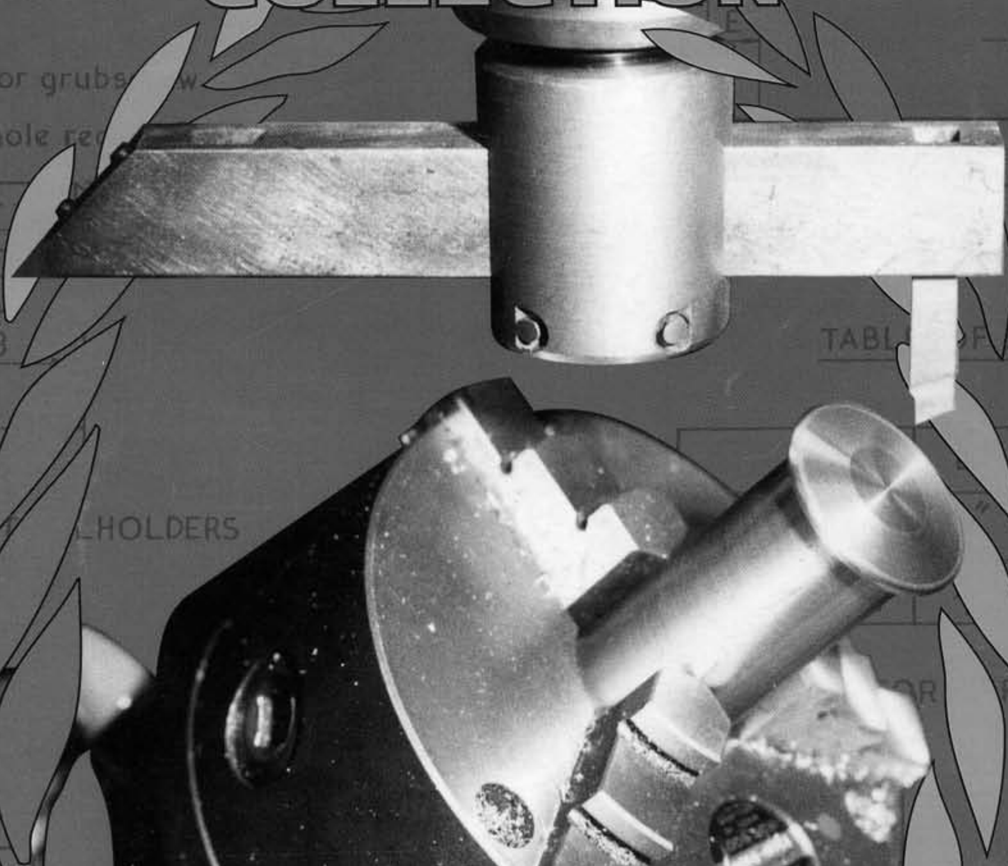
MODEL ENGINEER

CENTENNIAL CELEBRATION COLLECTION



8: Workshop techniques

FOR ENTHUSIASTS · BY ENTHUSIASTS

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Cover shot:
Spherical milling to generate the curved surface of a buffer head of a miniature steam locomotive.

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FOREWORD

It was a great pleasure to me when the Editor of Model Engineer took up my original suggestion that there was room for a second Workshop number in this Centennial series. The subject which I have selected is "Workshop Techniques", that is to say the accent is on the description of the processes rather than the pieces of equipment needed to carry them out. Inevitably there is some overlap and I have selected some articles which include descriptions of devices needed to carry out the processes.

The past is so rich in its provision of information. Inevitably some things date, while others remain evergreen. It soon becomes apparent how the hobby has changed over the years, both in style of writing and in content. Let me deal first with style: we have become less formal and I hope less patronising. Until the end of the 1950s the "Novice" was patronised in the magazine's pages, as good as saying "Well, laddie, you won't have a clue what I am talking about, so until you have practised it for at least seven years, don't even think of criticising". There was also considerable acrimony from time to time in the correspondence columns, writers often being downright rude to the authors if they did not like what was being said. I suppose that in another field one has only to recall the slanging which went on between L.B.S.C. and K.N. Harris (or K.N. Pepper as he chose to call him) to see how the magazine has provided not only serious reading and light entertainment but also a gladiatorial arena for those with the killer instinct.

Another thing which was common in the earlier years was the use of pseudonyms or noms de plume. Some of these gave away the author's roots, so there is no doubt that "Turner" worked in the heavy engineering industry, probably north of Watford, while "Artificer" must have been in the Royal Navy. So a lot of the writings were with cloak and dagger, some of it I believe being because people just did not want their employers to know that they had another interest, lest that should have been construed as taking up works time!

I have been able to trawl the years back to the early 1930's, again thanks to my custodianship of the copies belonging to the Stamford Model Engineering Society. The task has been made easier thanks to Mike Chrisp kindly lending me his copy of the index, which I must now return to him. I have also made use of the computer database version of the index and between the two systems I trust that not much has escaped. But indices only identify the areas in which to look; the real hard work comes in examining all the references and determining which ones best fit the shape of the publication.

One other fact which shines through over the years is the way in which general affluence has increased. I do not mean by this the way in which inflation makes things from days gone by seem cheap, but the fact that just before and after the war far fewer tools were available at prices which people could afford. But in those days there was a wealth of practical experience available and the expectation that the next generation would learn the skills through formal education at the feet of the masters. So we saw such series in Model Engineer as "For the Schools" and "Beginners Workshop" and indeed these were continued on into more recent times. It is not surprising therefore that the 1940's and 1950's were rich in the imparting of knowledge about basic workshop techniques. Furthermore it is unremarkable that many of those writings came from the pens of a small group of authors whose esteem was great; with the weekly publication frequency sometimes the same topics were aired by the same people within two or three years, the differences being marginal.

My choice of authors in nearly 40 articles gives rightful places to those such as Duplex, Martin Cleeve, Inchometer and Exactus, besides Tubal Cain and George Thomas. When it came to the area of foundrywork there was really no argument that Terry Aspin was "El Supremo". I personally owe a debt to him in that he inspired me by his writings in the 1950's when I first started reading Model Engineer. I do notice, however, one remarkable fact: his little friend Chuck does not look a day older than he did in those days! I wonder what that says about interest in the hobby. Representing modern techniques it is good to include Gordon Read and Stan Bray. I must not mention all the contributors by name: they are acknowledged in the correct places. The end result is a spread of articles over the years, with the strongest representation from the 1950's.

In selecting the articles to represent their techniques, I have normally fought shy of choosing material from part of an article or series on a completely different topic, since that has normally been biassed towards the particular job in hand. To illustrate this let me take the technique of metal spinning: there was some excellent writing on this subject in a traction engine series, but it was expressly slanted toward producing the brass top for a traction engine chimney and while that was capable of interpretation in a wider sphere I deemed the present article on the subject to be of wider interest and hence its selection.

On many occasions the topics were covered in a long series. I have had to be selective and in some cases edit mercilessly, but I trust that what is left will make sense to the reader. As an example, Stan Bray's series on adhesives was long and comprehensive. So I have had to pick the parts of it which tell most of the story: it is the old 80/20 rule, that 80% of the learning comes in 20% of the writing. In any case the original reference is given so that if you want to see the whole thing, get hold of the original copies. One thing is definite: I have not altered the English of any of the articles. Inevitably some of the older references mention names and addresses and even prices which are long out of date. I have endeavoured to bring this information up to date and in one or two instances where the information given is no longer relevant I have struck it out.

In presenting the articles I have divided up the topics into five general sections; you may think that some of them could better belong elsewhere, but that is a shortcoming of any cataloguing process. Thus metal preparation deals not only with the making of castings of different types, but also with other aspects of dealing with material before it is cut. In fixing techniques you will find the old and the new, while finishing techniques covers some of the more arcane methods at the disposal of the model engineer. Miscellaneous hand and machining techniques need no amplification, save to point out that they merely scratch the surface of what is available and practised within the hobby. Even if you master all the methods outlined you will have at your command a phenomenal armoury of skills and that is what the hobby is all about. That is why we continue to see so many fine models at the exhibitions up and down the country.

Now we come to that which has been omitted; inevitably my list of possible inclusions outweighed the 96 pages available. So reluctantly I have had to miss out a large number of subjects which are really very important. Until I got to the assembly stage of the information I had hoped to include the subject of springs by Tubal Cain. But there was no way in which a short extract would have done it justice and in any case there is one of the Workshop Practice series of books published on that subject by the same author. I could include nothing about painting of models; that is a whole subject in itself. Furthermore where does one stop with the section on Machining Techniques? There is a vast array of topics which would have been relevant and it is just my own individual selection in the end which forms the shape of this presentation. So, read on and see if you agree with what is written. It has been a pleasure to put it together.

D.A.G.Brown — ***Tinwell, Rutland.***

M.E. 137 1022, 1051 (1971)

The Backyard Foundry

"Chuck" gives some hints and tips

Metal Preparation
In this section I have included not only the techniques of getting lumps of metal to the correct shape (i.e. casting etc.), but also some other premliminaries before metal cutting starts in ernest.

Foundrywork Terry Aspin
I am delighted to include Terry Aspen's pet project in pole position, since he was one of the early inspirations in the middle 1950's; in fact my first major project was his ¼ in. capacity drilling machine – it is still running in the workshop of a Stamford nonagenarian.

MANY years ago, "Chuck" wrote a handbook which, although far from being a best seller has nevertheless found its way into the hands of many thousands of the model engineering fraternity. This was "Foundrywork for the Amateur" and judging by the many letters received - yes, and from all parts of the world, too - the book fulfilled a long-felt want. But "Chuck" often wonders just how many people who have read the book have actually taken the plunge and initiated a small-scale foundry for themselves.

Plywood Base

Perhaps the word "plate" used here is something of a misnomer. "Board" would in fact be a more accurate description because the home foundryman will probably make his plate from a piece of ⅜ in. plywood. Resin-bonded material will be an advantage if the conditions are likely to be damp and if the pattern is to be stored for any length of time. ⅜ in. ply will be rigid enough for a pattern plate twelve to fifteen inches square and such a pattern could take upwards of ten pounds of iron to run. A formidable quantity for a little crucible furnace!

Anyone who has already done any patternmaking will know that a split pattern can often make the task of moulding easier than when a solid "odd-side" type of pattern is employed. But the technique remains basically the same in as much as the half patterns must each be rapped in turn from the box, and the ingates must be cut by hand. The skill for this can be acquired, but a measure of concentration is always called for and there is an ever-present risk of damage to the mould while the handwork is carried out. Loose sand has a nasty habit of falling into inaccessible cavities where it remains to spoil the surface finish of the work.

The withdrawal of the pattern itself from the sand calls for no mean prowess and a steady hand if the mould is to remain intact. It is surprising that the packed sand, while capable of withstanding the flow of molten metal, is yet so fragile to the touch.

If one half of the mould is accidentally damaged so that it cannot satisfactorily be fettled, then a complete new mould has to be made up. This fact often persuades an amateur foundryman to make do with a fettled mould where his better judgement may indicate a re-make.

Flasks

It may well be that plate-pattern making starts with the moulding itself. Most modern flasks supplied for industrial use for general purpose moulding will conform to all requirements, but basically, a box for plate moulding must be equipped with a pair of substantial register pins of fair length. That is to say the pins must be quite parallel to allow a positive draw and long enough to control the draw until the pattern is clear of the mould. A typical box is shown in Fig. 1. This, of course, is an industrial flask, but there is nothing to prevent a wooden one giving satisfactory results if it is made with care, and adequate attention is given to the pins.

The plywood plate, then, is made large enough to cover the whole of the box with about a quarter of an inch to spare all round and to extend over the pins. It is bored to register with the pins and with sufficient clearance to allow it to slip on and off easily. This would be the first step in the production of a plate pattern. Fig. 2

From there on much depends on the shape of the pattern to be produced. There is a good deal to be said for a drawing of the pattern to be set out directly on the board and positive reference, like centres and angles, permanently marked by drilling through the board at the precise points. These holes can be ¹⁄₁₆ in. or less, and this positive location is particularly valuable where one half of the pattern is on one side of the board and it has to register with the second half on the other side of the board. When the reverse side of the pattern is being mounted, panel pins inserted in these holes serve as a guide and it is relatively easy in this way to obtain precision adequate for moulding, certainly when the usual allowance for machining is taken into account.

Fig. 4.

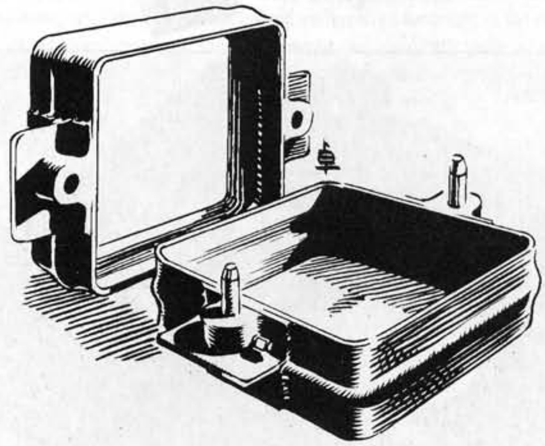


Fig. 1

For certain kinds of pattern the board or "plate" will be pierced right through, with a draught angle relative to the side of the plate on which the self core will appear. Since the plate increases the thickness of the pattern (but not of the cavity in the mould) by the same amount as its own thickness, blind holes in the pattern plate may well produce straight-through cores in the casting. Fig. 3.

The following may be elementary but it may be worth a mention. Before commencing to set out a pattern on a new plate it may be as well to indicate the inside edge of the flask with a pencil on the plywood, the same being registered on the pins. This would serve as a guide so that due allowance can be made for centring the pattern with regard to the amount of sand which will be left between the casting and the box side. With a steel flask this can safely be no more than half an inch, but with wood, a good deal more must be allowed to prevent scorching of the side of the box and, worse still, a possible runaway.

Fig. 2

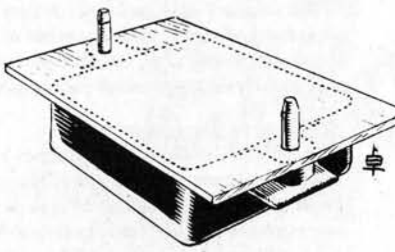
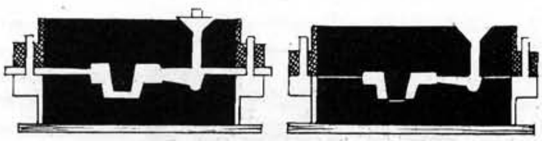
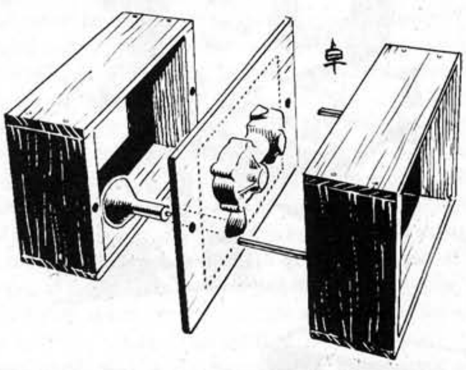
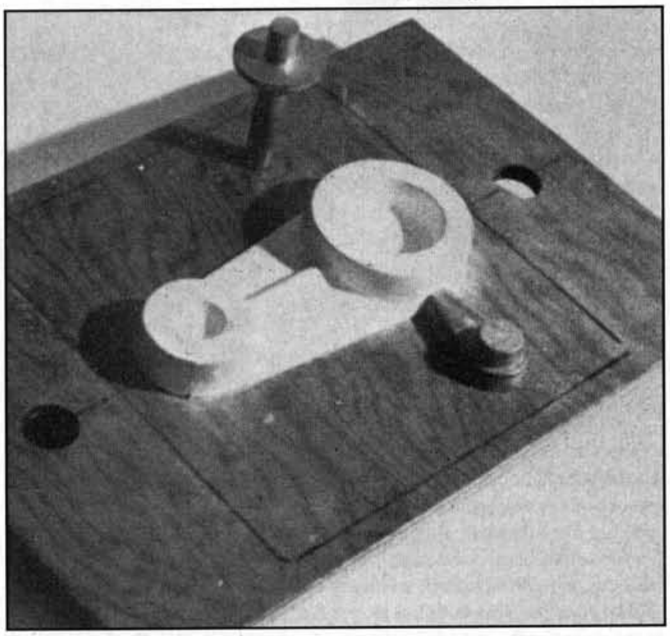


Fig. 3



A WOOD FLASK MAY BE USED FOR PLATE MOULDING





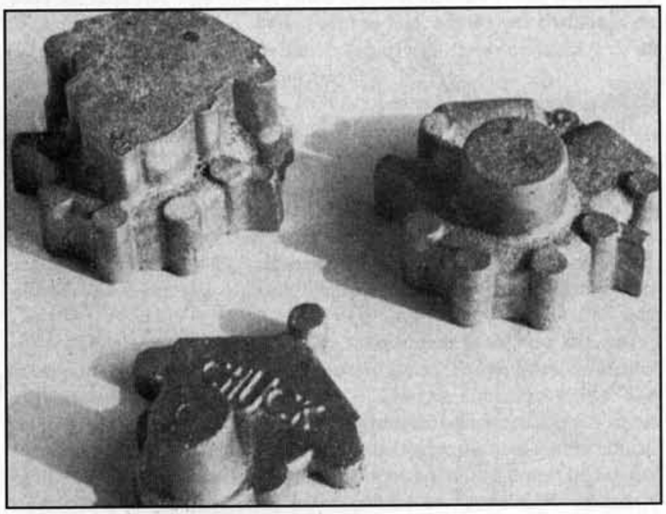
Single sided patterns

Some types of pattern lend themselves very well indeed to plate moulding. The flat-base type is obviously the best example. "Chuck's" favourite example is the pattern for a small machine vice where all the detail is above - or at least to one side of - the parting line. In a case like this such a pattern would follow exactly the form used for orthodox moulding and it would simply be mounted on one side of the plywood board, positioned to allow for an ingate and sprue. But here the first advantage of the plate pattern may be appreciated. Further small patterns to mould the ingates are added to the plate. A good deal of thought can be applied to the positioning of these to ensure the best run possible - particularly when there are two or more separate parts to the pattern and the ingates can be arranged to branch out from a central sprue. This will soon be found to be a much more satisfactory method than the cutting of ingates in the sand by hand. There is much less left to chance.

