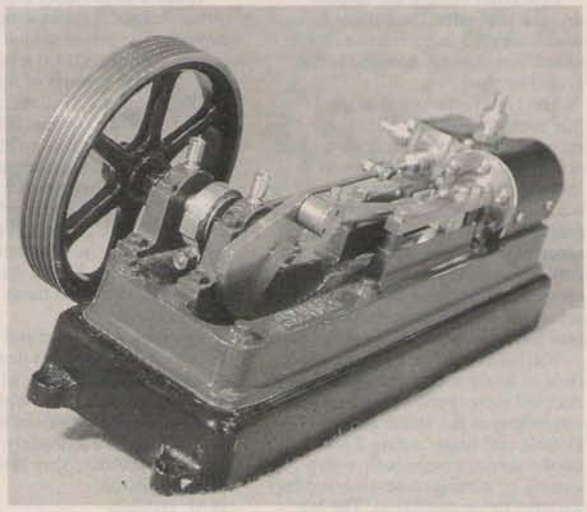
SALLY



EDITOR'S NOTE

In order to write and illustrate this series, the Author has in effect built two and a half models. Not as happens to so many of us because he made "scrappers", but so that he could explore and illustrate alternative methods of working, suitable for those who have the bare minimum of equipment, and for those who are able to afford more elaborate equipment.

Experienced and well kitted-out readers may choose to use milling machines, and even surface grinders in building the model, but the Author shows that even when utilising an angle plate made from a block of wood for certain of the machining operations the engine can be made to perform very well indeed!

One minor problem may arise in the building of this engine; the type has been in production for half a century or more. In that time several versions of the drawings have appeared, but there has been no major change in the patterns for many years. (The very first batch of this engine had the steam chest cast in one with the cylinder, and a 3¾in. flywheel.) For this series the Author has worked from the current drawings; and these, with minor embellishments are used in this series.

Tubal Cain

describes in some detail the building of the Stuart Models S50 Mill Engine. The series is aimed at the beginner, but the more experienced reader will doubtless pick up some pearls of wisdom as the series progresses.

● *Part I*

The official name for this engine is "S.50" in the Stuart Models catalogue, but – how dull! So, as almost all true mill engines were given names by their owners I have taken a liberty! Change the name if you wish – though *Sally* is a good old Lancashire name. This model was first introduced over 50 years ago as a fully machined set of parts for those who had no access to machine tools, but over recent years there was such a demand for unmachined castings, both at home and abroad, that most are now supplied in this form. Not surprising; for, though simple, she is a very handsome engine, whether standing or running and, most important, not at all difficult to machine.

The term "Mill Engine" is often mistakenly applied to any horizontal steam engine, but this is wrong. The typical feature is the long stroke relative to the bore and the slow speed; seldom more than 110 rpm. *Sally* is representative of the smaller types as found in the little mills which were dotted around the small villages of Yorkshire and Lancashire, often converted to steam from water power. I would guess at a scale of about 1/16, making the prototype 10in. x 20in., which might develop about 60 HP at 120 rpm with steam at 100 lbf/sq.in. This would run a mill having perhaps 3000 spindles, or in the case of a flour mill, one producing up to half a ton per hour. (The word "mill" covers a wide variety of trades.)

At 5/8in. bore x 1¼in. stroke and just under 9in. long *Sally* can be machined on lathes as small as 3¼in. centre-height, perhaps even smaller with some contriving. In building mine I have used the simplest possible process, and have given alternatives for the sake of builders who have limited equipment. Some of these alternative methods may help you to come to a decision about whether this or that accessory is worth having!

Preliminaries

The castings and material are vacuum packed under a plastic sheet in a useful cardboard box, **Fig. 1**. Not easy to release unless you know how! Run a sharp knife round each part, and lift it out – don't try to tear away the sheet – it won't! Take care with the bedplate, as there are parts underneath, including a small envelope full of screws. This will burst if you try to tear it away, so have a small box handy and simply cut off the end and tip the screws out. Take care also with the sheet of "lagging", as this is quite soft and must be handled gently. Having extracted all, check with the parts list on the back of the drawing. I suggest you use a felt pen to number each of the pieces of barstock, which can also go in a little box. But take care of the slide valve, part 25; don't jumble it up with the other pieces.

