder.



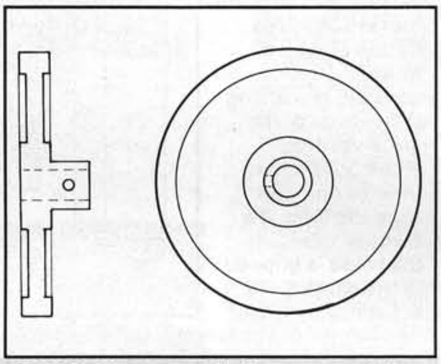
COOLING FINS. Minimum of six from 1/16" mild steel. Large hole to be a push fit on displacer cylinder. Small holes, clearance for assembly bolts.



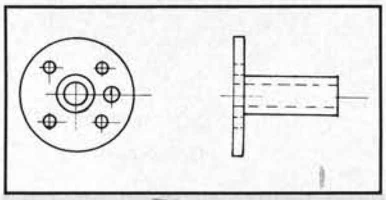
DISPLACER CYLINDER AND BACKPLATES. Cylinder from mild steel with brass cap silver soldered in position. Backplates of same material as fins. Silver solder one over cylinder, the other is fitted via assembly bolts. Four smaller central holes in loose plate tapped to accept rod guide. Central hole very easy clearance fit for rod.



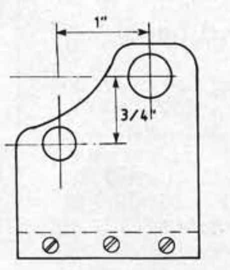
SUPPORT FOR DISPLACER CYLINDER. Make from 3/4" x 3/4" x 1/8" mild steel angle. Mark hole positions from job.

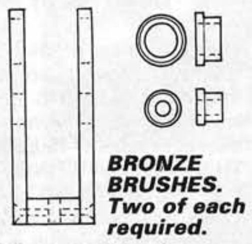


FLYWHEEL. From 3" diameter mild steel blank. Secure to crankshaft with 4BA grubscrew.



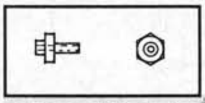
DISPLACER ROD GUIDE. One off brass. Four small holes 6BA clear hole for tube retainer. Tap 2BA.





BRONZE BRUSHES. Two of each required.

BEARING BLOCK. Fabricate from mild steel. Fit bronze bearings with Loctite 601. Note: Flanges on large bearings fit outside block, small bearing flanges inside block.



NEOPRENE TUBE RETAINER. One off, brass.

end caps made in two different fashions to see the result. On one there was a small boss turned on and the rod screw ed into a blind hole. On the other the rod went right through, again being fitted with a suitable jointing compound. Both methods were equally satisfactory.

Cooling fins

The cooling fins were made from 1/16th inch by 3 inch mild steel strip. Whilst size is not critical the larger the fin the better the cooling – likewise, a couple more than shown would do no harm. One of the pieces of metal is to serve as the end plate for the displacer cylinder and so will need a little more work on it than the others. The fins were cut to size and clamped together after marking out the position of the hole for the displacer cylinder and the holes for the bolts that hold the assembly together.

The four holes were drilled whilst the pieces were held together, and any size from 3-5mm or 6BA to 3Ba would do. Once the holes are drilled the pieces are bolted up tight and mounted in the four jaw chuck with the centre hold mark running true. The hole can be bored and it must be a push fit on the cylinder. Contact is essential for the cooling action and it just will not do to make the hole so that there is no contact. When it comes to assembly time, simple spacers are made from mild steel and placed between the fins to give the required clearance.

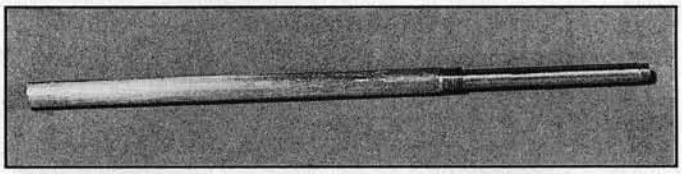
Displacer cylinder end plate

One of the fins is used for this part, the obvious one being that on the bottom of the pile. It is the same as the other fins except that it has three or four holes drilled in it to match the backplate, which takes the rod guide. It is perhaps as well to mark those fixing holes on the end place at this point. Then simply silver solder the end plate onto the displacer cylinder.