The ingate moulds are made with the same care as the pattern, but much more draught than normal can be allowed than would be permissible on the machinery casting. The purpose here is to obviate any risk of a difficult draw. A small boss of extra depth is provided on the ingate opposite to the base of the sprue. This forms in turn a small well in the sand which receives the first inflow of molten metal. The centre of the boss is drilled right through - say $\frac{1}{8}$ in. - pattern plate and all and the hole so formed on the - now - upperside of the plate will receive a locating pin in the centre of the sprue stick itself.

The sprue stick is made as a loose part to allow of its withdrawal from the upper surface of the mould and it can be provided with an enlarged cone at the upper end which will, in turn, form a pouring basin in the top of the mould.

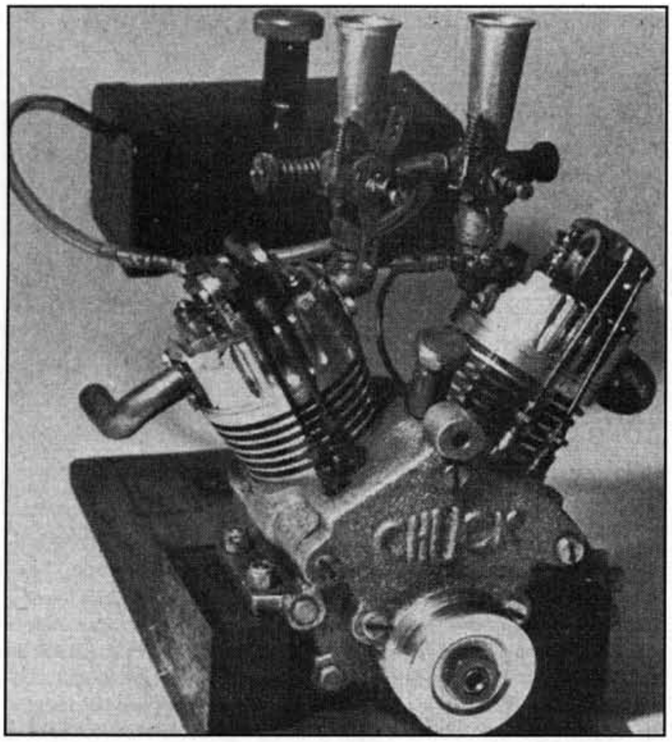
In this way it will be seen that all the work of moulding is done first on the pattern plate before any contact with the sand.



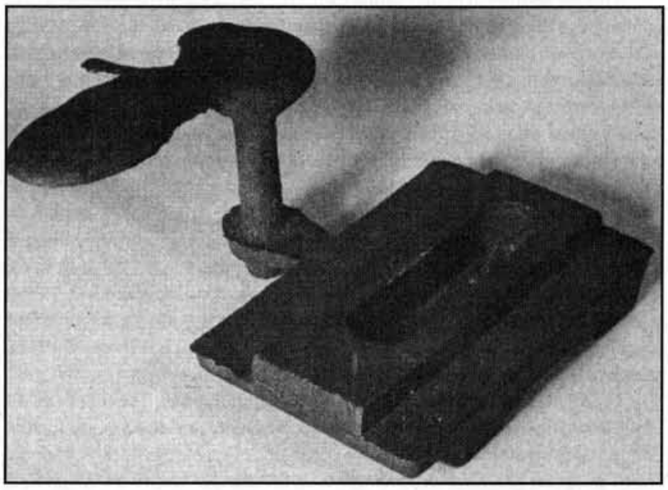
The Cavity

In the case of the elementary plate under discussion, all the mould cavity will be in the drag box with only the sprue in the upper part. To make the mould, the flask is assembled with the plate in position between the two halves, registered by the pins.

The side containing the detail - the drag - is rammed up first and the moulder will soon appreciate that he can focus his attention on a solid ramming without the usual risk of the pattern moving. In fact all his attention can be given to packing the sand thoroughly, with due regard to the hollows in the pattern.



One of Chuck's twin-cylinder petrol engines.



Where these hollows are deep, they will of course form self cores and as such may need venting. One way of doing this is to hold a metal rod - say 1/8 in. dia. - in the centre of the hollow while the packing is in progress. When the box is nearly filled, it can be partially withdrawn and plunged in and out until there is a small amount of packed sand between it and the pattern; then it can be taken out altogether.

The upper surface of the mould is now strickled off smooth and the complete box inverted to reveal the blank side of the plate. The sprue stick can be located with its peg and the second part of the box rammed up.

This is where the technique differs completely from that of conventional moulding. The sprue is first rapped and drawn. The pattern is rapped while the flask is still closed. Light taps with a wooden mallet are given to the edge of the plate all round the box. Clearance of a few thou. where the box pins pass through the plate will allow all the movement necessary to loosen the pattern.

The first side of the box to be lifted clear is the female side. i.e. that without the pins. The pins in the other part will guide it clear and will then guide the plate clear in turn. Since there has been no disturbance of the sand, there is no loose stuff to fall into the mould.

Blacking can now be applied to the inside of the mould in the usual way and the only fettling which may need attention is the lower end of the sprue where the stick has left the plate. The few grains of loose sand which may be present here can be blown away and, after closing the two parts, the mould can be clamped and poured.

Fettling and repairs to the cavity in the event of an accident are just not worth carrying out. Unless it is that a persistently faulty pattern is incapable of being withdrawn satisfactorily, the remedy for accidental damage is simply to scrap the faulty half and remake that. With the usual type of pattern it would be necessary to scrap all of the mould and re-make it completely.

Two sides

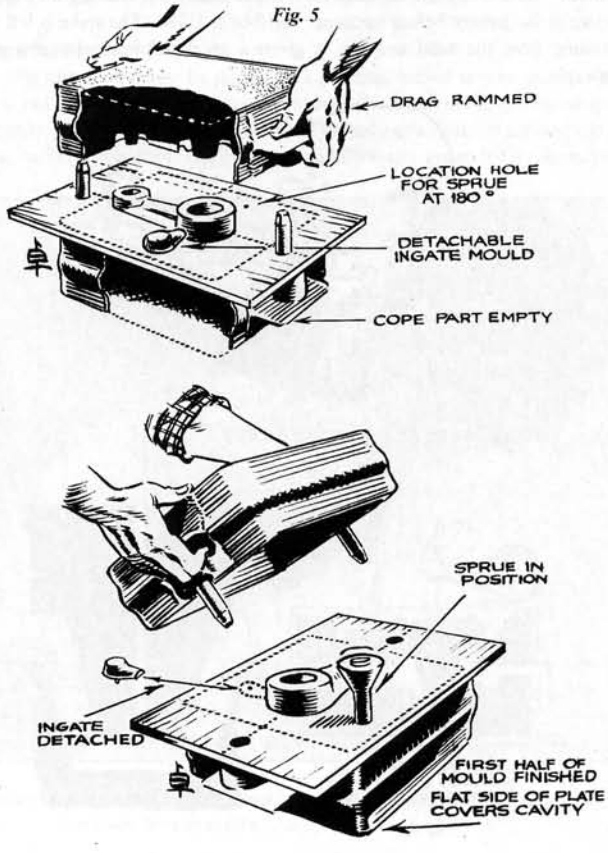
A less straightforward pattern than the "flat base" type is one having more or less pronounced contours to be moulded in each half of the box. Conventional moulding would be carried out using either an "oddside", where the shape would permit it or, for better results, a split pattern. Although weird and wonderful shapes are often moulded by the "oddside" method, the technique does call for an extraordinary skill on the part of the founder. Lack of this ability usually results in the acceptance of a mould cavity very much fettled and producing a casting requiring even more fettling; with consequent wear and tear on the grinder!

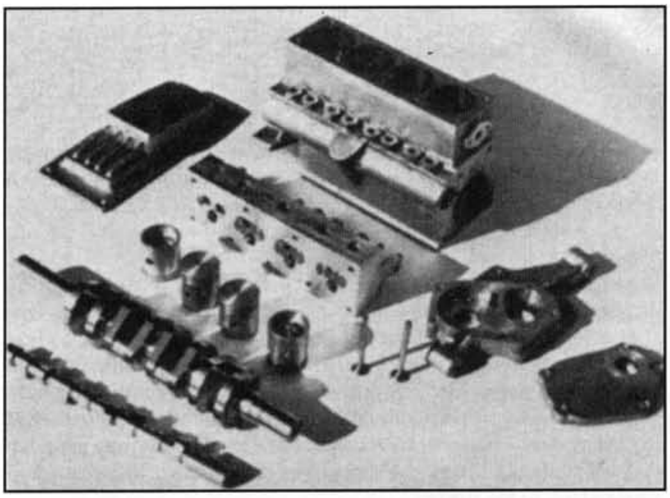
The split pattern, on the other hand, is designed to divide easily on the centre line when the filled boxes are parted so that each half can be rapped separately from the sand. The double sided plate pattern is for all practical purposes a split pattern divided and the halves mounted back-to-back on the board. The advantage here is the resultant ease of manipulation. Moulding such a pattern calls for no greater effort or concentration than the moulding of the simple pattern plate already described. The ingate mould and the location for the sprue are, of course, again added to the plate and if there is one side of the pattern having more pronounced contours than the other, this is the one usually chosen to occupy the drag part of the box and to carry the ingate.

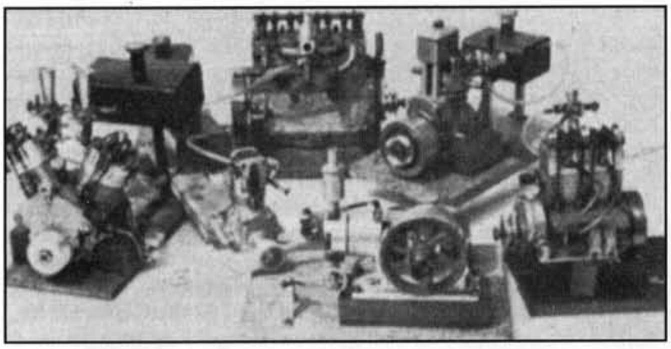
Chuck has found the plate itself to be a decided help in the initial construction of the patterns. Model work, for the most part, involves the handling of rather miniature components. The patterns used by the modeller are no exception in this respect and often the would-be foundryman finds himself trying to hold together tiny pieces of wood at odd angles to each other while the glue sets, or juggling to insert small tacks, with all the fingers of both hands and his teeth employed full-time as clamps.

The plate, on the other hand, is a substantial member in its own right and its own bulk, in so far as the finished casting is concerned, can be ignored. Thus it becomes a rigid base on which the pattern proper can be assembled. If the drawing of the pattern has been transferred to the board in the first place this all becomes very easy. Quite obviously, too, a multiple pattern can be laid out in the same way, with ingates arranged from a central sprue. All the parts for a miniature, i.c. engine moulded and poured at one go!

Fig. 5







A group of Chuck's engines.

Chuck will not have been the only amateur moulder to have satisfied himself with one small pattern at a time, each in its own flask, in preference to the extra hazard of a multiple mould, and the attendant risk of damaging one cavity while attempting to fettle an adjoining one!

Occasionally, when a traditional type of pattern has been designed to leave a rather pronounced core, making it difficult to separate the boxes initially without part of the sand adhering to and coming away with the pattern, a moulder will resort to the technique of rapping the pattern while the box is still closed. This crafty bit of know-how is performed by locating the rapping spike in the pattern before the upper half-box is filled. The spike is left protruding from the sand and this is given a good rapping before the parts are split.

VENTING DEEP CORES -SEE TEXT

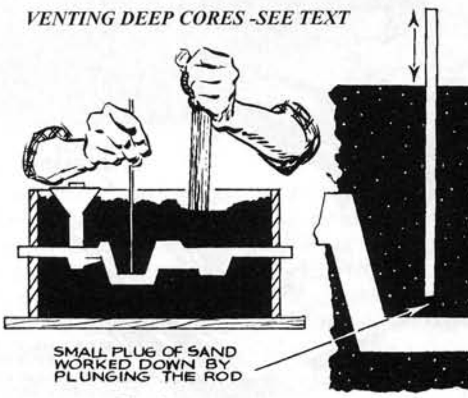
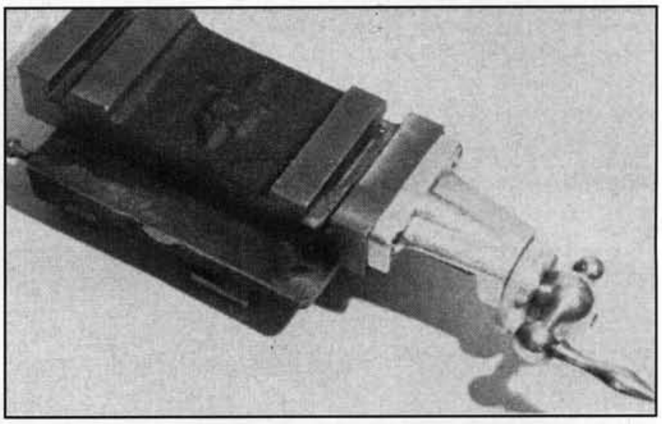


Fig. 6



Of course, the plate pattern obviates that sort of performance because these are always rapped before the mould is parted.

A special feature of the plate pattern is its ability to produce a full mould from only half a pattern. Fig. 4 is a particular example. Of course, such an arrangement is only valid when the opposite halves are identical. This is the pattern for an iron overarm for a milling machine, total weight, 4½ lb.

It is necessary in the first instance to mark out the centre line accurately in relation to the "pin" holes at either end of the plate. The off-centre error would be doubled when the plate is inverted to fill the second half of the box.

Also the additional mould which forms the ingate has to be detachable like the sprue. The locating hole for the sprue itself, likewise, instead of being concentric with the "boss" of the ingate must now be arranged on the same side of the plate but at 180 degrees to it. But the method is a time saver and it ensures that an identical sided casting does have identical sides!

The illustration shows the sequence in moulding such a pattern. The pattern plate with detail uppermost and ingate filled is laid on the empty cope. The drag box is superimposed and rammed up in the normal way.

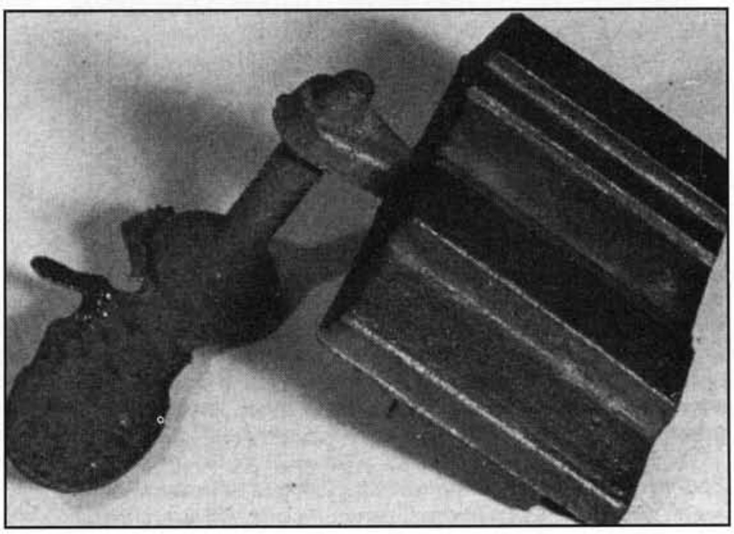
The whole box is now inverted so that the drag is in its rightful place at the bottom. The pattern plate is rapped and withdrawn in company with the empty cope, whose pins guide the draw. The ingate is now removed from the plate and the sprue positioned in the diametrically opposite hole.

The pattern plate is now re-positioned, flat side downwards, on top of the open half-mould, making sure that the plate has not been reversed end-to-end in the process! Let the "Chuckism" Fig. 6 serve as an awful warning!

The final stage in the process follows the usual routine. The sprue stick is withdrawn, the sides of the plate are rapped and, when the cope is lifted clear, the mould is complete.

If adequate attention has been given to the draught angles on the pattern, if the sides are perfectly smooth and if the final painting of the plate has been given plenty of time to harden, it may well be found that the pattern will strip from the mould without a prior dusting with parting powder.

This means that when blacking is applied to the cavity before the mould is closed - Chuck dusts on the powdered graphite through a fine sieve - it will be found to adhere much more easily to the sand.



The "LOST WAX" Process of making castings

Lost Wax Casting W. Savage

This short article is put in as a complete contrast to conventional casting. Little good material has been published on the subject.

The report of a lecture by Mr. W. Savage to the Sutton District Model Engineering Club

Forming the wax pattern.

IN RESPONSE to many requests, I propose to let a little light into the subject of casting by the Lost Wax Process. The methods which I propose to speak about are mainly of dental origin, which have been known in the dental profession for many years.

The article required to be cast is made in wax, of the type obtainable in the dental profession. The sheets of wax are made in many thicknesses, the one I propose to work in being 4mm thick. A pattern of the required object is first made in wax and embedded in one of the special heat-resisting plasters. The wax is then destroyed by heat, leaving a space within the plaster into which the metal is forced to produce the object required.

Silver Ivy Leaves

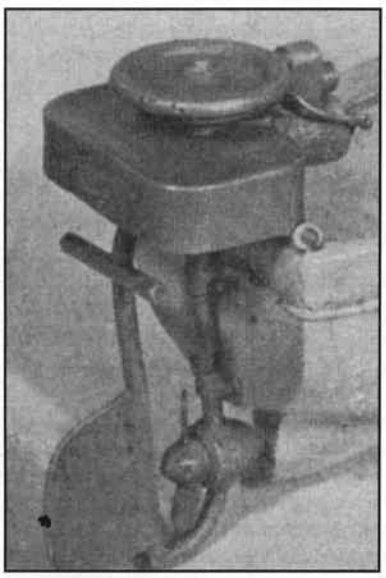
I propose first to show how to cast an ivy leaf in silver, to make it into a brooch for the adornment of our lady friends. There are several means of forcing the metal into the mould, one being by centrifugal force, known in the past as "bucket casting". To carry this out, a handle is provided, with a short chain, on the end of which is a flask and ring containing the mould. The metal having been melted on top of the mould, it is then swung in a circular motion, rather like swinging a pail of water around one's shoulder. This can be varied by using a horizontal motion, which is usually performed in these days with a spring mechanism. Another method is by forcing the metal into the mould by compressed air, or by steam pressure, which is the method I propose to demonstrate. First, we take a natural ivy leaf, and by means of plaster of Paris, we take an impression of the face of the leaf. When set, the leaf is removed from the plaster. Dental casting wax is now warmed over a spirit lamp, and gently pressed into the plaster impression of the leaf. This is now thickened slightly, to make it strong enough for the purpose for which it is intended. Having formed a leaf in wax, we now have to consider a way in for the metal. This is done by fastening, by means of heat, and, of course, into the centre of the back of the leaf, a piece of wax, formed in the shape of a wire, a little more than $\frac{1}{16}$ in. thick in diameter. In the photograph it will just be possible to see the leaf pattern in wax on the plaster impression.