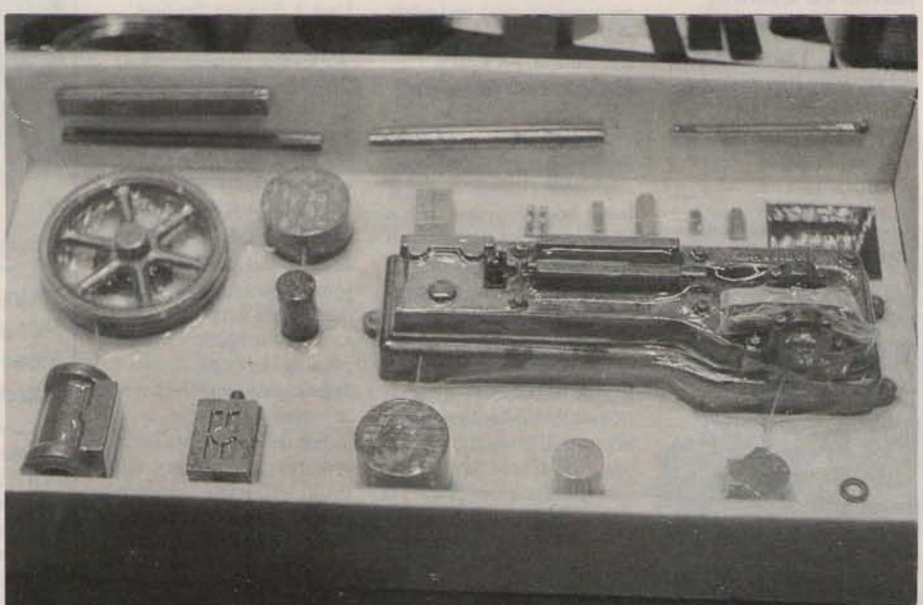


Fig.1: The box of parts as delivered. A plastic bag of small parts lies underneath the bed.