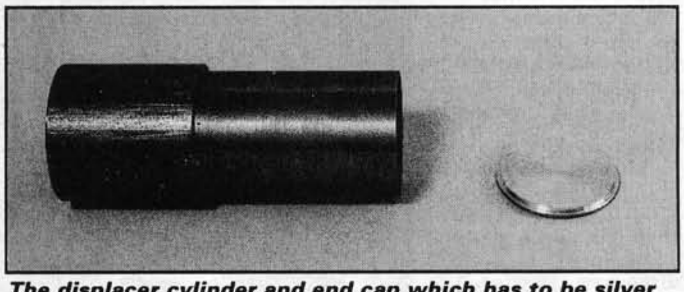
The end plate

Once again, this is the same size as the fins and also has the four holes to match as well as the three or four to screw it to the angle which bolts it to the base plate. The central hole is much smaller than the cylinder diameter and the rod guide, which is a simple machining job on the lathe, is bolted to it. It is essential that this is concentric to the cylinder.

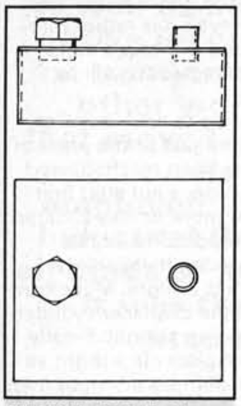
The rod guide has a bush screwed into it to accept the neoprene tube that acts as a transfer pipe to get the displaced air to the power cylinder. The hole for this needs to be drilled and tapped right into the backplate. It must come completely within the bore of the cylinder and, when assembled, there should be a gasket fitted and sealing tape put round the thread of the boss. A gasket will also be needed between the end and back plates; this can be made from thin card.



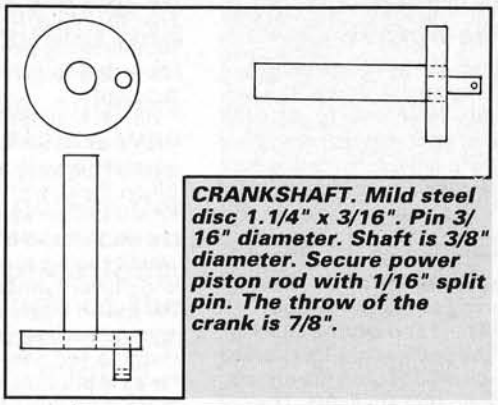
The displacer rod; careful and accurate machining to length and good tight threads are essential in order to keep the displacer airtight.



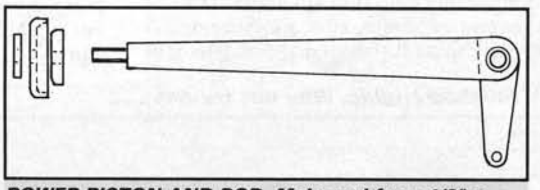
The displacer cylinder and end cap which has to be silver soldered into place.



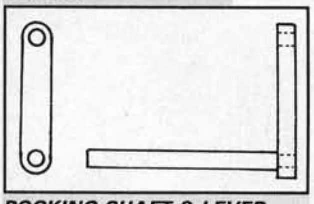
BURNER. Fabricate from thin brass 2" x 2" x 3/4" approx. Use thin tube for wick. Filler cap may be screw or push fit.



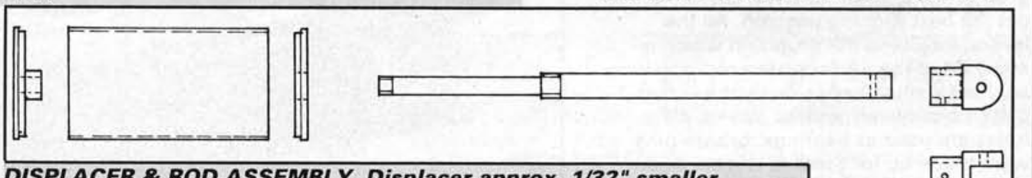
CRANKSHAFT. Mild steel disc 1.1/4" x 3/16". Pin 3/16" diameter. Shaft is 3/8" diameter. Secure power piston rod with 1/16" split pin. The throw of the crank is 7/8".