Special Investments

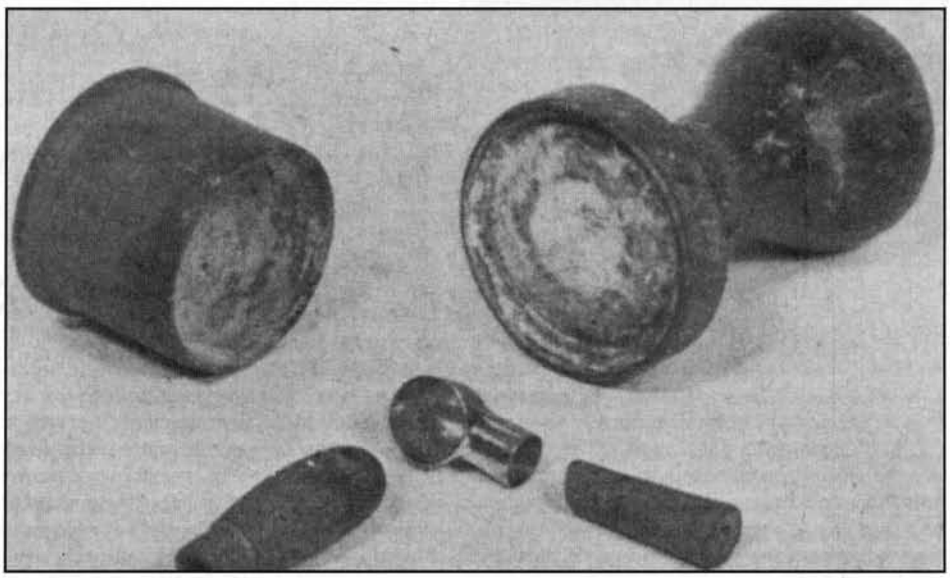
We now take a metal ring sufficiently large enough to take the pattern and using one of the special investments, which is of a plaster nature, mixed with water, the pattern is painted over with the investment. To ensure that this sticks to the wax pattern, it is a good idea, immediately before painting the investment, to paint it over with acetone. The second investment material, which is coarser in texture, is now mixed, and the ring filled with same, the leaf being sunk carefully into it, so as to be about half-way down within the ring, face downwards. The wax wire that we put into the back of the ring should just show on the top of the investment for location purposes. Having allowed the investment to set, a conical-shaped depression is cut in the top, using the wax wire as a guide, to within about 1/8in. of the wax leaf.

Using the Pressure Pad

The ring should now be placed on a gas ring, heated slowly, and brought up to red heat. The next operation is to melt the metal in the conical-shaped depression, and bring the pressure pad of wet asbestos, quickly, and with pressure, on to the top of the ring. Steam is immediately generated by contact of

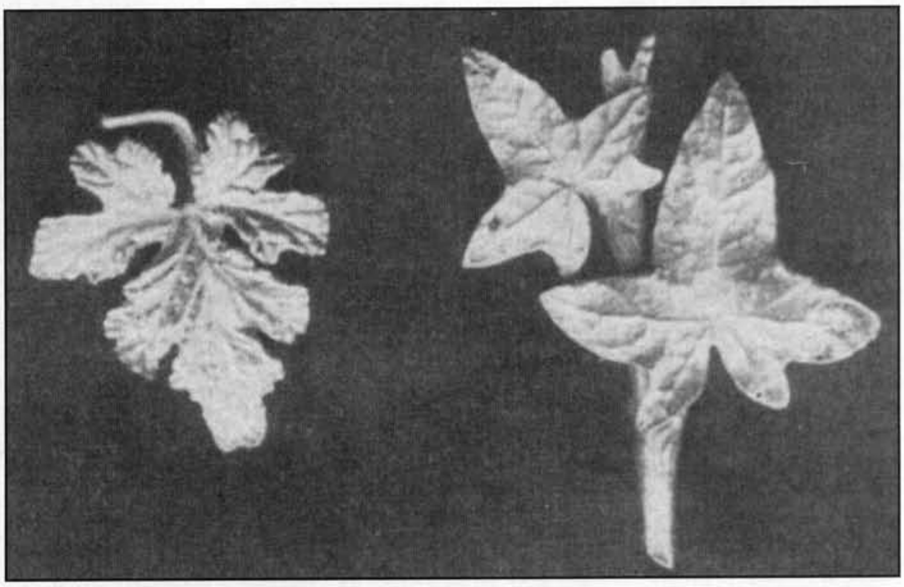


A model outboard motor cast in one piece.

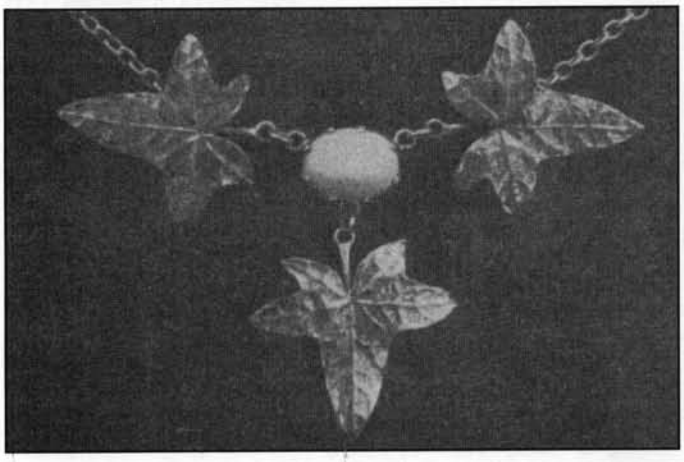


The open-ended ring and pressure pad, also wooden cores used in making the pattern for the ship's ventilator seen in centre.

Melting the silver in depression ring.



Brooches in silver, actual size.



Necklet in gold, actual size

the wet pad with the heated ring, which forces the metal into the space left by the destruction of the wax. This pressure should be maintained for a sufficient length of time to allow the metal to set. The whole may now be plunged into cold water, which will cause the investment to disintegrate, leaving the casting to be finished off by any suitable means. By this process, any small casting can easily be made, and though perhaps not always a success at the first attempt, it can be mastered after a little practice.

After the demonstration, a few articles cast in this process were handed round, and are shown on the photographs. They include a model outboard engine cast in one piece (nothing moves, of course), two brooches cast in silver, one being of an oak leaf geranium (this was made using the actual leaf as a pattern) the other two ivy leaves complete on stem, an ivy leaf necklet cast in gold with hand-made setting for the stone. Other photographs show the ring and presser, and a silver casting of a ship's cowl ventilator, together with the two-piece pattern on which the wax was moulded. The pressure pad is a loose fitting lid fastened to a wooden handle, with ¼ in. of asbestos millboard inside. I am indebted to Mr. A. R. Turpin and Mr. E. T. Westbury for the photographs published with this article.

M.E. 167 142 et seq. (1991)

Pattern Making Terry Aspen

There is unfortunately only space for a taste of Terry Aspen's little friend Chuck on another subject that he knows so well. I have had to truncate a long series, so if your apetite is whetted, you should go back to the 1991 series.

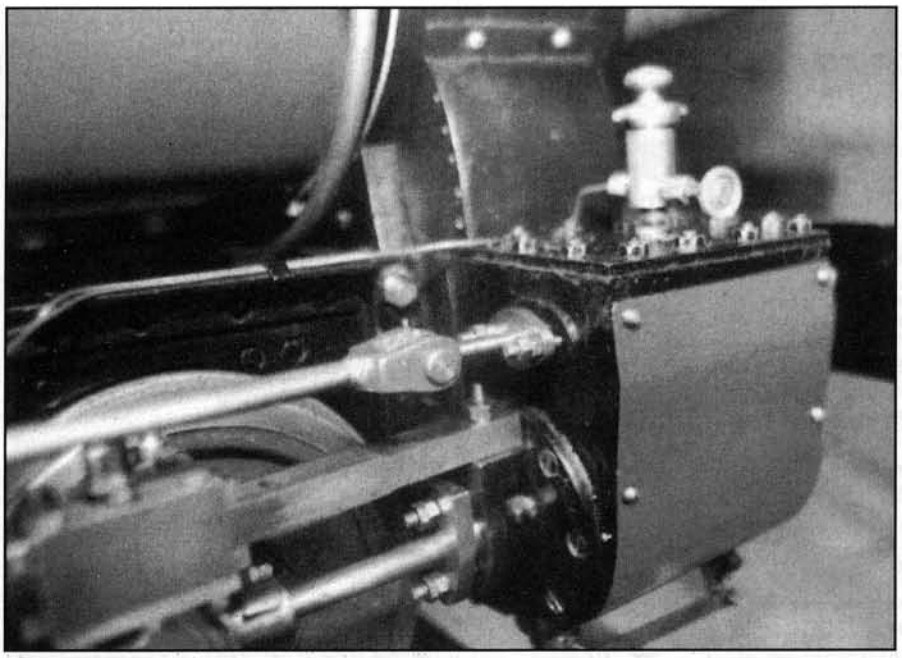
CHUCK IN THE PATTERN SHOP

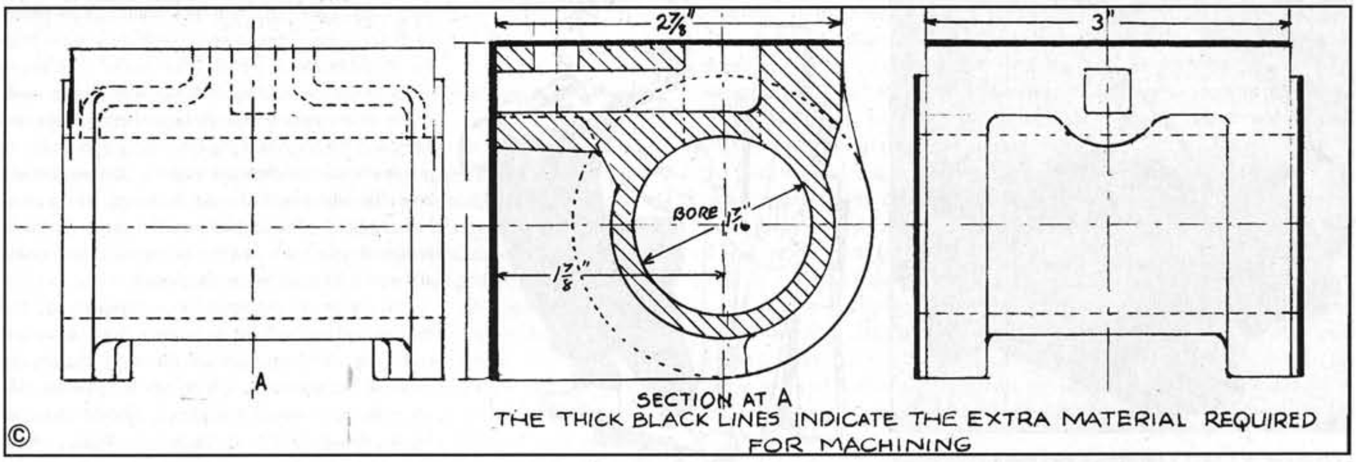
Chuck (B. Terry Aspin) has described his interest in small locomotives and described his method of building them. For those who may wish to go their own way he now discusses foundry work - starting with his way of pattern making.

ALTHOUGH perhaps there are relatively few members of the model engineering fraternity who have direct access to a foundry there are, without a doubt, many who have felt the need (or the urge) to make a special pattern for themselves. Of these special patterns, Chuck believes, a very large proportion are for locomotive cylinders. At first sight this would seem to be an extremely simple matter and, indeed, it can be made a terribly simple matter!

Perhaps a better description would be simply terrible! Chuck has seen very basic patterns of this kind which appeared to have been copied from some commercial "model" castings or from the drawings thereof. Such patterns have almost always been carved literally from a solid block of wood and, very often, the wood seems to have been chosen, apparently for its hardness. A favourite timber seems to be mahogany which, in the pattern, retains its coarse grain through coats and coats of thick paint.

Occasionally these solid patterns are intended to produce castings which have to be machined all over, including pilot drilling for the bore. With some concession to foundry technique other solid patterns will have small cylinders of wood attached at each end to represent core prints. Others will have these





prints turned integrally with the block. Perhaps it is that the thinking behind the block of hardwood is, since the pattern is to be the basis of producing a hard metal object, that itself, must be hard!

If the would-be pattern maker will take the trouble to examine the drawings of full size cylinders, however, he will quickly discover that there is no parallel in real life with the solid block technique. By and large it will be found that castings for full size cylinders, as may be expected, are a good deal more complicated than that. To begin with, to reduce the tendency towards stresses, every effort will be made to keep the sections of the casting to a fairly constant thickness. As regards the model casting, of course, no-one would suggest that stresses of that kind are ever going to be a problem, but that is still no excuse for ignoring the advantages that a properly designed casting has to offer.

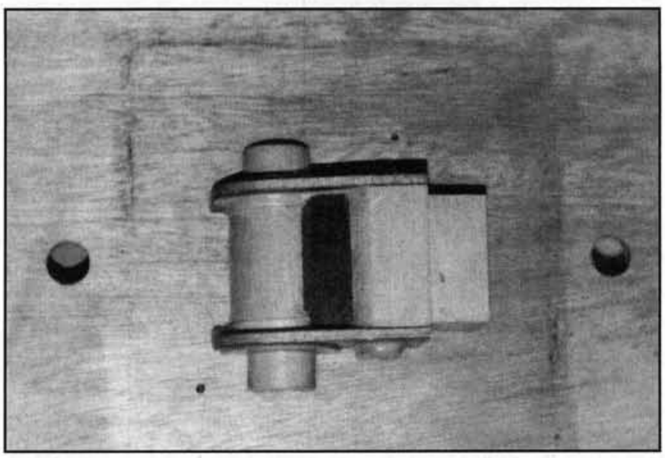
Casting from Two (or more) Part Patterns

The alternative to the solid block of wood is the pattern which is built up from several pieces and it is usually an advantage if the pattern is made in at least two parts. This as an aid to moulding. The most basic type of sand mould is made in a two-part box and the moulding process is much simplified if the cylinder pattern is also made to split with the mould. Therefore there is some wisdom in keeping this in mind from the outset; at a stage as early as that of designing the pattern in fact!

The main characteristic of a steam cylinder is precisely that, it is a cylinder. With piston valves it is two cylinders and, in the preparation of a pattern, it is sensible to commence by making the cylinder (or cylinders) as the basis of the whole operation. Perhaps the simplest example would be an outside cylinder intended to be fitted with slide valves and a separate valve chest.

The initial work is a wood turning operation but, first, the wood has to be prepared for the job. Not one piece but two, and these need to be rectangular in section, of such dimensions that, placed together they form a square section of two equal parts. Their length has to exceed by perhaps an inch or so the total length of the cylinder and its core prints. The exact amount of extra timber is not critical but it is an advantage to have ½ in. of waste to cut off when the turning is completed. The two pieces of wood are held together with dowels of a sensible diameter for the work in hand. Only two dowels are called for and these are positioned at equal distances from the middle of the timber within the length which will ultimately be the cylinder outside diameter NOT including the end flanges.

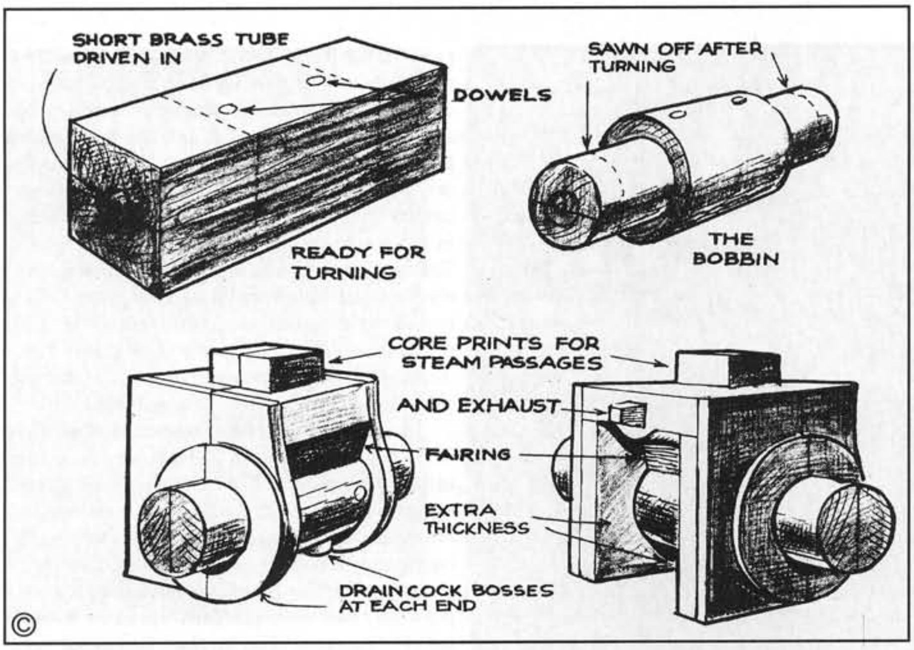
Before the turning can commence the work has to be centred and, to prevent the work separating when in the lathe, a quarter of an inch or so of thin brass or copper tube is located round each centre pop and driven into the end grain of the wood. Most model engineers will probably start by putting one end of the work in the four-jaw chuck and centring the other but it may well prove profitable ultimately to make use of both centres. They are there if you need them.