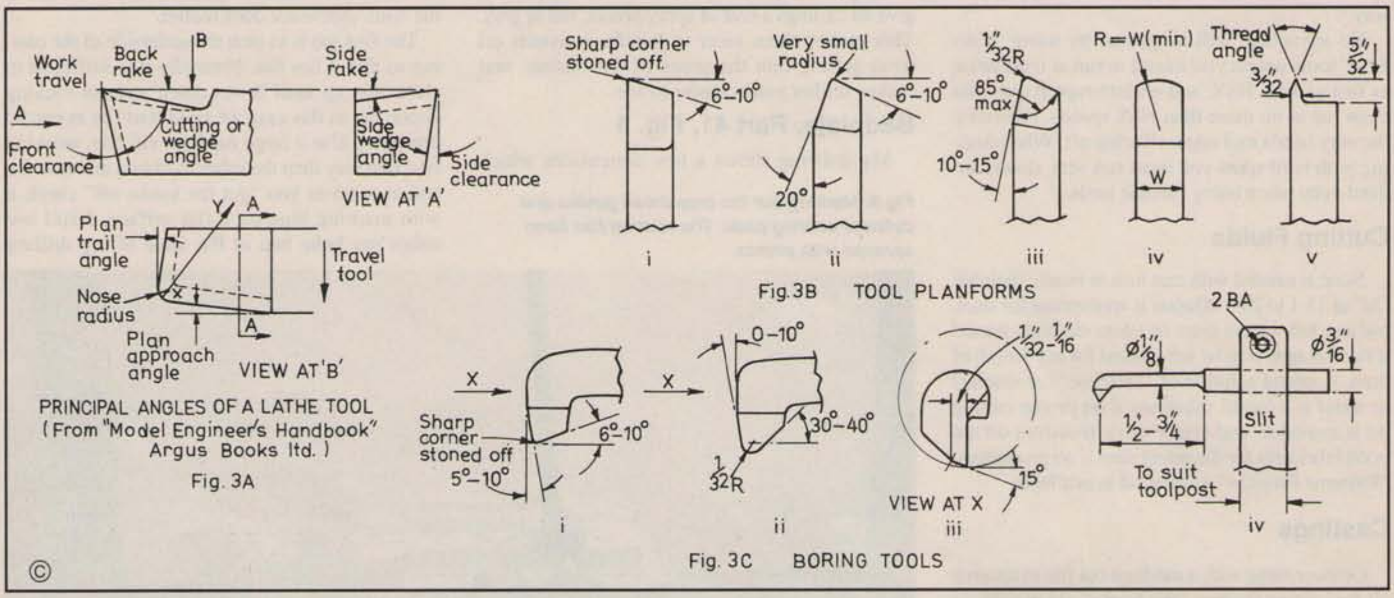
Cutting tool angles and speeds

A few words on these two subjects first, for the benefit of those who have but recently acquired their machine – and for those who may be apprehensive about machining cast iron. To take the second matter first, you need have no fears. Iron of the quality supplied by Stuarts causes no problems at all, and in any case cast iron is easier to machine than steel as a rule. However, the cuttings can be rather dirty, due to the graphite content, so start by cleaning out your swarf tray and remove any oil there may be, to prevent it from ending up as mud! If your lathe has felt wipers to the saddle, take these out, wash and dry them and replace them. (I always keep a dry wiper as a spare for use in these circumstances.) Then, when you take each first roughing cut, let this be reasonably deep, to get under the skin at one go. Even after you have treated the castings as I describe later there may well be sand inclusions on the surface which will murder the tool point. For finishing, have the tool very sharp indeed, exactly at centre height, and do your best to make sure that the **final depth of cut is not less than 0.002 inches**.

it can leave an acceptable finish. Normally the tool face is set at right angles to the travel, but if a shoulder is to be finished the "plan approach angle" should be slightly negative – the point a trifle ahead, that is – so that when the shoulder is to be finished a fine shaving cut can be taken by withdrawing the cross-slide.

Boring tools

These are shown in **Fig. 3(C)**. That at (i) is for roughing, and you will see that it has a very small plan approach angle. This reduces the forces tending to spring the tool away from the cut, very important with long and slender boring tools. Never-



PRINCIPAL ANGLES OF A LATHE TOOL (From "Model Engineer's Handbook" Argus Books ltd.)

Fig. 3A

Fig. 3B TOOL PLANFORMS

Fig. 3C BORING TOOLS

Now look at **Fig. 3(A)**. This shows the geometry of a tool and the "names of the parts" as it were. You will see an arrow X-Y in the plan view; this is the direction of the "total rake angle" and hence of the flow of the chip across the tool. Note also the arrows showing the direction of the tool travel along the work; obviously all plan angles will be reversed in the travel changes – as, for example, when facing.

Tool Angles are shown in the table. None of

			TOOl ANGLES		
			Angle – degrees		
Workpiece Material	Class of work	Back * Rake	Side Rake	Front * Clearance	Side Clearance
Mild steel	Rough Finish Parting	6-10 14-22 15	16 0 0	6-9 6-9 6-9	6-9 2 ½-½
Cast Iron	Rough Finish Parting	8 6-19 5	12 0 0	6-9 6-9 6-9	6-9 2 ½-½
Brass	Rough Finish Parting	0 0 0 to -2	0-3 0 0	6 6 6-10	5 6 1
*Use this column for SIDE angle on knife tools.					

these are critical, those for clearance being rather more important than the rake angles.

Fig. 3(B) shows the shapes of various tools in plan. At (i) is the knife tool which can be left or right handed. There is no back rake at all with this shape. It is the most powerful tool when a lot of metal has to be removed, but it does leave a poor finish. On this duty it should have the sharp point very slightly rounded, or it will collapse. The tool is also used when it is necessary to machine up to a shoulder. In this case a small flat is formed on the end, width about twice the rate of feed, when

At (ii) is the general purpose roughing tool, which does almost all roughing work where there is no shoulder involved. Indeed, many practitioners use this tool even then, but bring up the knife tool to form the shoulder as a second operation. Its advantage is that the chip is thinner, and it does leave a better finish than a knife tool. (iii) is a similar tool, but set up for finishing. In this case, if working close to a shoulder the tool can be angled over in the toolpost to bring the front face at 90 deg. to the line of travel. It then acts as a modified knife tool when roughing, and as a round-nose tool when finishing. At (iv) is a "shaving" tool, used when superfine finish is needed. Cuts must not exceed 0.005in. and the edge must be honed to be razor sharp. The tool shown at (v) is the shape I use when cutting fine pitch threads – I shall say more about this when we come to threading jobs later. You will see that it is much narrower than those shown in "the books" and that it can get right up to a shoulder if need be. It will cut up to 14 TPI, or 2mm pitch.

theless, the final roughing cut should always be repeated at the same setting. (i) is the recommended shape for finishing, and must be used on light cuts – but again, always try to leave at least 0.002in. to be taken out on the final cut. It is vital that the tool does not rub. The front clearance angle must be more generous when boring for obvious reasons – the tool is working *inside* the curvature of the work, see (iii). Always check this before cutting. (iv) shows a tiny tool for truing drilled holes before reaming.