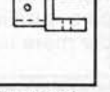


POWER PISTON AND ROD. Make rod from 1/2" x 3/16" bright mild steel. Fit bronze bush in big end. Piston from leather cycle pump washer, undersize radiused. Brass support and brass locknut. Thread 2BA. Silver solder drop link to rod (bush passes through both). Use bronze pin to fit small end to lever.

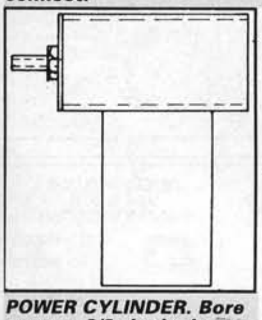


ROCKING SHAFT & LEVER. From 1/4" x 1/8" and 3/16" dia. mild steel. Silver solder. To assemble, use bronze pin to connect.

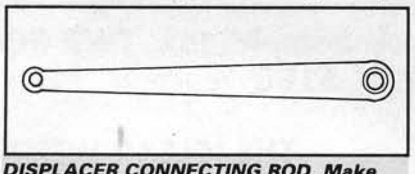




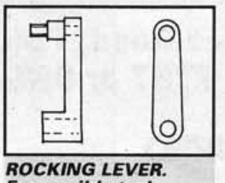
DISPLACER & ROD ASSEMBLY. Displacer approx. 1/32" smaller diameter than bore of cylinder. Make as thin as possible. End caps tighten with rod, use sealant in joints. Length of rod to suit job. Secure to joint with 1/16" split pin.



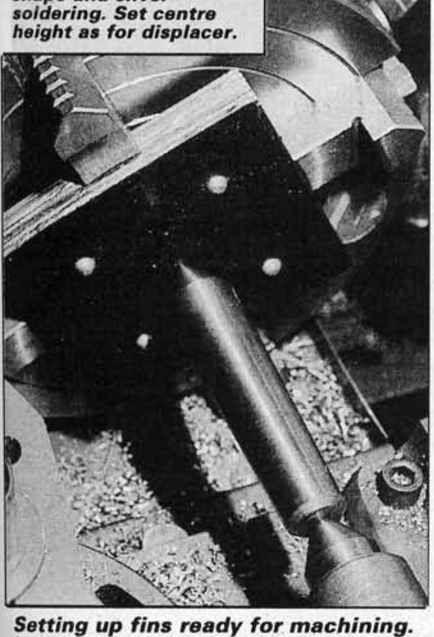
POWER CYLINDER. Bore approx. 2/3rds the bore of displacer cylinder, length to suit stroke and piston. Fit neoprene tube between cylinders. Make base by folding sheet to shape and silver soldering. Set centre height as for displacer.



DISPLACER CONNECTING ROD. Make from 3/8" x 3/16" bright mild steel. Fit bronze bush in big end. Length of rod to suit job. Fit small end in fork with bronze bush.



ROCKING LEVER. From mild steel approx. 1" between centres. All other levers must have same centres. Secure to shaft with 6BA screw after adjusting to 90 degrees. Fit nut to keep connecting rod in place.



Setting up fins ready for machining. Two centres are used and reference is made to a scribing block to ensure a reasonably true set up.

Power cylinder

The actual cylinder can be made from any metal. The bore should be honed smooth as it is essential that it is both airtight and free-running. For this sort of work make a small lap from a piece of mild steel rod. Make two saw cuts down part of the length (say about half an inch long) and stick pieces of emery cloth in the slots with super glue. Put plenty of oil in the cylinder bore and slowly traverse the lap along its length whilst rotating it very slowly. Make sure the lap does not come out of the bore whilst rotating as this will result in bell mouthing of the cylinder.

The end of the cylinder is straightforward enough. Chuck a piece of suitable material, drill and tap it, and then turn a tiny step to fit the cylinder bore. It is silver soldered in position and the piece to fit the plastic tubing can either be machined directly to the end or threaded into it. The support can be folded from sheet metal; the one in the photograph was made from a piece of bronze bar. It was the remains of a casting which was like a pepper pot with blow holes. As usual it had been kept in the hope it would come in handy some day – it is doubtful if it could ever have had any other practical purpose though! It is not very likely that readers will have such a piece around and, if they do, they will probably be able to think of a better use for it than a cylinder support. However, folding a suitable support from mild steel would not be at all difficult, or alternatively it can be made in the same way as the bearing supports, which will be described later on.