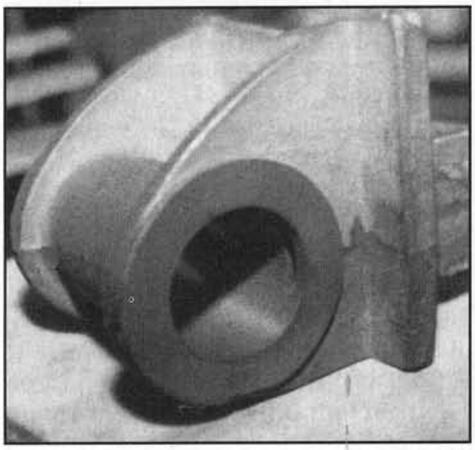
A cylinder pattern for Chuck's 5 in. gauge Wren locomotive, with extended core-print for the overhung core to the valve chest.

Choice of Timber

Chuck is often asked what kind of timber to choose for pattern making but it is no longer a valid matter to quote the textbooks on this. It is many years since his early endeavours in the matter of foundry technique and, in those days, a great choice of woods was available - at low prices! Now, unhappily, the situation is very much changed and some woods like obeche for example are virtually unobtainable. Some model shops may stock wood in a variety of



A finished cylinder fitted to the 5 in. gauge Wren, Gee Wizz.



From one of Chuck's patterns, a part machined casting for a 5 in. gauge Hunslet.

INFERIOR MATERIAL

sawn sections which may be useful, but if this has a pronounced grain like spruce or is hard like beech or ramin, it is better to leave it in the model shop.

But the redeeming feature of model pattern making is that, for the most part, it calls for only a small volume of timber. If one is on a nodding acquaintance with a furniture manufacturer some of his off-cuts may well fit the bill. Chuck only hopes that his readers will be as happily situated in this respect as he is himself! The general specification would be wood which is reasonably easy to work and of fine grain. Conte board ain't much use, but a variety of thicknesses of plywood may be pressed into service with some advantage. While he is out shopping the pattern maker will also need some white glue, some fine brass pins and some sandpaper.

In his early days as an amateur Chuck's textbooks told him that the professionals made their patterns of yellow pine. His patterns were often made from wood cut from butter boxes and so on! Pride has no place in the foundry! Chuck is still an amateur and his suggestions for making model cylinder patterns and his sketches thereof are based on what he believes will be the requirements of an amateur.

At the same time he realises that it would be quite impossible to generalise in the matter of locomotive cylinder patterns and he therefore offers the present simple design purely as an example of what can be done. The method, however, will be seen to hold good at least in part for a wide variety of cylinders. He also understands that the first obstacle the average model engineer has to overcome is his apparent aversion to working in such an 'inferior' material as wood.

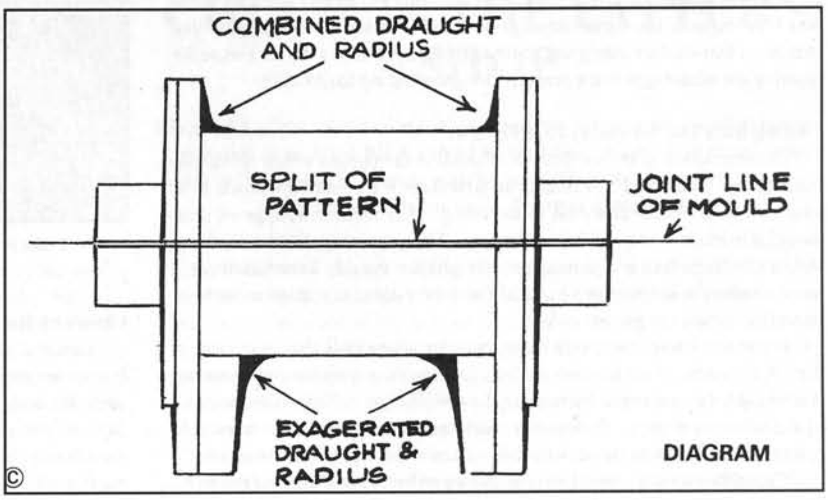
Another comment he has heard from time to time is that "it seems such a lot of trouble to go to" just to make a pattern! But he finds such a remark difficult to reconcile with the amount of effort some modellers have made to hack boiler formers from block-board and so on. After all, it's only softened copper to be formed!

A Simple Cylinder

The sketch is of an outside cylinder without a bolting flange. That is to say, a cylinder which is secured in place by means of set screws directly into the casting from inside the frame. Not the sort of thing one is likely to meet with frequently in real life, but a device which is employed on models. If a flange is called for there is more than one way of achieving this and an explanation will follow later.

To follow this drawing in its present form the first thing the pattern maker would require to produce is a "bobbin" which would represent the outside diameter of the cylinder, in this case $1\frac{7}{8}$in; and the core prints at either end. With a proposed bore of $1\frac{7}{16}$in. a core of $1\frac{1}{4}$in. dia. would allow plenty of material for cleaning up so both ends of the bobbin would be reduced to this dimension. The length of the bobbin remaining at full diameter in the middle is determined by the distance between the end flanges; $2\frac{3}{8}$in. Allowing for $\frac{1}{2}$in. projecting core prints at each end the total length of the bobbin will be $4\frac{1}{2}$in. which will also be the length of the core-box required. The surplus wood at the ends can be removed with a saw and the two parts of the bobbin are now held together by the dowels.

Attention is now turned to cutting out the end flanges and as these are $\frac{3}{16}$in. thick they can conveniently be cut from plywood following the dimensions on the drawing. Chuck can hear voices asking "But what about shrinkage? Should there not be an allowance for contraction?" Well, perhaps there should but, since the contraction of cast iron is little different than $\frac{1}{16}$in. to the foot it is his view that, in a casting of this size, shrinkage can be ignored. Provision does have to be made however for subsequent machining of the pattern. In the case of the bore this has already been allowed for by the difference between the core diameter and the size of the finished cylinder. On the overall casting a machining allowance must be added on the valve face, the back, which bolts to the frame, and the bolting flanges at each end. The addition, which is indicated on the drawing, can be in the region of 2mm and,



ATMOSPHERIC VARIETY

since the dimensions of the end flanges govern the overall size of the cylinder, these additions should be made before cutting out.

Both ends are cut out as one and the hole which forms the centre of the circle should be made a reasonably close fit on the core prints. The pattern is to be split vertically so the division of the bobbin should line up with the vertical centre-line of the cylinder. It is a good idea to saw partly through the centre line from the top and the bottom using the finest blade you can find. This will be an aid to the ultimate splitting of the finished pattern.

The pattern can be erected at this stage using P.V.A. glue and, as far as practicable, keeping the glue away from the immediate area of the split. Using a flat surface the assembly is checked for squareness in every direction before the glue sets. In the meantime the additional material for the end flanges can be cut from 3mm ply. These consist of two rings $2\frac{1}{2}$ in. dia fitted over the core prints and glued in place as before. Many model cylinders Chuck has seen have been machined flat over the whole end of the cylinder, but having the flange proud of the main casting is more in keeping with normal practice. (He also thinks it looks better.) For the rest it is mainly a matter of filling in between the plywood ends to achieve the section shown in the drawing. The indication of the exhaust passage is ignored at this stage. This filling-in consists essentially of two rectangles of wood. A narrow one from the outside of the pattern to the centre division and a wider one from the bolting face to the centre division. On this pattern these would need to be $\frac{5}{8}$ in. thick.

To provide sufficient 'meat' on the reverse side of the casting to receive the bolts from inside the frame, two more bits of wood $\frac{5}{16}$ in. thick are required. They are a matched pair so they can be cut out together and they extend from the back of the pattern to the centre line. They are cut out to match the curve of the cylinder and are glued on the inside of each of the $\frac{3}{16}$ in. plywood flanges at the rear. The basic pattern is completed by 'fairing off' at the front and back with pieces of triangular section as indicated in the sketches.

Adding Details

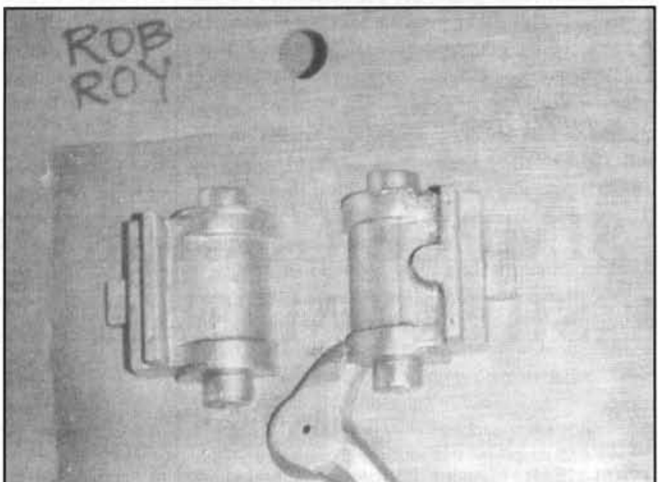
At this stage it will be noted that the pattern is not likely to be solid on the inside but it will present a smooth contour to the sand and that is what is important. If this pattern is to produce a casting cored for the cylinder only, as so many model castings are, there are only three small details to be added. More material is required in the region of the exhaust and that is indicated by an inverted arc on the drawing and by a slight taper on the section. Half inch drain-cock bosses are also indicated although, in fact, these are represented by small quarter rounds glued on the inside faces of the plywood flanges under the cylinder.

Chuck is sure that all readers will be aware that foundry patterns are usually finished off with radii or fillets between the angles. It is possible to purchase leather fillets to do the job professionally but a satisfactory result can, in fact, be obtained by the use of modelling material; such as plastic wood, "Milliput" and so on. There is also the matter of draught. Not the atmospheric variety but the slight angle given to the sides of a pattern to allow a cleaner withdrawal from the sand. As far as the present example is concerned, the draught will be of greatest importance at the back of the pattern where the deep hollow leaves its own core in the sand. Here the radii can, with advantage, be more pronounced and, although it has been stated that the inside cheeks should be $\frac{5}{16}$ in. thick, it would be advantageous if they tapered from $\frac{3}{8}$ in. or more at the cylinder to the required thickness at the outside edge.

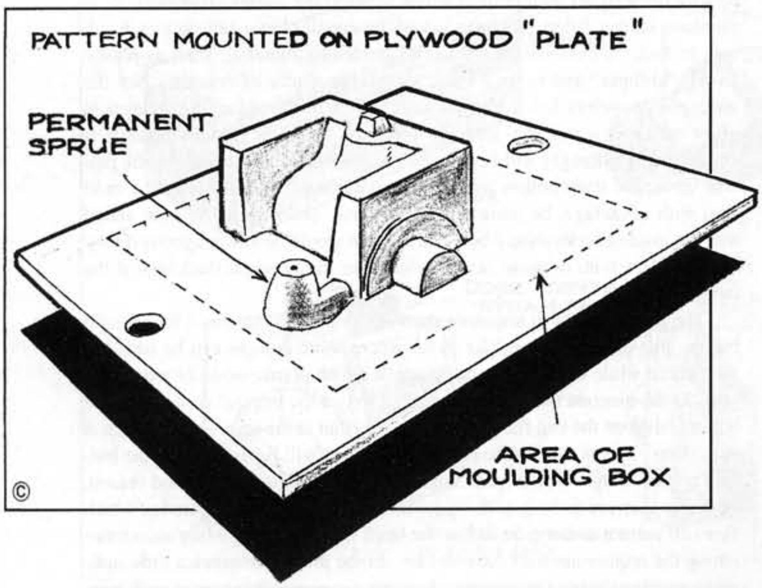
The four sketches in sequence show nothing of the radii and the draught but the line diagram (Page 12,) shows where some draught can be added to the pattern while the radii are being applied with plastic wood or what have you. In the diagram most attention is focused on the internal contours of the pattern between the end flanges; particularly that at the reverse side which is very deep. This is usually the pattern half which will be moulded in the bottom box or 'drag'. The outside faces of the flanges may, with good reason, be left as they are so long as there are no undercuts. This is a paradox which faces all pattern makers; to follow the spirit of the drawing while accommodating the requirements of the moulder. In the present instance a little judicious sanding during the process of painting can usually produce sufficient relief to allow a satisfactory withdrawal from the sand.

In the matter of painting Chuck rejects the use of oil-bound paints or enamels. In the first place they slow down the progress of the work while waiting for one coat after another to dry. He pins his faith in cellulose. Particularly clear sanding sealer. It dries very quickly to a hard surface, which responds well to sanding between coats, and cures to a good non-sticky finish. Before the advent of cellulose finishes pattern makers used shellac, but the newer material is far superior (Chuck's opinion).

If, as suggested a few paragraphs back, the pattern is to produce a casting in which only the cylinder is cored the prints indicated in the sketches, for steam passages and exhaust, can be ignored. Assuming that the final separation of the two parts has been completed, using the same fine saw and avoiding cutting through the dowels, the job is ready for moulding. If, as has been suggested, the deeper part of the pattern is to be moulded in the drag, the dowels should be withdrawn from that and allowed to remain in the other part where they are fixed. They will probably need to be shortened to about $\frac{3}{8}$ in. and relieved so that the pattern halves will separate without discernible resistance. The drag box can now be rammed up over a half pattern which lies flat on the bench in the usual way.



A turn-over pattern plate for cylinders and valve chests for Rob Roy.

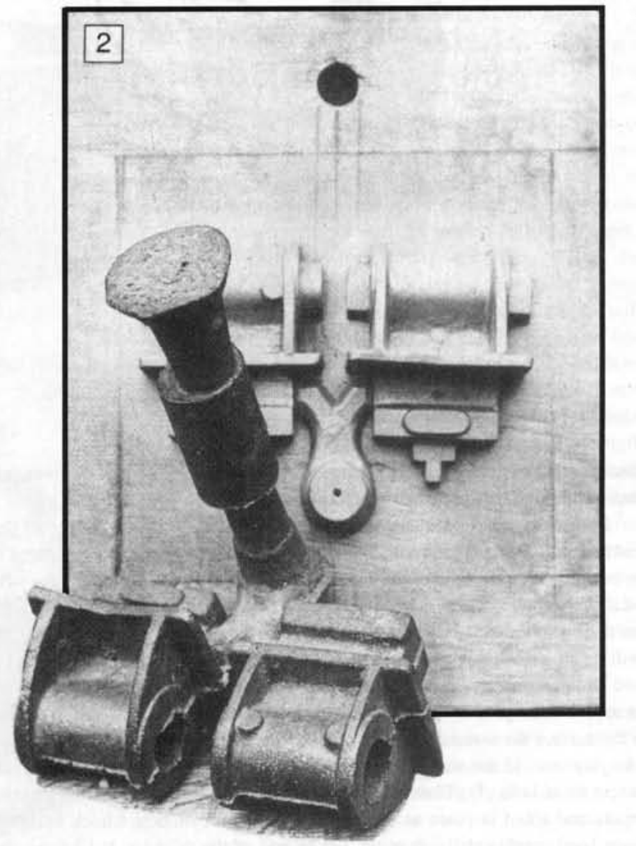


The Plate Pattern

These "few choice words" from Chuck, however deal rather with making patterns than moulding 'em so it will be assumed for the time being, at any rate, that his readers will be largely au fait with the moulding process. While remaining on the subject of patterns, however, there is a way in which Chuck can assist the moulder if he is prepared to go to a little more trouble. It is the matter of mounting the pattern on a 'plate' to suit the moulding boxes or 'flasks' to be used.

The plate is a rectangle of plywood about ⅜ in. thick which is cut large enough to cover the entire moulding box, including the pins, with an excess margin of about an inch. For a box nine inches square, for example, a plate 13 in x 10½ in. would be adequate. Holes are bored in the plate on the centre line to match the box pins and these are eased so that the plate will slide on and off the pins freely. The dowels are removed from the pattern so that a drill of the same size can be passed through and the first half of the pattern is positioned on the plate with due regard to its distance from the sides of the box and space to accommodate the pouring sprue.

Here is one of the big advantages in the plate pattern. There is plenty of time to consider the location of the sprue and this can also take the form of a small pattern which is attached permanently to the plate. It is usually located on the underside of the plate after the dowel holes have been extended right through and the other pattern - half positioned thereon. The sprue pattern should be given an exaggerated draught so that there can be no problem with it in the withdrawal and it can be finished, like the main pattern, with sanding sealer. Indeed, the same should be applied; at least one coat; to the whole plate. To complete the job the usual 'sprue stick' should be endowed with a brass pin - say ⅛ in. diameter - in its end and the centre of the sprue pattern pierced to correspond. Moulding loose patterns is really work for the expert and, although an amateur can acquire a good deal of confidence if he does a fair amount of it, he can never attain the skill of the professional, after perhaps a lifetime in the industry. The plate pattern as described gives the beginner the opportunity to do a first-class job at the initial attempt. Some other real advantages to the modeller will be described at a later stage.



The pattern plate and a pair of cylinders for Chuck's 3½ in. gauge locomotive Holy Smoke

M.E. 102 866 (1950)

SIMPLE GEOMETRY OF SHEET METAL WORK

Sheet Metal Developement
M.G.A. Ford / Andrew Smith

Here are two different approaches to a straightforward problem, of which the first is quite conventional. These days with CAD developement is less time consuming.

by M. G. A. Ford

THE idea of saving time need not appeal to every model maker. If he be of the true faith, his work will never be done, no matter how quickly he pursues his immediate ends; in any event, time and care go hand in hand.

There are some simple operations, however, which seem to persist in taking more than their fair share of trouble, and they are usually so simple that no attention whatsoever is paid to reducing them to their proper perspective.

Perhaps the chief among these annoying side-trackers of the earnest model maker, is the small shape, possibly only in cardboard, which must, nevertheless, fit its adjoining member properly and look solid. For example, a cone of a certain shape must be made. The part may be ever so insignificant, but the true modeller must have it just so. Let him do it quickly and "first time", however, instead of by the sometimes lengthy method of trial and error.

It may be that we already know this method (see Fig. 1). Why not? It is certainly simple enough to work out for oneself. For those who have not used it before, however, it may release many spare minutes to spend on something of far greater importance.

So long as either the slant height or the perpendicular height is known, and the diameter of the base, nothing else is required. If not given, the slant height must be calculated from the true height by means of Pythagoras.

