the whole assembly. If a little care has been taken in applying the Araldite, the assembly should be reasonably cylindrical. I have not found it necessary therefore to skim down the outside of the armature to render it truly circular. If the armature is slightly imbalanced mechanically, then it can be balanced when the flywheel is fitted.

If it is not possible to fit a flywheel and the motor vibrates at high speed due to mechanical imbalance, then the armature will obviously have to be skimmed true. Here of course, a collet chuck will be necessary to maintain concentricity. The motor can now be permanently re-assembled. The only fixing required is to Araldite the brush housing to the magnet assembly. Care should be taken at this stage to ensure that the bearings are perfectly in line. It is also advisable to run the motor to check that all is well. The second end thrust bearing is now assembled on the outside of the drive shaft and the worm pressed up against it. End float should be adjusted to the barest minimum and the worm fixed with Loctite penetrating adhesive.

If there is room for a flywheel, then this should be fitted. As well as the well-known smoothing effects, it is also useful for balancing the motor. The flywheel is lead rimmed on a brass disc and the diameter should be as large as possible for maximum effect. In order to balance the assembly, it should be fixed on the armature shaft and the motor run at full volts. Any imbalance will show itself as vibration. A tiny piece of lead shot is taped to the outside of the flywheel and the motor run again. The process of finding balance is akin to balancing a car wheel, but without the advantage of a stroboscopic tester. Eventually the motor will run without vibration. Since the lead weight will probably not fit within the bodywork, it is necessary to remove an equivalent amount of lead from the opposite side of the flywheel. This can be done by twisting the point of a drill in to the soft lead. The small piece of lead and the fixing tape can be removed and the motor should run as before. The method of balancing is not strictly accurate but will be effective enough for our purposes.

While the foregoing specifically relates to one particular motor, the principles can be applied to any. Recently Sidney Stubbs has described gear box construction in the model railway press and his article states the principles by which he works. These had been laid down many years ago by the late Alex Jackson and will stand repeating here, as they are the basis of all design work in small motor construction:

Small diameter shafts and commutators to reduce friction.
Many turns of fine gauge wire on the armature.
Adequate bearings with end thrust ball races.
Accurately machined, lead rimmed flywheel, although I would add that this is not always possible within the confines of some of the more obscure prototypes.

Riveting in the Lathe

NORMAN DALE, now 78 and a central figure in what many of us call the 'Northern School' of finescale pioneers, gives a workshop technique for successful rivet effects:

About ten years ago, I decided to build a couple of L & Y 0–6–0s in EM gauge. One locomotive was the Barton-Wright version with 4 ft 6 in driving wheels, the other by Aspinall with 5 ft 1 in driving wheels. Soon after Aspinall took charge at Horwich, there was a shortage of goods shunting engines, which he put right by converting 230 of the Barton-Wright 0–6–0s to saddle tanks. Later, when the first batches of Aspinall's new 5 ft 1 in 0–6–0s were built, some of the surplus but still serviceable tenders from the old Barton-Wright locomotives were fitted to them. I decided that both would have the same Barton-Wright pattern of tender, it being quicker to build two or more items in batch form.

As you can see from the photographs, there's a fair bit of rivet detail to these tenders. How to translate the prototype rivet detail into neat lines of 4mm scale rivets took some serious 'armchair modelling'; it would be ideal, I thought, if I could rivet a complete tender side without moving it around by hand in my home-made riveting tool.

Thus began a project which resulted in an indexing device producing three basic pitches from my lathe lead screw. Using a riveting tool held firmly and remote from the lathe, it provides me with beautifully consistent rivet pitches. The three basic pitches multiply to give at least 12 usable pitches for 4mm modelling, more for larger scales. It has proved immensely easy to use and has since found other uses. In describing this project, I hope that those of you with access to a lathe can benefit from my experience.

THE TOOLS

I have an old EW lathe with a 2.5 in centre height and 10 in between centres. All the work in making my riveting tool was done on the EW lathe. The riveting tool enables me to do work which would otherwise be impossible, especially bearing in mind that my eyes are 78 years old. The tool is shown at *Fig. 1.* I don't propose to describe its manufacture here, but, by providing a drawing of it, I may encourage you to have a go. The lathe, fitted with lead screw and back gear, cost me £19 1s. 0d. in October 1956 and was produced at that time by EW, a small firm in Wantage, Berkshire. If you're thinking of buying a second-hand lathe, I can recommend one of them.