Parting Tools

I have not illustrated these, as their shape is obvious – long and thin! But not, please, too thin. Much of the jamming experienced by amateurs is due to the use of too narrow a parting tool, which can then deflect sideways in the cut. I recommend not less than 3/32in. (2½mm) wide. The amount of stock "saved" by using 1/16in. is not worthwhile. The front end should be dead square across – the angled end shown in some books is appropriate only on heavy production work. Iron parts off very easily, but with steel you need a good flood of cutting oil, so directed to get right to the tool point. In all parting off operations the secret is a really steady rate of infeed.

Cutting Speeds

"Recommended cutting speeds" are worked out to give an economical tool life – balancing the machining time against the cost of resharpening. With a few exceptions there is no advantage in high cutting speed other than reducing machining time. Carbon steel ("Tool Steel") tools will lose their temper and go soft if run too fast; High Speed Steel ("HSS") tools abrade and crater, and may form a built up edge, if over-run. Excessive speed may cause chatter if the machine is worn or the tool flexible – this applies especially when boring. The speeds quoted in the following pages are those used with HSS tools having minimum projection from the toolpost on a machine in good condition. (Those using Carbon Steel tools should reduce these speeds by 50-60%.) But there is no reason at all why you should not run at *lower* speeds if you, or the machine, feel happier that way.

No advantage will be gained by using "Carbide" tools unless you intend to run at least twice as fast as with HSS, and on interrupted cuts you must run at no more than HSS speeds, otherwise the very brittle tool edge will chip off. When dealing with hard spots you must run very slowly indeed even when using carbide tools.

Cutting Fluids

None is needed with cast iron or brass ."Soluble Oil" at 15-1 to 20-1 dilution is appropriate for steel, but any felt wipers must be taken out and cleaned if the machine is to be left unused for any length of time. A strong solution of "Stergene" (or similar) in water is a useful substitute if no proper cutting oil is available, and castor oil or neatsfoot oil are good lubricants for threading steel if no proprietary "Extreme Pressure" cutting oil is available.

Castings

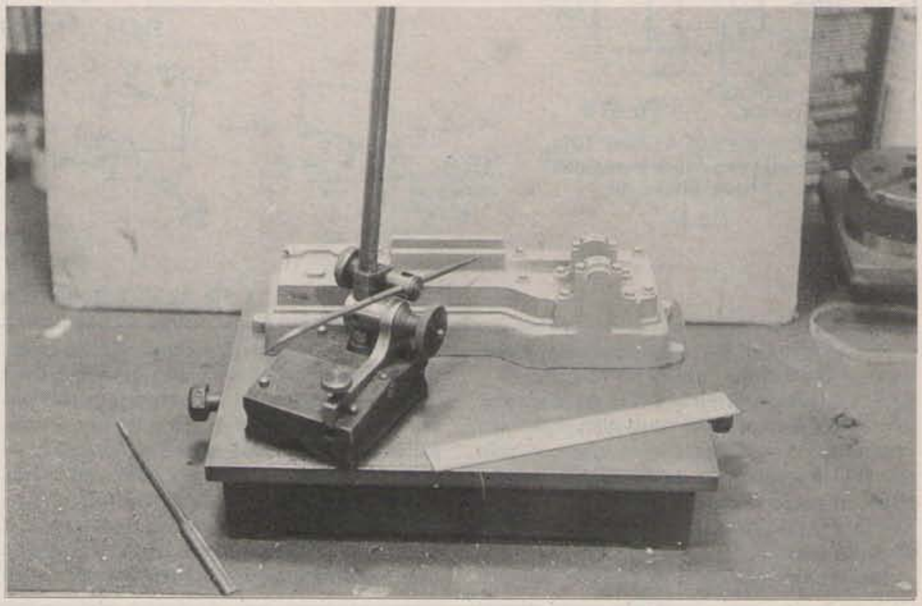
Go over these with a medium cut file to remove all the casting flashes: "the books" always say "a worn file" for this job, but you do need one which has some cut left on it! In the case of the flywheel you will find a fillet all round the rim. I always remove such on my coarse grinding wheel, avoiding application of too much pressure, as such fine fillets can be quite hard. Use round and half-round files to deal with the spokes, especially the radii between spoke and hub or rim. This having been done, go over all castings again giving a rub over all surfaces. This is to remove any small excrescences. These may not show up now, but once you start to paint you will find them a real nuisance. We can fill any depressions, but the slightest pimple will cause trouble. The other thing to watch is adhering sand, especially on the underside of the bedplate and in the cylinder bore and ports. You may have to prod this quite vigorously with a sharp point – but not your best scriber! Finally, give all castings a coat of spray primer, red or grey. This makes them nicer to handle, prevents oil from getting into the pores of the casting, and makes scriber marks easier to see.