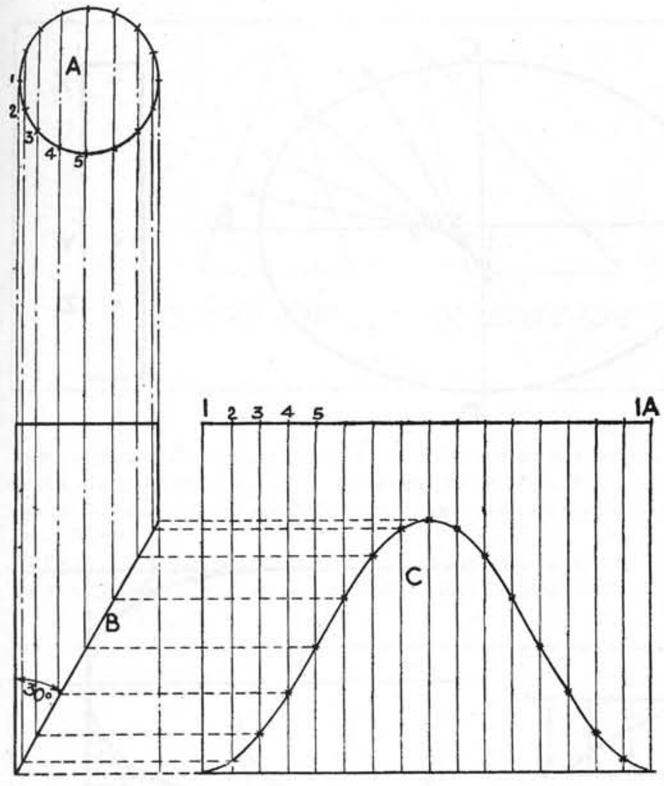


Fig. 2

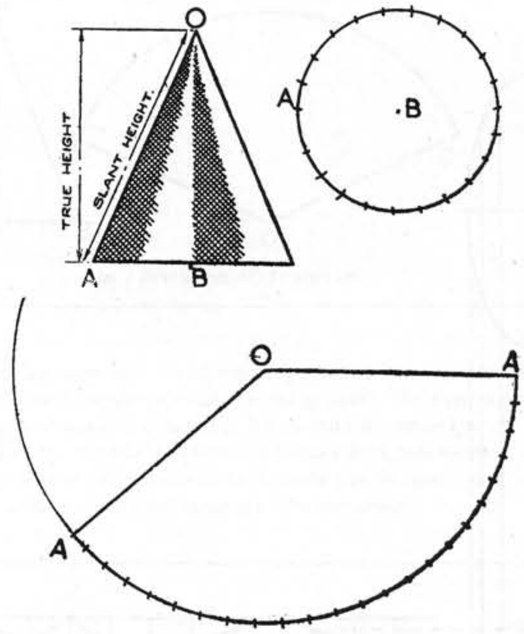


Fig. 1

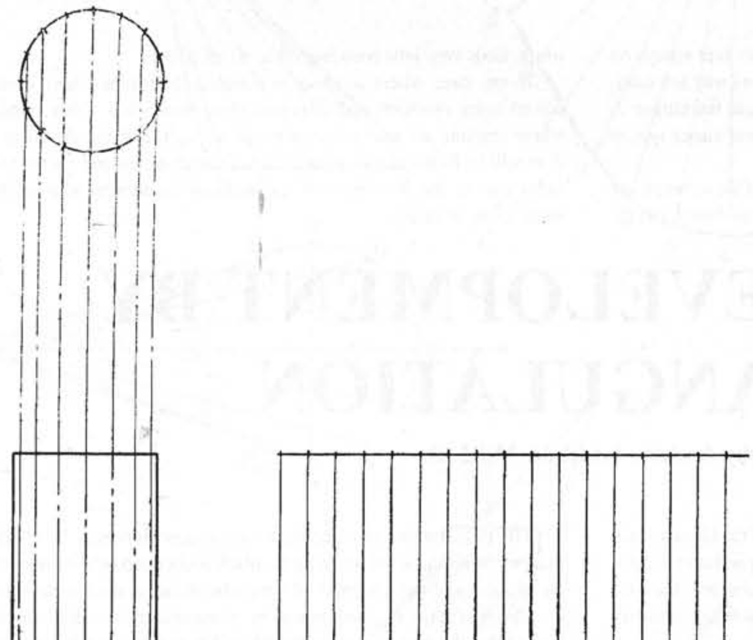


Fig. 3

An arc, radius the slant height, and length the circumference of the base, joined to the centre by the radius of each end, will give the required shape. (If it is inconvenient to calculate the circumference of the base of the cone, it is a simple matter to draw it and step off the distance by means of dividers).

Probably the method of cutting a cylinder to fit an inclined plane is less widely known. This certainly does save some nasty moments, as it can be seen from Fig. 2 that the result is not very easy to imagine in advance, and it is no simple matter to "slice off" a cylinder at an angle.

The plan of the cylinder, a circle "A", is drawn above the line "B", representing the plane which the base must fit, and the correct angle - in this case 30 deg. The third projection, "C", has a side 1-1A level with the top of the cylinder, equal to the circumference of "A", and stepped off into sixteen divisions corresponding with those around "A". From each point on "A" in turn, a line is first dropped to "B" and from the point at which it strikes "B", a second line is drawn across to "C" until it meets the perpendicular from its corresponding number. Thus, for instance, point "5" is connected from the circle "A" to the line "B" and across to the perpendicular from point "5" in "C". By joining the sixteen fresh points thus formed, the contour is constructed to which the cylinder's base must be cut. (N.B. - A flange, to fix the two edges of the cylinder together, is here shown at each end of "C". These flanges, of course, have no bearing on the geometrical construction). The sort of curve which results from applying exactly the same practice where two cylinders must be joined to each other at right-angles can be seen in Fig. 3.

Once the principle is grasped, any contour can be easily obtained and, broadly speaking, the more complicated the shapes, the more time can be saved in this way. The author once spent time considering how to cut a cylinder base to fit securely on to a sphere, before realising that a straight edge would suffice.

It will probably already be clear to the reader that, if a pipe or tube of, say, elliptical cross-section were to take the place of the pipes of circular section in Fig. 3, an ellipse and a circle would have to be employed instead of two circles, although thereafter one would proceed as before (See Fig. 4.). It may, therefore, be of interest to read of two simple methods of drawing an ellipse, which, while not quite perfect, are near enough for almost any purpose.

An ellipse has two axes, the major, or long axis and the minor, or short axis. In Fig. 5, these are shown by "AB" and "CD" respectively. Take a straight strip of wood or metal and at one end make a point "X". A second point, "Y" is placed at a distance from "X" equal to half the minor axis; a third point, "Z" is located half the length of the major axis, from "X". If point "Y" is

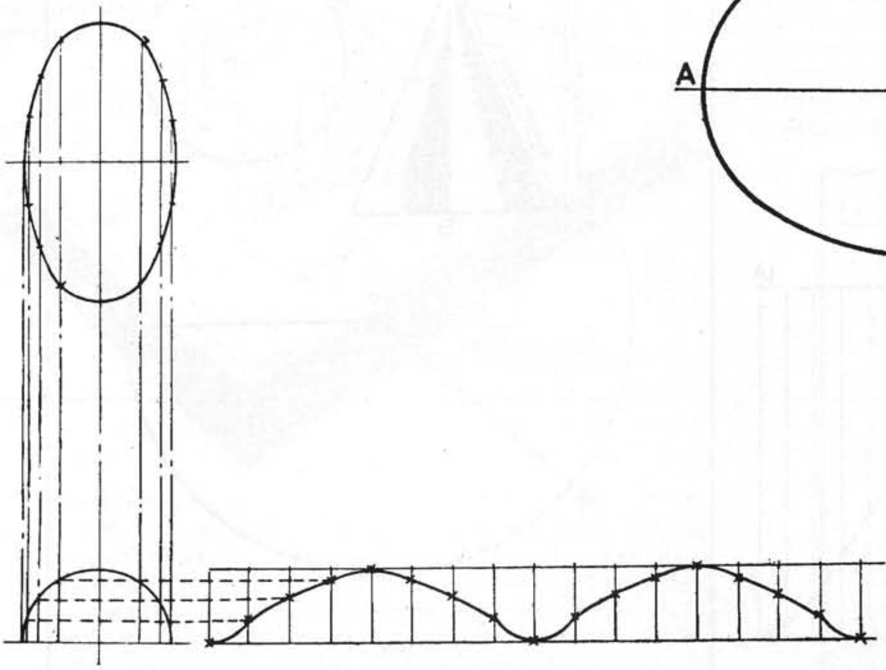


Fig. 4

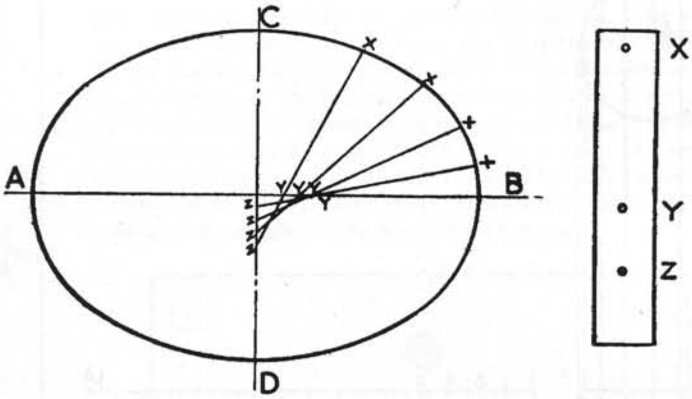


Fig. 5

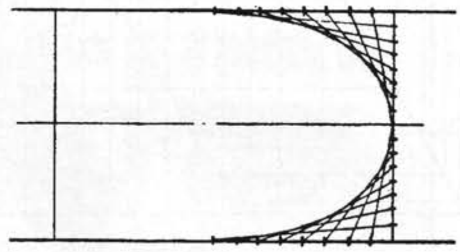


Fig. 6

placed always on the line of the major axis, while point "Z" is kept always on the minor axis, point "X" will always lie on the ellipse. In this way any number of points "X" may be found and joined together, will make the ellipse. A slightly rougher, but still serviceable method, and a good deal easier one, is shown by Fig. 6.

The figure is almost self-explanatory. The sides and ends of the rectangle are divided into the same number of equal parts. These are joined as shown, and the result needs very little rounding off to be an ellipse.

In any case, where accuracy is essential the means I have described have solved many problems and dispersed many headaches. Very often, too, even where absolute accuracy is not required, a rough freehand sketch of this procedure will be found to give a good idea of the shape needed for the job, and provides one of the few ways of speeding up production with anything but a sacrifice to neatness.

CONE DEVELOPMENT BY TRIANGULATION

by Andrew Smith, A.M.I.E.D.

WHILST the method of forming the development of the blank to produce a plain or truncated cone is know to most mechanics, difficulties are frequently encountered in circumstances where the cone is not a right cone but is instead of the form known as an oblique cone (see Fig. 1.).

In the case of the right cone, the method of producing the development is shown in Fig. 2, where with O as centre and OB, the slant height of the cone, as radius, the arc PQ is drawn. The curved length PQ is, of course, equal to the circumference of the cone base, and may be obtained by stepping off from a subdivided plan view, or by calculating the circumference, that is 3.1416 AB. In practice the angle POQ is often computed. Taking as an example a cone having a base 10 in. diameter with a slant height of 15 in.

$$\text{Angle POQ} = \frac{10 \times \quad \times 360^\circ}{2 \times \quad \times 15} = 120^\circ$$

or

$$\text{Angle POQ} = \frac{\text{Diameter} \times 180^\circ}{\text{Slant height}} = 120^\circ$$

The development of an oblique cone cannot, however, be obtained in this manner. With shapes of this type the blank is obtained by assuming that the article is made up from a number of triangular strips having a short base length.

The first stage in development by triangulation is to draw the front elevation so that the true lengths of the edges AB and AC may be ascertained (Fig. 3.). Draw the plan of the base, that is a circle, and divide the perimeter into an even number of arcs of equal lengths. Project the division points up to the elevation base BC intersecting at D, E, etc., also downwards to cut the horizontal centre-line of the plan. Now the lines DA, EA, etc., on the elevation for the perpendicular heights form triangles, the sides of which conform to the outline of the cone. The bases of the triangles are equal to the distances DD, EE, etc., on the plan.

From the intersection on the centre-line of the lines EE, etc., on the plan, mark off the respective lengths of DA, EA, as given on the elevation. Complete each triangle as shown, the hypotenuse of which gives the true length at the stated position.

With the true length at each position known, draw a vertical line AC equal in length to AC on the elevation. On either side mark off the distance equal to a division on the plan. With AC as centre, mark off H and H_1 equal to the true

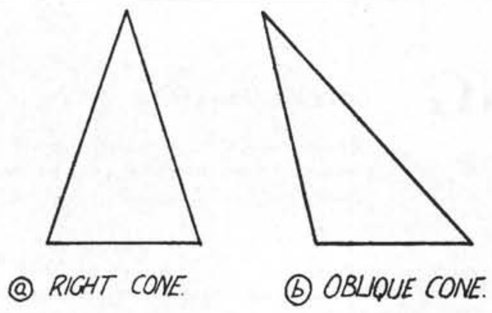


Fig. 1

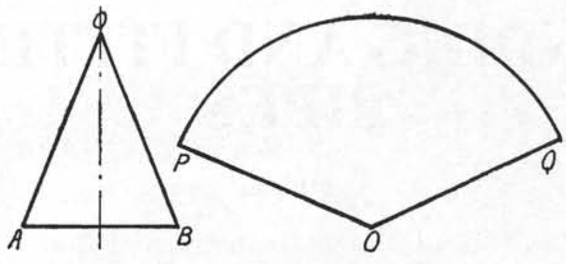


Fig. 2 Developement of right cone

length taken from the true-length diagram. Continue this for each position, finally, taking the true length of AC from the elevation. Now draw a line through the points of intersection; this gives the blank shape enclosed by the lines ABCBA.

Finally Fig. 4 illustrates an example of this method put to use recently by the writer, in setting out a forge-hood to meet an offset flue pipe.

The first stage, after completing the elevation of the required connection, was to project the cone upwards to find its apex. The main outline of the development was then obtained as for an oblique cone of base equal to the large diameter and height equal to the distance from base to apex. The truncated portion was then determined in a similar way, working from a base equal to the diameter of the small opening on the connection.

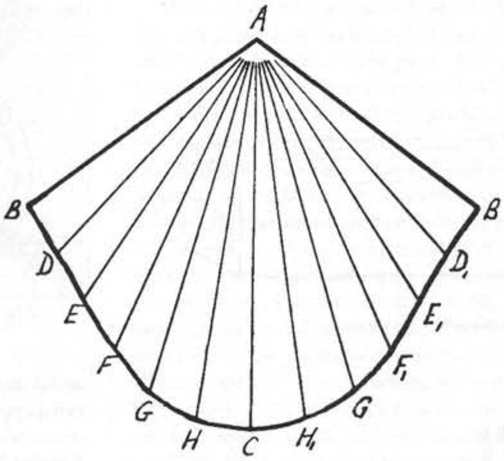
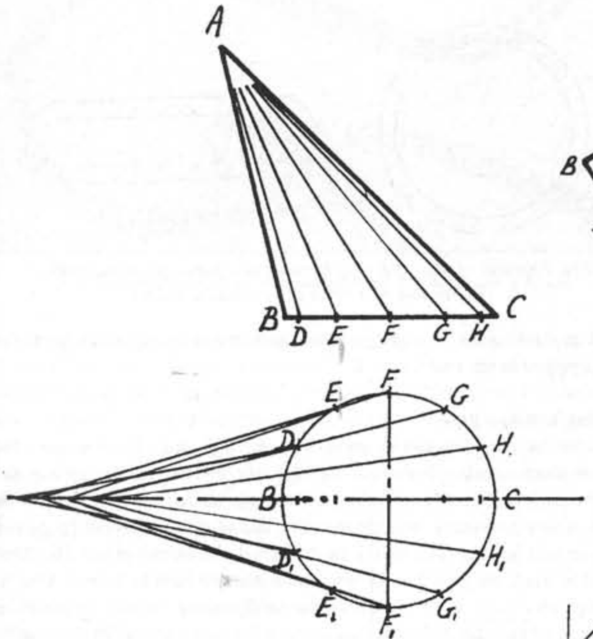


Fig. 3 Development of oblique cone



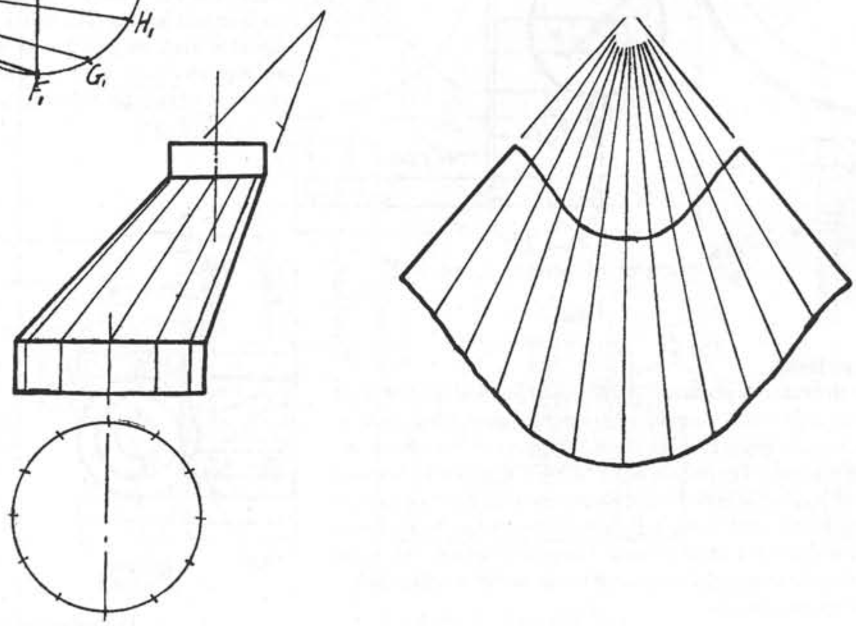


Fig. 4 Setting out a forge-hood

M.E. 102 866 (1950)

BENDING AND FITTING PIPES

Tube Bending Duplex

I have included this in the material preparartion section because it really deals with setting up metal for subsequent fabrication

by "Duplex"

THE bending of copper, brass and steel piping is an operation the amateur is often called upon to perform, and the results are not always satisfactory. Machine methods of bending undoubtedly give the best results, and, in fact, are almost essential where a uniform series of bends is required. Nevertheless, bending by hand will be found quite effective for all ordinary work, and moreover, the necessary equipment already exists in the workshop; this consists of commonplace mechanical components to serve as formers for bending the tubing.