The power piston

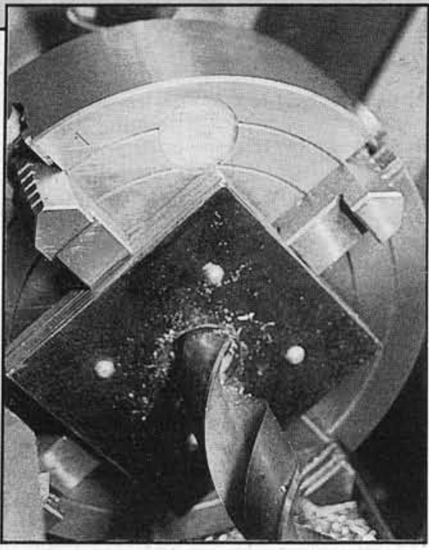
One difficulty with this particular engine is that the form of construction, transferring the air by means of a plastic tube, means that the power cylinder is set well forward of the displacer. This means either an overlong connecting rod for the displacer or, alternatively, a very short one for the power piston if normal methods are to be used. The long connecting rod idea has much to commend it as, the longer the rod, the less the downward thrust as it moves. However, it will in this case make the engine very long and ugly looking.

The short connecting rod to the power piston tends to drag it down at an angle, with the result it rides on two edges and this gives both a bad seal and unwanted friction. Several ways of curing the effect were tried, without any real success. Then it was recalled that a reader of *Model Engineer* had written to say that he had successfully used an old-fashioned leather cycle pump washer. A trip to the local cycle shop showed there were several types available but most were plastic. However there was a leather cup washer amongst the stock and it was decided to use this.

A short piston was made of brass, well curved at the end to allow the washer over it and, instead of the normal piston rod and connecting rod, one combined piece was made up with a bearing at one end and a thread at the other. A stout nut fits on the outside of the pump washer and prevents it coming off as the piston is drawn out. The washer was well lubricated with oil and acts like a dream. Its shape ensures a perfect seal even though it does travel at an angle and there is absolutely no leakage.

Crankshaft and bearings

The bearing housing is fabricated from two pieces of mild steel strip and a thicker piece which acts as a spacer, the parts being screwed together. On the model shown this was done with hexagon bolts but countersunk screws would ensure clearance of the rocking levers. The holes for the bearings are bushed with bronze bushes; take note that one of those for the rocking shaft has the large boss inside so that the bearing can finish flush with the plate and allow room for the lever. The crankshaft is simply a disk fitted with a pin, mounted on a shaft, and provides no



Drilling the fins.

complications whatever. Nor does the flywheel.

Rocking shaft and levers

There are two levers attached to the shaft. One is fixed whilst the actual level which is driven by the displacer is fitted with a grub screw in order to allow adjustment to get the best running position. All the levers, including the drop arm which is attached to the power piston rod by silver soldering, must have exactly the same distance between centres. Where plain holes are used as bearings, bronze pins were made up for them to run on. Split pins were used for assembly instead of the more usual nuts. This saved messing about threading the parts and still allows easy dismantling if need be.

The burner

Methylated spirits was used for running the engine but a small gas jet would also have done the job. The burner is not critical in size and, although a drawing is shown of a suitable type, readers will no doubt make their own from whatever material happens to be available...

Running the engine

Before starting the engine, oil the moving parts well including the power piston. Remove the flywheel and put the chuck of a hand drill on the crank shaft. This can be rotated in both directions until the engine runs smoothly with no high spots. The burner can be lit and, after a minute or two, the engine turned over – the flywheel having of course been put back on. If all is well there is no reason why it should not start first time. However, it is rather rare for this to happen and it is much more likely that some fiddling about will be required.

Hot air engines seem to have a will of their own at times and just as the point of absolute despair has been reached, start off on their own! If it does not start first time there are some more or less standard checks that can be made. Ensure the plastic tubing connecting the displacer and power cylinders is airtight. Make sure the gasket between the displacer cylinder and the backplate is also airtight. Finally, check to see if the displacer is airtight as far as is possible. If all these are right then there is no reason why the engine should not run successfully for many years to come.

The finished engine. Why not try one . . .