Bedplate, Part 41, Fig. 4

My drawing shows a few dimensions which may be absent from earlier issues of the *Stuart* drawings, and I suggest that you amend your copy if this is the case. Also, ring round the three 7BA clearance holes to remind you not to drill these until later on. Note that the "reference centreline" in the side view should be taken from the approximate centre of the bosses on the casting; the 1-15/16in. and 1½in. dimensions are not critical, but the 7/16in. *difference* does matter.

The first job is to treat the underside of the casting so that it lies flat. Normally it is sufficient to clean this up until it sits down without rocking about, but in this case we need it as flat as can be managed. Use a large medium cut file, working first one way then the other to obtain an even cut, and as soon as you "get the knobs off" check it with marking blue on a flat surface. I still use either my lathe bed or the table of my drilling machine even though I do have a surface plate. At all times take care to remove as little metal as possible once the job is free from rock. Note that we are not looking for a fitting flatness, but we do need contact spots all over, the point being that when we come to machine the top it is very unlikely that the rig will bed to the full length of the casting.

Fig.5: Marking out the crosshead guides and cylinder seating pads. The casting has been sprayed with primer.



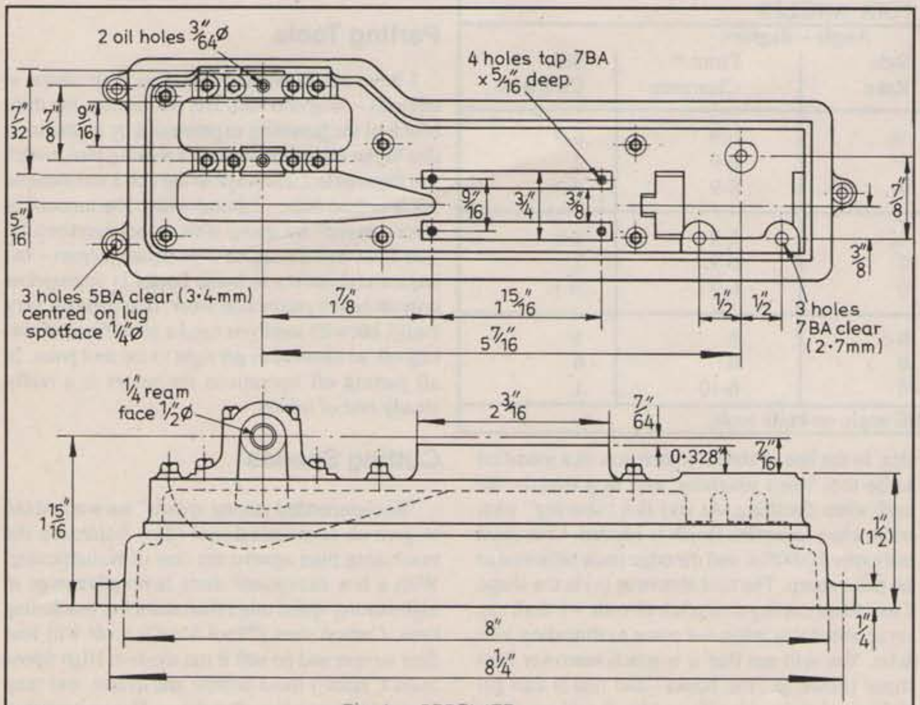


Fig. 4 BEDPLATE

Now mark out the heights, using the centreline through the main bearing as datum. (**Fig.5**) The centre of this bearing should lie at the centre of the radius you see on the drawing, so set your scribing block or height gauge there – the radius of the facing on the casting is ¼ inch. Ignore the 1-15/16in. dimension. Scribe this centre on both of the main bearing outer faces – it is your "datum level" – and set two centrepops thereon so that you can see the centre better. (But don't put a pop actually at the centre.) Reduce the elevation of the scriber point by 7/64in. (0.109in.) and scribe along the outside of both the crosshead guide ribs. Then again by 21/64in. (0.328in.) – that is, 7/16in. or 0.424in. below datum – to mark each of the pads round the cylinder-fixing bolt holes. Note that the really important figure is the 21/64in.; take care over this one – we shall use means to get it dead right when machining.

● *To be continued*