In this article simple methods of bending will first be described. This will be followed by some notes on fittings and their attachment to pipes. Finally, full instructions will be given for constructing a commercial bending machine, designed especially for use in the small workshop. This machine will not only deal with pipe work, but will also be found capable of making bends in metal of widely varying cross-sections.

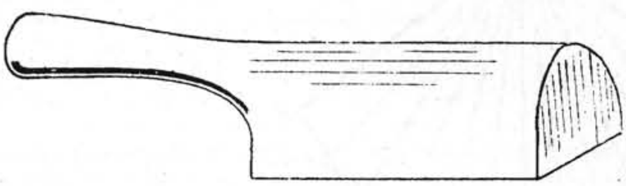


Fig. 1 A plummer's dresser.

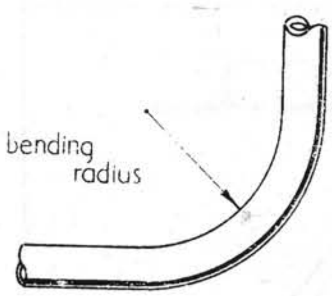


Fig. 3

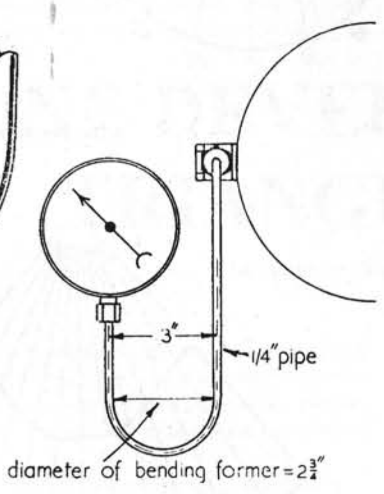


Fig. 4

Bending Pipes by Hand

Pipes having an external diameter of $\frac{5}{16}$ in. or less may be bent unfilled. That is to say there is no need to load the pipes with one of those substances used by coppersmiths to fill pipes before bending. Sand, lead, resin and "Cerrobend" are all used as filling materials. The purpose of the filling is to prevent kinking and deformation, and the choice of material will depend upon whether the pipe is to be bent in the hot or cold state. Thus, steel pipes of large diameter, as are used for motor cycle exhausts, are filled with sand. This practice applies only to the making of a single pipe with simple equipment, for the factory would employ a bending machine for this purpose.

Small copper pipes are bent cold, but those of large diameter may be filled either with lead or "Cerrobend"; the latter is a commercial alloy consisting of Wood's metal and melts at a temperature much below the boiling point of water.

Resin has been mentioned as a filling, but, today, it is seldom used owing to its liability to break up at the point of bending.

A method at one time used by plumbers when bending lead piping was to insert a tightly coiled spring into the pipe to keep its section uniform during the bending process.

Bending Formers

It is bad practice to bend pipes without some type of former, and failure to do so will inevitably result in the bend becoming uneven. There is no need to be at a loss for a suitable former, for the workshop abounds in objects which will serve admirably for this purpose. To name but a few: cone pulleys or pulley castings, the circular tables from drilling machines, off-cuts from steel bar,

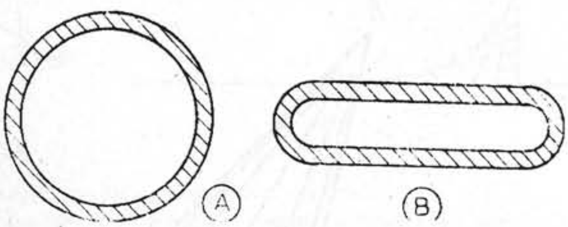


Fig. 2 Section of pipe after: (A) bending to a curve of correct radius; (B) bending to a curve of too small a radius.

and even glass bottles, though these latter must be well wrapped in rag before being gripped in the vice.

Bending Unfilled Pipe

Before any bending can be carried out the pipe must be prepared. This involves three separate operations: cutting to the approximate length required; straightening; and finally annealing if the material is copper or brass. The length of pipe required is best measured by taking a piece of stout gauge copper wire and bending and fitting to the actual run of the pipe. The bends should be made easy, so that the pipe can readily be bent to shape. After the wire has been bent to fit the work, it is straightened out and measured, an allowance of an extra inch or so being given for the bends in the pipe itself.

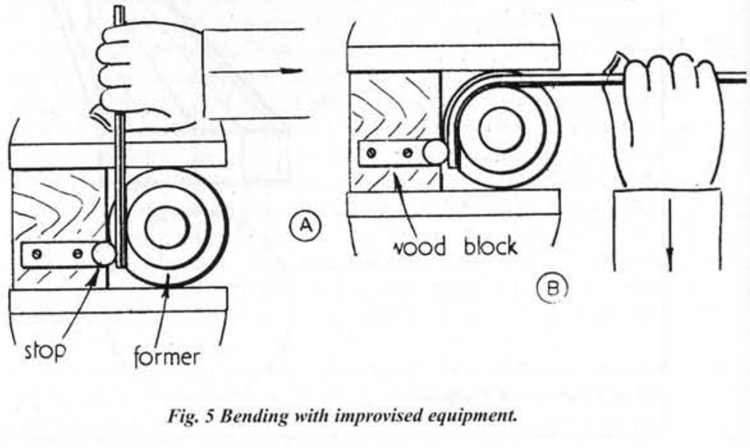


Fig. 5 Bending with improvised equipment.

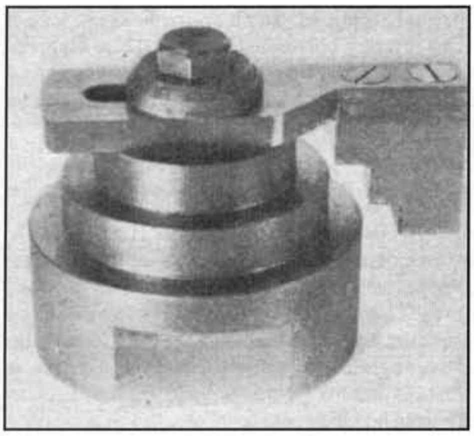


Fig. 6a The bending block.

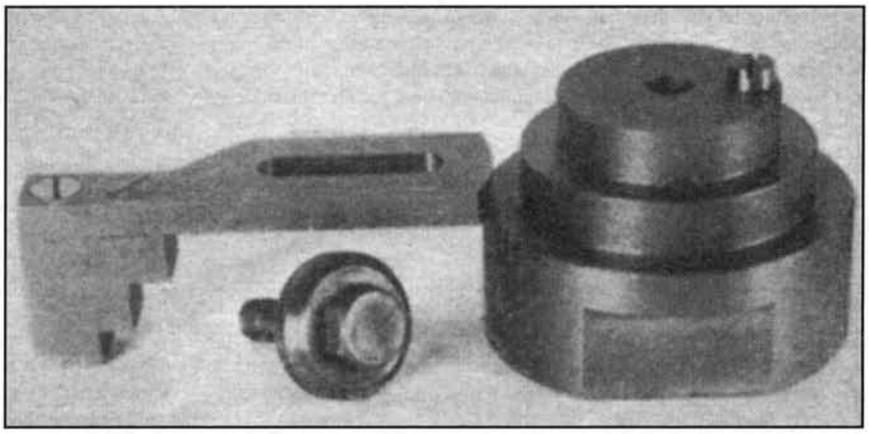


Fig. 6b The bending block dismantled, showing the component parts.

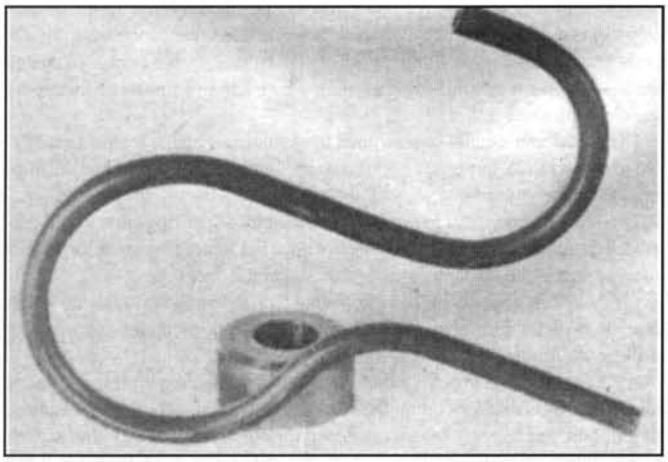


Fig. 7 An example of pipe bending made on the bending block.

The pipe is now straightened by rapping it on an anvil or a lead block. A metal hammer must not be used for the purpose, for this would only cause dents in the pipe; instead a piece of hardwood, about 1 ft. in length, and some 2 in wide by 1 in. thick, is employed to strike the pipe; meanwhile the work is held up to the eye so that the position of any kinks can be detected. Plumbers and sheet-metal workers use for this purpose the tool illustrated in Fig. 1 and known as a dresser. The best are made of boxwood, but beech will serve equally well. If much work, either on pipe or sheet metal, is contemplated, the making of this tool will be well worth while.

The next step is to anneal the pipe, should it be made of copper. This done by playing the flame of a blow lamp or brazing torch along the pipe till it assumes a bright blue colour. There is no need to quench the work in water, as this has no beneficial effect on the annealing process but merely cools the work quickly. In passing, it should be observed that badly bent pipes should be annealed before being subjected to the straightening process described, for the more malleable condition of the metal brought about by annealing greatly facilitates the subsequent work of straightening the pipe.

Mild-steel pipes do not need annealing, for ductile metal has to be used for the manufacture of these pipes by an extruding process. Moreover, there is but little tendency for metal of this kind to become work-hardened during bending operations.

Brass pipe is usually made from what is known as bending-quality brass, and this material, again, suffers no material physical alteration when being worked.

Pipes made from aluminium alloys need different kinds of treatment. The soft alloys need no annealing, but this process is necessary with the harder varieties such as duralumin. A rough method of assessing the correct temperature is to heat the metal until the application of a piece of yellow soap to the work turns the surface black; but is must be emphasised that this procedure is merely empirical and it is by no means necessarily the best method for all aluminium alloys. When both the maker and the specification are known, it will be better to consult the manufacturer in order to obtain authoritative instructions as to the proper procedure.

The pipe is now ready for bending. A former of the correct diameter is gripped in the vice and the pipe is bent round the former by being pulled with the hands. The selection of a suitable size of former depends upon two factors; the first and the more important of these is the size and wall thickness of the pipe. These dimensions will decide the minimum radius to which a pipe can be bent freehand without its cross section becoming flattened. In Fig. 2 a section of pipe is shown: A, after being bent correctly, and at B when the pipe has been flattened by being bent to a curve of too small a radius. Apart from the unsightly appearance produced, it will be obvious that a pipe flattened in this way will have its bore constricted; it is, however, possible to make good the damage, in part at least, by

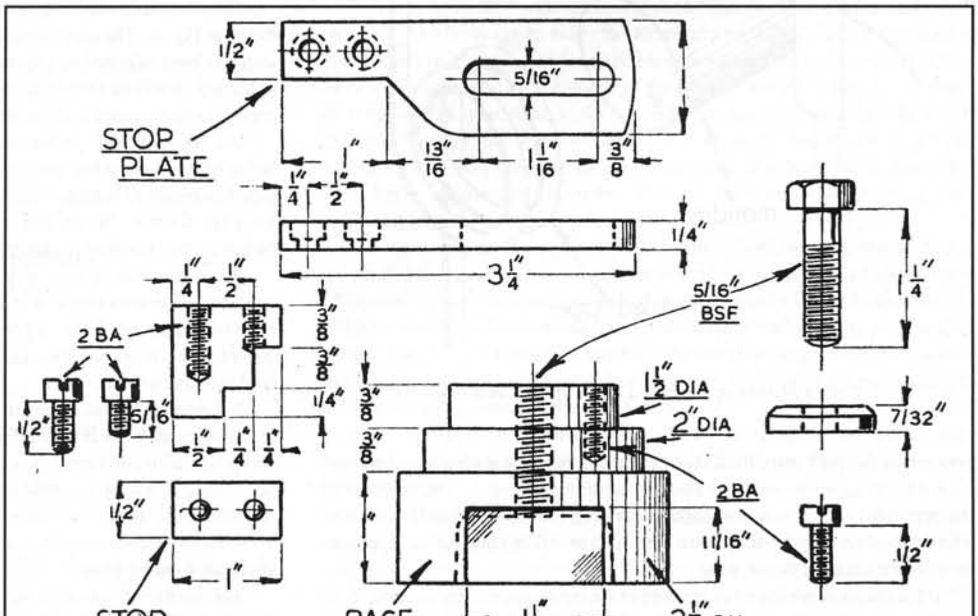


Fig. 8 Details of bending block

compressing the pipe bend between the jaws of the vice. Clams must, of course, be used on the vice jaws to prevent injury to the surface of the work.

Experience has always shown that convenient minimum radii for bending unfilled pipe of No. 20 s.w.g., as commonly used for fuel lines, are as shown in the table below:-

$\frac{1}{8}$ in. outside diameter	.. $\frac{1}{4}$ in radius
$\frac{3}{16}$ in. outside diameter	.. $\frac{1}{2}$ in. radius
$\frac{1}{4}$ in. outside diameter	.. $\frac{3}{4}$ in. radius
$\frac{5}{16}$ in. outside diameter	.. 1 in. radius

These measurements are taken from the centre of the circle to the inside of the bend, as shown in Fig. 3.

As rectangular bends are so often used to change the direction of the run of a pipe, these figures should be found of practical value.

The second factor which decides the size of the bending former is the dis-

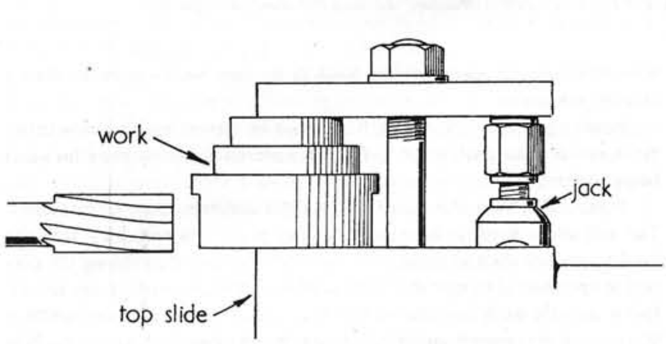


Fig. 9 Mounting the base block, end-milling the flats.

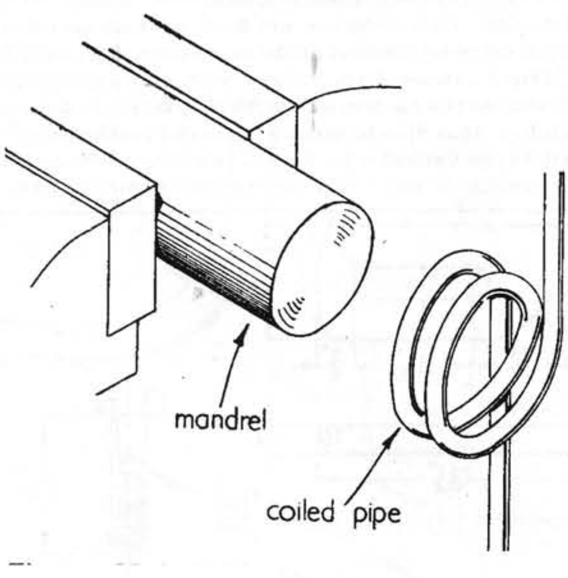


Fig. 10 Method of bending a series of coils on a pipe.

position of the pipe work itself; for example, a pressure gauge has to be connected to an air reservoir in the manner illustrated in Fig. 4. The diameter of the pipe used is $\frac{1}{4}$ in. and the distance between the pipe centres is 3 in. The former employed for bending must then be 3 in - $\frac{1}{4}$ in., that is $2\frac{3}{4}$ in. diameter as represented in the drawing.

If the length of piping on either side of the bend is sufficient to allow both hands to obtain a firm grip, the bend can be made without difficulty. Often, however, the standing portion of the pipe is so short that it is impossible to hold it with one hand against the leverage exerted by the other. In these circumstances, a work stop must be contrived. This may take the simple form of a piece of wood in which a steel stop pin is fixed. The wood base is gripped in the vice beside the former and is adjusted so that the pipe is lightly gripped between the stop and the former as shown in Fig. 5A and B. This arrangement allows the bend to be made quickly and without difficulty.

A Bending Block

A neat and self-contained bending block may be made from a three-step cone pulley casting such as can be obtained from Mr. W. H. Haselgrove. The illustrations, Fig. 6A and B, show the construction clearly, and it will be seen that an arm carrying a stepped stop-piece is attached to the top of the block. The arm, which is free to slide radially on a dowel pin screwed into the block, is secured, after adjustment, by a hexagon-headed $\frac{5}{16}$ in. B.S.F. screw. The block has two flats at its base to enable the appliance to be gripped in the vice. The device illustrated will bend to radii of $\frac{3}{4}$ in., 1 in. and $1\frac{1}{4}$ in., and an example of pipe bending made upon it is shown in Fig. 7. Detailed working drawings of the appliance are given in Fig. 8. The making of this pipe bender calls for little comment, and the work is quite straightforward. The base, with the exception of the recess on the underside, is machined all over to the dimensions shown in the drawing. The two flats on either side of the base are, for preference, formed by end-milling, or by fly-cutting, in the lathe. To enable the vice to obtain a firm hold, care should be taken to form these flats to lie parallel with one another.

The work can usually be machined by mounting it on the toolpost stud fitted to the top slide, but if this stud is not long enough for the purpose a clamping piece can be used instead as shown in Fig. 9. One of our lathes is regularly used in this way, and to avoid the multiplicity of packings that would otherwise be required, a small screw-jack with a flat top is employed to support the free end of the clamping strap, as shown in the drawing.

If the part is gripped under the tool clamp on the lathe top slide, the slot in the stop plate can also be end-milled instead of being formed by drilling and filing.

The stop itself must be formed by hand unless a shaping machine or power hacksaw is available for cutting the steps. A hacksaw machine, now awaiting description, has recently been constructed for doing work of this kind as well as for cutting up materials; this machine not only saves much time, but it can be relied on to cut much more accurately than the ordinary hand hacksaw.

The heads of the two 2-B.A. screws for securing the stop-pieces to the arm should be made a close fit in their counter bored holes, and the dowel screw should also fit accurately in the slot formed in the arm. For this reason it is better to make these screws specially, rather than to rely on commercial screws which commonly have their heads of varying diameter.

Using the Bending-Block

The method of using the bending block is essentially the same as that illustrated in Fig. 5. The pipe is placed against the appropriate step, and, after the stop has been adjusted to grip the pipe, the central clamping screw is firmly tightened. It will be found that the pipe can now be readily bent to the required curvature in the manner illustrated in the drawing.

If a copper pipe is well annealed it will cling closely to the former while being bent; on the other hand, if the annealing has not been well done, or the pipe has begun to harden from being manipulated, the work will spring away from the former. When this happens, the copper must again be annealed before further bending is undertaken.

When two bends have to be made close to and at right angles to one another, it is best to begin by making the bends in the same plane and then to twist one of the bends into a position at right angles to the other. Such a procedure is much simpler than attempting to form the individual bends at right angles to one another.

It is sometimes necessary to put an anti-vibration coil in the pipe which, in a motor car, leads from the fuel tank to the carburettor. The coil is usually composed of two full turns, and may be made quite easily by bending the pipe on a piece of round bar held either horizontally or vertically in the vice as shown in Fig. 10.

Bending Loaded Pipe

The smaller sizes of piping can be bent readily round formers, but the provision of suitable simple equipment to deal with pipes of $\frac{3}{4}$ in. diameter and upwards is likely to be beyond the capacity of a small workshop. However, that need not stop those who wish to do so from bending the larger

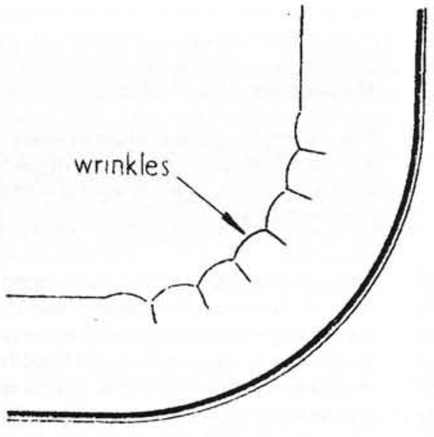


Fig. 12 Showing deformation of pipe wall resulting from over bending.

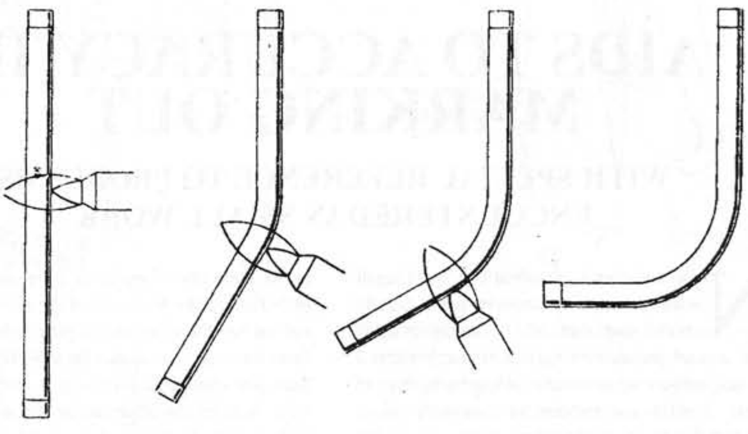


Fig. 13 Stages in the heating and bending of a large pipe.

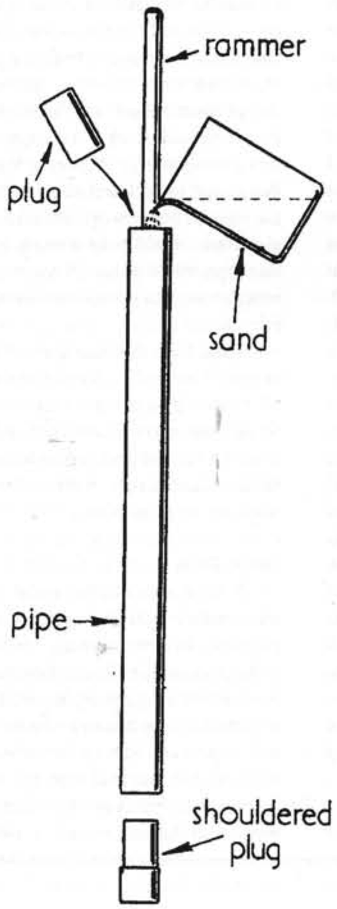


Fig. 11 Loading a large pipe with sand.

diameter pipes. With a little care, and an appreciation of the physical conditions in the pipe itself, good work can be turned out with no more elaborate apparatus than a strong fork-shaped piece of wood to serve as a bending block. The fork of a growing tree is admirably suited to this purpose, and, in the past, when engaged in motor cycle racing, we regularly used this method for bending steel exhaust pipes of a diameter of 2 in. or more.

Before bending is started, the pipe must be filled and, in addition, a wire template of the bend must be made to act as a guide during the bending operation.

Whilst lead may be used for loading short lengths of the smaller sized pipes, the cost of filling a large pipe would, at the present time, be prohibitive. Since, however, a sand filling is equally satisfactory for either copper or steel piping, and as this substance will withstand heating, the process of bending a sand-filled pipe will be described.

In the first place, two metal plugs must be made. One of these is shouldered and is firmly driven into the pipe as represented in Fig. 11. The pipe is now stood upright, and dry sand, preferably silver-sand, is poured into the pipe. The pouring must be carried out by stages and the sand is meanwhile well rammed into the pipe. During the pouring operation, the pipe is bumped on its plugged end and well rapped with a piece of wood to assist the sand in forming a compact mass within the pipe. When the pipe has been filled, remove just sufficient of the sand to allow the second plug to enter for about 1 in., then hammer the plug home. Both plugs should be made to enter the pipe for rather more than 2 in. for it is sometimes convenient to be able to hold the pipe in the vice by gripping one of the plugs.

The wire template is now applied to the pipe to ascertain the point where the bending should start. After this point has been marked with a pencil, the pipe is gripped by one end, either in the vice or in a stout wooden fork, and a blow lamp is applied to the pipe on the outer side of the start of the bend.

It is best to do the bending in a subdued light, or even in semi-darkness, for it will then be easier to judge the temperature reached. When the pipe is at a medium red-heat, the end is pulled round, but this must not be carried too far or kinks will form on the inside of the bend as shown in Fig. 12. If they are not too prominent, these kinks can be hammered back to restore the symmetry of the pipe, but when the pipe has been badly distorted it is almost impossible to restore the even surface of the metal. It is advisable to deal with these kinks as they occur, rather than to wait until the bending has been completed.

The blow-lamp is next applied a little further along the pipe, and the bend is extended by again pulling on the free end of the work. Fig. 13 shows diagrammatically the successive stages in bending a steel exhaust pipe, and it will be clear that, on the outside of the bend, the metal is being continually stretched whilst on the inside of the curve the metal is being subjected to compression. It is this compression, when excessive, that causes the pipe to bulge and wrinkle in the manner illustrated in Fig. 12.

After the bend has been completed, and any wrinkles hammered into place, a file may be used, with discretion, to clean up any blemishes remaining on the pipe.

The golden rule in bending pipes of large section is to make the bend in easy stages, and to keep applying the wire template to the work, for this will enable any errors to be corrected before they have become too pronounced.

If a blow-lamp is used to anneal a copper pipe which has been loaded with lead, care must be taken to avoid pulling on the pipe immediately the flame is removed; for the lead, at the point of heating, may still be soft, and not in a condition to keep the pipe from kinking at the point of bending.

M.E. 108 453 (1953)

AIDS TO ACCURACY IN MARKING OUT

WITH SPECIAL REFERENCE TO PROBLEMS ENCOUNTERED IN SMALL WORK

Marking out W.T. Barker

This is a much neglected subject in recent years, but there is a lot of sound advice in this abbreviated article. In particular I like what is said about accuracy.

NOW and then I get asked how I put small holes in small component parts exactly where I want them and the answer is that I take normal precautions against errors, but that I am not immune to occasional bloomers in spite of them. Further investigation so commonly elicits the fact that these normal precautions are missing from the enquirer's methods and that errors both in marking off and in drilling, etc., are so frequent that perhaps some account of methods I use resulting from over 50 years' addiction to the hobby of model-making may be helpful to others.

Accuracy is only a relative term. We model makers cannot achieve the fine limits normal to present-day industry nor is it necessary. We use the methods of our grandfathers in the days before micrometers, jig-borers, slip gauges and a host of other offsets to human fallibility were invented and do our marking off with scriber, rule and square, and quite tolerably accurate work can be done that way provided reasonable care is taken, but don't imagine that it is only necessary to read notes of this sort, and then go off and do it. It is not quite so easy as that. Accurate marking off is only part of a larger whole. The best of marking off may be wasted unless the model maker can machine and file his pieces correctly to size and shape, truly flat and square where necessary beforehand. He must cultivate for instance, the capacity to "see square" and it comes only by practice. It is quite possible to train oneself to "see square" within 1 deg. and it is often necessary to be able to do so.

It isn't everyone, perhaps, that has these capabilities. They depend partly on physical and mental characteristics, eyesight, delicacy of touch, patience, etc. One of the closest approaches to accuracy possible to the human eye is in the visual observation of the coincidence of two fine lines: e.g. the principle of the Vernier scale. Test your own ability. It can easily be done with a minimum of apparatus. All you need is two similar graduated rules 3 in. or 4 in. long, a little piece of flat plate to rest them on, some sort of a clamp and a set of feelers. Clamp one of the rules down on the piece of plate (letting the front end of the rule project a little) on say the top-slide of your lathe so that the front end is square against the tool-slide. Draw this back just enough to be firmly in contact with the rule. Now lay the other similar rule in edge contact with it and observe - all the graduations of both rules should exactly coincide. The probability is, however, that they will not; either rules are not as well made nowadays as they used to be or perhaps irregular shrinkage in hardening affects them. Select a pair of lines that appear to you to coincide exactly - then put the 1½-thou. feeler in between the loose rule and the tool-slide, and see if you can observe any displacement - if not try a 2-thou. and so on. Unless you can see definite displacement at 3 or 4-thou. you will need stronger aids to vision if you wish to improve your standards of accuracy. I made a test of myself, the first for some years, just before writing these notes and found that with a piece of 0.001 in. foil I could see no change. With the 1½-thou. leaf, I thought I could, but it might have been just knowing what to expect. With a 2-thou., leaf displacement was clearly apparent. Aids to vision of course were used - spectacles and a Herbert Bino-Mag, and indeed for close marking off either this instrument or a watchmaker's eye-glass will be essential for most people.

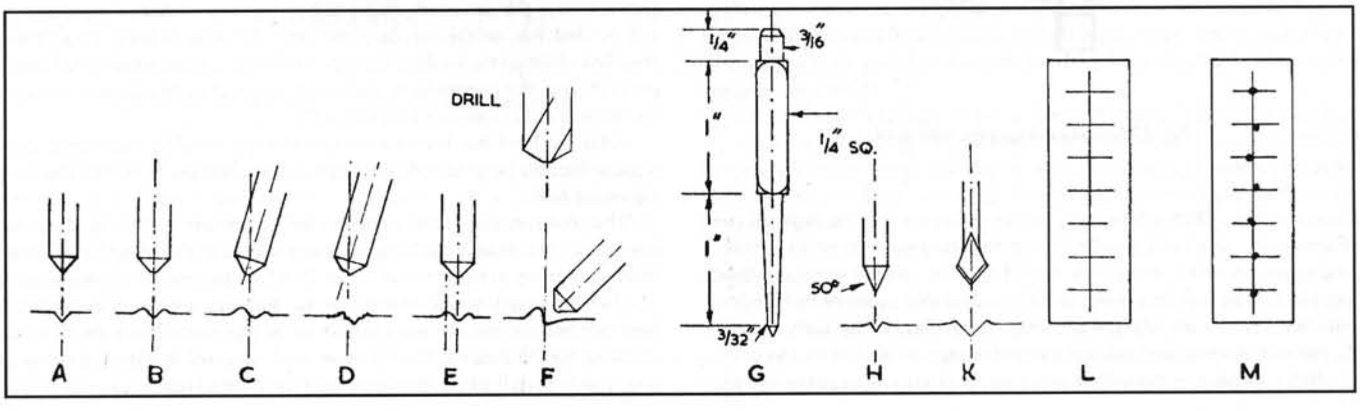
This is the first step in the search for closer accuracy and we find that it should be possible, with due care, to locate a point by eye within about ± 0.002 in. with a good quality steel rule. We needn't question how accurately rules are graduated. For model-making it can be assumed that if it is undamaged, it is a truly accurate scale. It also follows from this that if you have a square with a graduated blade or clamp a rule upright against it, or to an angle-plate, and a scribing block with a fine point you should be able to set that point and scribe a line at a known height above its base within about ±0.002 in. or 0.003 in.

Now a few words about rules. Some are more suited to the model maker's use than others. I once met a learner whose only rule was the blade of a 12 in. combination square, and it hadn't occurred to him that here was a chief reason for his failures. It was nearly 3/32 in. thick and I couldn't have read within 1/32 in. with it. Use the thinnest rule you can get. A half-inch wide Rabone or Chesterman semi-flexible blade rule is probably as good as any available, not because it is flexible, but because it is only 0.012 in. to 0.015 in. thick. The machine draughtsman is about the only professional worker today who uses graduated scales to transfer dimensions in the way we modellers do, and you will find his scales are graduated on a finely bevelled edge to reduce sighting errors to a minimum, but however useful otherwise, a draughtsman's steel scale is too large and clumsy for most small work. Years ago when rules were more important to engineers than they are now, there used to be bevel edge toolmaker's rules on the market, but they are not made nowadays as far as I know. I still have a lovely little 3 in. rule of this type made about 50 years ago, and anyone lucky enough to get hold of one should treasure it (see Sketch P).

Apart from this, use thin rules 0.020 in. thick or less; 4 in. or 6 in. lengths are more useful than 12 in. and it is useful to have still shorter ones. Some years ago I cut up a 6 in. rule to make ¾ in., 1 in., 1½ in. and 2 in. pieces with a little holder to handle them easily with. They greatly assist marking off small parts.

Other Tools

Besides the rule, the model maker's principal instruments will be, square scribers, centre punches, dividers, scribing block, jenny calipers and a pin hammer. Remember that if you are to do precision work these are all precision tools - even or especially the hammer - to be treated with care and respect and kept in first-class condition - and of a suitable size and type for small work. For instance, how many model makers, I wonder, have tried (and failed) to use a 6-in. square on a



component part of a model whose dimensions may be say about ½ in. x ⅜ in.? The smallest squares to be bought are about 1½ in. blade, and even they are too large and clumsy for much tiny work. It is not difficult, and a good exercise in accurate work, to make a tiny square for your own use. The inside square is the most useful, and it has to be provided with a handle to be held in a pin-vice. Sketch T gives details and dimensions of the one I use myself, and I couldn't get far without it.

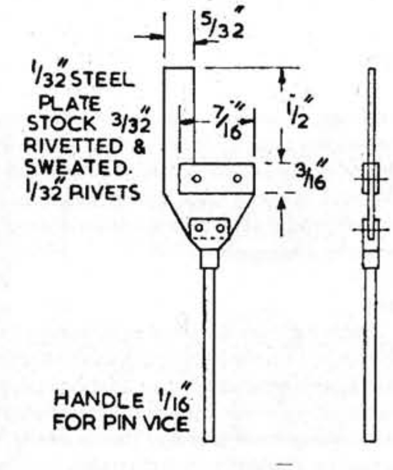
The points of centre punches, scribers, dividers and jennies must be kept quite sharp. The test for your centre punch and incidentally your own delicacy of touch is to be able to feel it drop into a previously scribed line. Then draw it along that line carefully until it meets the scribed cross-line, where you want your hole centre to be. You should be able to feel it drop into the intersection. If your hearing is good enough, you might even hear the faint click. If you can neither feel it nor hear it you will need to improve your tools or touch, or both until you can, or give up the idea of doing accurate small work. Tests for your scribers, divider points, etc., are to be able to feel them drop into the fine graduation lines on your rule.

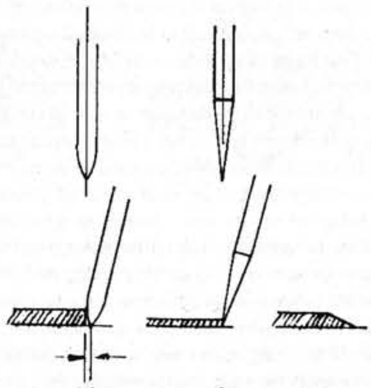
The usual bought centre punch has a point angle of about 90 deg.; don't use anything broader for model work - though I've seen them all angles from about 80 deg. to 120 deg., and I suppose the average model maker, if he thinks about his punch at all, envisages its point, and the indentation it makes in terms of Sketch A: (Note - Sketches A - K are shown much exaggerated in size as I am only dealing with small work.) Actually the state of affairs is much more like B, which shows in fact a good accurate placing and a square strike, and might result in a correctly drilled hole, but if you look at the drill (at F) there is still some element of chance about it. At C the operator has struck his punch "off square" with the quite unexpected result: that it tends to get deflected in the opposite direction to what you would expect and the softer the material being used the more pronounced is this effect. The burr builds up higher against the steeper slope of the punch and tends to force it in the direction of the easier one. This is why three things are vitally important for accurate use of the centre punch.

1. To keep the point sharp and truly conical.
2. To find the correct centre before striking.
3. To keep the punch upright for the strike.

In addition to these chances of error, sometimes, who knows, the user's punch may be more like D with a nasty little bit flaked off the point. It has happened to me so I know it can to others, and the resulting indentation might be any old shape, with just a matter of good or bad luck where the drill wanders to.

At E is shown the case where the worker has made a bad shot, definitely off the centre line while F shows what happens if he makes the not unnatural, but perfectly fatal mistake of trying to correct his error by tipping his punch over 40-45 deg. and striking towards the desired position. It only makes a bad error worse. True he may drive the punch by main force nearer the scribed line and seem correct to the eye, but a high burr has been raised on one side and a depression created on the other, both precisely where they will do most harm in deflecting the drill point still farther away from the correct





N O P

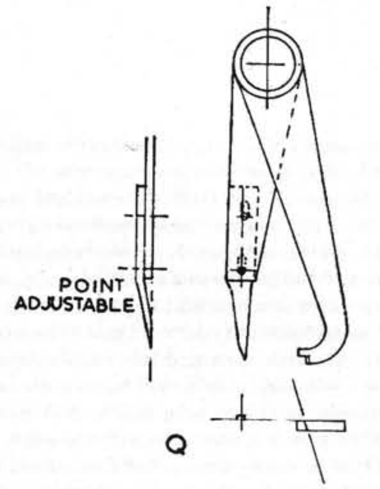
position. The only thing to do in a case like E, is to smooth off the burr with a fine file and try to reset with a spotting punch or spear drill.

Using the Centre Punch

In point of fact, a centre punch like that shown in sketches A to F should never be used for first spotting for tiny holes in small and accurate work. Use it afterwards if you like to deepen and widen a positively located spot, but only with the greatest care. The type required is a spotting punch shown in sketches G and H and it may have to be made by the user for himself, since as far as I know, nothing of the sort can be bought small enough for fine model work. Possibly Moore & Wrights may have something like it in their range. If so get one, as it is likely to be a better tool than a home-made one. This is the type of punch to feel along scribed lines with. Keep the point always stoned up sharp and NEVER strike it with anything heavier than a 2 oz. pin-hammer. The kind of indentation you ought to get is shown at H and while you can enlarge this with a heavier 90 deg. punch it is safer and better for accuracy to do it with a sharp watchmaker's spear point drill held in a little archimedian turn, and with this tool you can quite easily set punch marks over a little if out of position.

By the way I should have included in the list of marking off equipment earlier, some means of holding small parts secure and steady, flat and square while marking off, punching, and of course drilling. It is quite essential that the seeker after accuracy should provide himself with a finger-plate of the kind I described in The Model Engineer for February 22nd, 1951 or some similar appliance. It is one of the most important tools in my workshop, as good as a third hand and in almost constant use.

Sketches L and M show suggestions for further practice and test of ability. Take a little piece of metal, brass for preference, flat and with at least



Q

one straight edge. Scribe a line down its length with the jenny (Fig. Q), of which more anon. Take your dividers and set them as carefully as you can to some standard dimensions (say ¼ in.). If the points are sharp you should be able to slide them in the two selected graduations with no tendency to slip out. From a selected point on the scribed line walk your dividers down it for six steps, mark the sixth, and measure from the starting point. If you are within ±1/64 in. of 1½ in. that is quite accurate enough. If not try again, practice will quickly help you especially to swing the dividers round on a point each step without slip. When you find that you can achieve this fairly readily, it means that you can rely on yourself to mark off with dividers within average limits of about ±0.002 in. to ±0.003 in. and that is good enough for all model-making, however much it might be sniffed at in a modern tool-room.

Warning

I must add two warnings on the use of dividers. First, don't use a large pair (4 in. to 6 in.) on small work. Their legs are too springy and you need to reduce this to a minimum. It is a good plan to cut a 3 in. or 4 in. pair well short, down to 1½ in. or 2 in., keeping the broader stiffer upper parts of the legs of the full section down as far as possible and taper them off fairly quickly to the new points. Many model engineers have no doubt discovered, on trying to set one up true in the lathe, that it is almost impossible to scribe a true circle with the average spring dividers as sold due to leg spring. It can be done by holding the dividers still and turning the piece of work, but it isn't always possible to do this.

Secondly, don't use the method (suggested as a test only) given above of walking dividers down a line for marking off a row of hole positions, except perhaps in the very special case of marking round an oval, or irregular shape, where you can begin and end at the same point. It makes the small error nearly always present a cumulative one. Marking off around a circular pitch line can be done much more accurately by the mechanical methods to be described later.

Now take the piece of plate and mark off cross lines with a square as shown, and spot-punch lightly at each intersection, sliding or drawing the punch down the longitudinal till you feel it drop into the crossing point. That is the point to spot. Then with a small dead smooth file remove all the burrs without obliterating the scribed lines and examine the result with an eye-glass. Always use an eye-glass for scribing and spot-punching unless your eyesight is exceptionally good. A first attempt may look like M or worse. Scribe another longitudinal and try again, and again if necessary.

Sketches N and O illustrate bad and good scriber points and they apply equally to scribing block, dividers and jenny. N also shows the combination of a bad scriber with a thick rule (or square blade - most squares as sold, have blades too thick for model work, and need extra care when scribing). The error introduced here could easily be 1/32 in. When new, a scriber may have a nicely conical point, as O, but when blunted don't try to sharpen it on a grinder. You will only soften it. Sharpen by stoning three or four flats with a carborundum slip and/or oilstone and though the shape gradually changes to taper square or triangular it will function just as well.

Inaccurate Tools?

Jenny callipers have been stigmatised by some people as useless and inherently inaccurate tools, but don't believe them. It is true, however, that the average commercial product looks as if it has been designed by someone who never had to use it. It can be a most useful adjunct capable of as accurate work as any of the rest of your marking off equipment, but to fit it for small work the commercial article has to be modified. Fig. Q shows the alterations.

1. File away part of the leg to provide a horizontal lip to rest on the edge of the work and bevel off the back end as shown. Note - make the lip as long as you can, longer than shown in the sketch if there's enough metal in the dog leg, the longer the better to support the scriber at close settings.

2. Cut the scribing leg short and fit a new adjustable point and give it a set so that the scribing point, which should be flattened, bears close against and can be supported by the edge of the lip. Sharpen only on the outer faces.

To do this accurate work the high point of the bevel at the back of the lip and the scriber point must be closely in line. Always hold the tool square to the edge of the work, and draw it slowly along tilted slightly forward. When scribing a line very close to an edge, and it is quite possible to scribe down to 1/64 in. if ever necessary, very exact adjustment of the depth of the point in relation to the supporting lip is necessary.

Drills

The best of marking off can easily be ruined by faulty drills. You need to be much more particular about keeping small drills (1/16 in. and below) sharp than larger ones. Forcing a tiny drill when blunt means almost certain breakage. There is absolutely no need for elaborate twist drill grinders for these small sizes or indeed for any twist drill below about 1/8 in. diameter. It is much to be doubted whether any of the types likely to be owned by an amateur could be relied on to sharpen any drills between 0.030 in. and 0.060 in. diameter so well as can be done by hand with a slip after a little practice; and even if it could, I would back myself to sharpen a dozen of varying sizes by hand while the grinder was being set up for one. Neither is there any necessity for curvature behind the cutting lip. A straight flat back off is quite satisfactory though I admit that I myself, more often than not, give a double set. The angle of the lips is also unimportant within 10 or 15 deg. either way, so long as both are approximately the same and meet across the centre of the flutes. With care and practice it becomes possible to sharpen small drills by hand with great accuracy merely by eye.

I fancy that the present-day craze for power operated machines, and mostly too heavy and clumsy at that, is at the root of a lot of the difficulties some model makers experience in doing fine work. If you must have a drill capable of 3/8 in. or 1/2 in. holes then don't expect it to be suitable for drills down to 0.030 in. or 0.040 in. These drills have to be felt in operation. In one case I remember the vibration of the machine at top speed was enough to make any attempt at small critical drilling hopeless. I've never found high speeds necessary, I bought and tried a high speed, so-called precision drill some years ago, but very soon gave it up. It broke my drills and I have scores of them from 20 thou. up to 3/32 in. that have been in regular use for 30 years and more. I doubt if the highest speed I can reach with my little treadle drilling machine is over 400 r.p.m., and I seldom go all out. A lot of my smallest drilling (16-B.A. tapping or about 0.024 in.) is actually done with a hand drill at say 200 r.p.m. or less; but this is a specially small and precision type of my own make.

Tiny twist drills are over long in the flutes and very fragile. The cost of them today is such that it is worth an effort to save them. I encase all those from 0.020 in. to 0.039 in. diameter that I use frequently in watch maker's bouchon wire. This is thick-walled brass tube sold in 2½ in. lengths, in a large variety of diameters from 1½ in. to 5mm, and with bores rising from ½ in. to 2mm by 10ths of a millimetre, I believe, and though I don't think any suppliers of watch repairers' sundries stock the whole range (they are of Swiss manufacture) it is seldom that I have found any difficulty in getting any size bore within reason that I need. Put your small drills in suitably sized pieces of bouchon wire. They would be a good fit (say within 0.001 in. or 0.002 in. and project at the drilling end for 1/8 in. to 3/16 in. and a spot of soft solder at the tail end is enough to hold them. If by bad luck you break a tip you can shorten the bouchon, and expose a new length of drill just as if it was pencil.

These bouchon wires average about 6d. each at the present time, and are made dead straight; bores central and to high dimensional accuracy. One bouchon wire will case three small drills. Of course it is quite possible to drill out 3/32 in. or 1/8 in. brass rod for this purpose, but to drill a 20-thou. hole say through a ¼ in. length of it and straight, would be a tax on any model maker's equipment and skill.

M.E. 74 491 (1936) & 120 631 (1959)

Rivetting Inchometer / J. Dunn

The most concise advice on the subject dates from 1936, forming onf of a long series of practical advice by Inchometer. I have also included a seperate short article on a very sturdy rivet squeezer from more than 20 years later.

Rivets and Riveting

Fixing Techniques

This group is disparate both in content and time, my oldest selection going back to the 1930's.

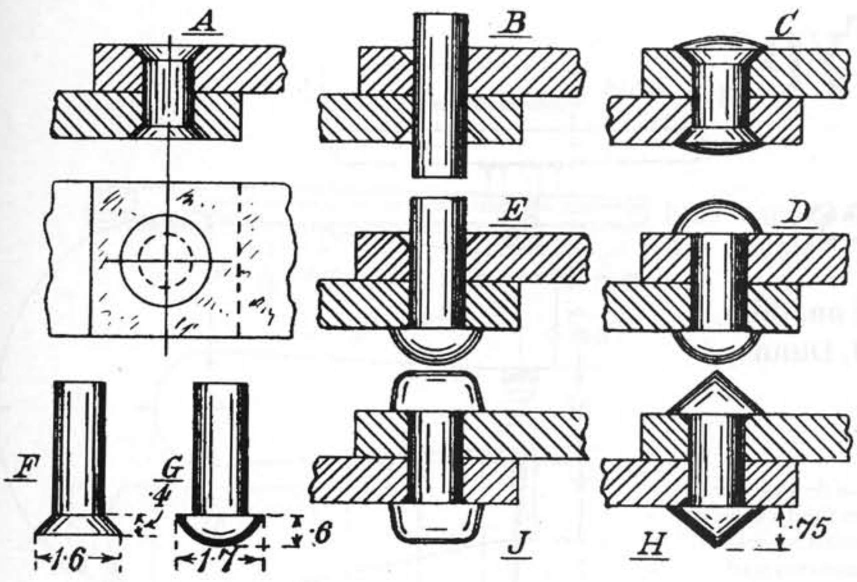
By "Inchometer"

"THE simplest fastening is the rivet, employed to unite, wrought iron, soft steel or copper plates. A rivet is virtually a bolt, with the head, body and nut in one piece. It is a permanent fastening, only removable by chipping off the head"; from "The Elements of Machine Design", by W. Cawthorn Unwin. To this clear, concise definition I will add that other metals, brass, aluminium, zinc, lead, material such as wood, ebonite, vulcanised fibre and leather may be united by means of rivets, and to dissimilar material to themselves, leather to steel, for example, as with the lining of a band brake. You are perhaps aware that the shell and end plates of steam boilers are usually fastened together by rivets, but I am not intending to deal with their use in boiler construction specifically. It is mainly by the aspect of general utility in mechanical work that I give some elementary information for your guidance.

With structures resisting internal pressure, boilers, compressed air reservoirs and the like, others responsible for carrying load stress, bridge girders, cranes, and so on, size, position, arrangement and shape of rivets are details which require to be calculated and predetermined by rules and formulae, or decided by known experience with like structures in similar conditions of use. You will not require, in general, to be concerned with such exactness, and may refer to "Model Boiler Making," 10d post free from the Publishing Dept. (The modern equivalent publication is a little more! - Ed). If you have in view making a steam boiler, stationary, locomotive or marine type, it gives ample details about rivets and riveted joints.

Various Types of Rivets

The countersink rivet is shown by A, complete in position, fastening one piece of material to another. It may be a length of wire or rod, indicated by sketch B, inserted into holes drilled in the pieces to be joined. Each hole is bevelled at the outer end, countersunk, as shown. The protruding ends of the rivet are gradually burred over by repeated blows from a hammer until they spread and fill the countersunk spaces. A firm support is required at one end of the rivet whilst the other end is being hammered. Usually one partially



Forms of rivets, A,B, C countersunk; E cup and countersunk; D spherical or cup head; J pan; H conical; F,G proportions for heads, approximate, in terms of shank diam.

burrs over an end, then turning the rivet and joint upside down, hammers and partially spreads the other end, and so on until the two countersinks are filled. The effect is not only to hold the pieces, but the burring produces a nipping which gives very intimate contact, squeezes the pieces together. So that the burring is practicable, and without splitting or cracking the rivet, the material of the rivet itself must be ductile and soft. Considerable art and practice are required. The hammer for small sizes of rivets should be light, and have one pane spherical; you chiefly use this in striking. Grasp the shaft at full length so as to give a rebounding kind of blow. Aim at the centre of the rivet and gradually work towards the circumference, to facilitate spreading. Possibly, you will find that too much protruding length has been allowed, and may notice the spreading commence to crack or bulk so that it will never form properly into the countersink. Adjust matters by filing away some of the length and then start burring again, and so on, until you get a good formation. Conversely, you may not have allowed enough length, the only course then is either to remove the rivet and insert another or to be satisfied with a partially filled countersink, this may not be of consequence, according to importance of the duty required. When the ends of the rivet are finished level with the surface of the plate, as indicated by A, the term "flush riveting" is applied. For some purposes, the ends must be level with the plate, but when this condition is not essential, they may be left proud, as indicated by C, this adds to the strength of the bevel and is convenient as a finish. Rivets, F, having the tail already formed, are obtainable in copper, brass, and soft iron of various diameters and lengths, and annealed ready for use. The round head type of rivet, D, is known technically as "snap head", its ends may be burred over to correspond with one another as shown in the sketch, or one into a countersink as indicated by E, when required to be flush. The rounded ends are first formed by hammering to as near spherical as practicable, and then finished by means of a punch tool, termed a snap, provided with a cupped end of spherical shape, hardened and tempered. This kind of rivet may also be obtained, G, with the tail ready formed. Two other forms are the conical, H, and the pan head, J, they are not much used in model work.

Occasionally it is suitable to add a washer to a rivet, as indicated by K, particularly when one or both of the pieces to be fastened together are of soft material, to distribute the pressure and prevent indentation.

Position of Rivets

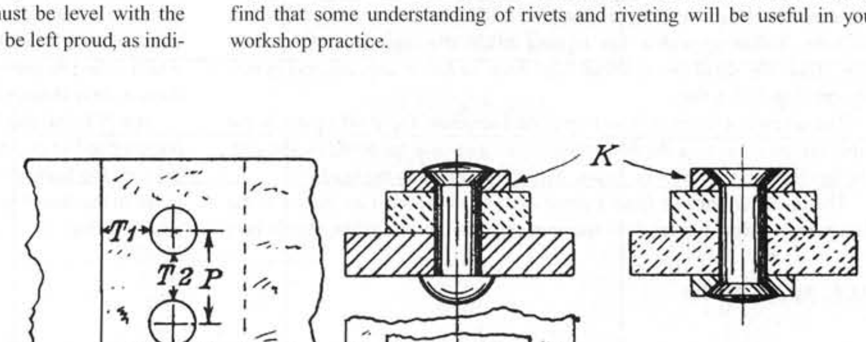
The general rule is that there should be a distance, T1, between the edge of a plate and the hole, and T2 between two adjacent holes, at least equal to the diameter of the rivet. Subject to this limitation, one uses discretion, according to the specific purpose to be served. For joints of small copper boilers, Mr. Henry Greenly mentions that the rivet diameter should be at least 1½ times the plate thickness, and the pitch, that is, distance between centres of the holes, not more than 3½ to 4 times the rivet diameter. Customary proportions of rivets are given by F and G, reckoned by its shank diameter size, the latter usually adopted is slightly more than twice the thickness of the plate for single lap joint and twice the thickness with a double row of rivets and single lap. The hole is made slightly large in diameter so that the rivet is easy in it, the rivet shank tends to swell during the riveting process. For boilers, rivets should be of the same material as that of the plates; soft iron rivets are permissible with steel plates.

Closing and Removing a Rivet

The precise amount of protruding length to allow for filling a countersunk hole, or forming a particular outstanding head shape must be ascertained by trial, about ¾ the rivet diameter for countersunk and about 1½ to 1¾ for snap head patterns will serve as a guide. The only way to remove a closed rivet is to cut away the head or the tail and then to drive the rivet out of the hole by means of a punch. You can chip or file off a snap head or drill or mill it away. If countersunk, centre it with a centre punch and drill away the bevelled part.

Hot and Cold Riveting

In model and home work, rivets are generally closed in cold state, usually they are of small diameter and need not be heated. With full size practice, hot riveting is widely used, the shank of the rivet is heated to redness before the rivet is put into the hole, having been inserted, a head is then formed to shape either by hand hammering, machine percussion or squeezing. An advantage of hot riveting is that the rivet contracts in cooling and imparts an intense nip to the plates. The practice would scarcely be possible in very small work; copper, steel or iron rivets may be closed hot, but not brass. In good practice, the holes of the two plates are correctly in line before the rivet is inserted, you should not depend upon the rivet to pull them into line with one another. Do not attempt to close a rivet without it stands on a solid support. For odd repairs and so on, a French nail, or a carpenter's screw with the thread portion cut off may serve as a rivet. You may never construct a boiler or a tank, but will surely find that some understanding of rivets and riveting will be useful in your workshop practice.



Rivets and riveting: P is the pitch between two rivets; T 1 and 2 usual least amount of metal allowed; K rivet and washer.