The tool has a 7/16 in diameter tang machined on one side of it which, when gripped in the lathe chuck, sets it at the lathe centre height. This is useful for riveting in the lathe with the material held firm in the top slide, or in a vertical slide with a machine vice (which is always fixed to my vertical slide). The snag here is being limited by the travel of the saddle

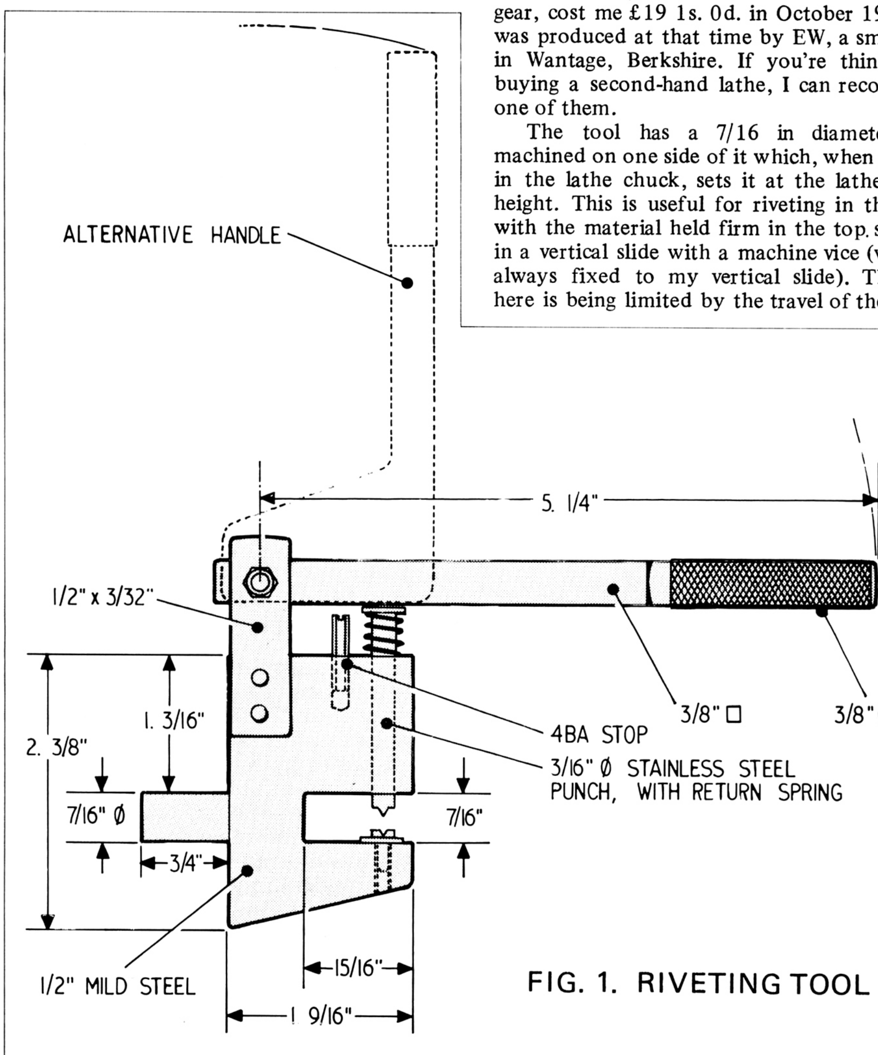


FIG. 1. RIVETING TOOL

or cross slide which, on my EW, is only 2.5 in. This travel can be used for short lengths of accurate rivet embossing by making up a list of the required rivet pitches and carefully moving forward to each reading. For greater heights, it means re-setting the job and picking up the rivet pitch, which isn't easy. A bigger lathe than the EW is desirable for such work, but that's what I've got, so . . . Don't try the short cut of drilling and tapping the tang to the main body – it may take a little longer but a proper arrangement prevents slop-induced errors. The riveting tool is suitable for 4mm work, although modellers in 7mm would be wise to increase the overall sizes a little, especially at the jaw depth. The jaw depth for 7mm should be at least 1.5 in to leave space for about 0.625 in of material at the rear. A general 7/4ths increase in size (175%) seems the most logical way to scale it up.

Not long after finishing the tenders some eight years ago, the original operating handle of the riveting tool broke and I altered the tool as shown on the drawing. This is workable for most jobs held in the three-jaw chuck but, if I should build any more tenders, I will make an upright handle similar to the original as shown by the dotted lines on the drawing.

FIG. 2. TOOLING ARRANGEMENT (PLAN)

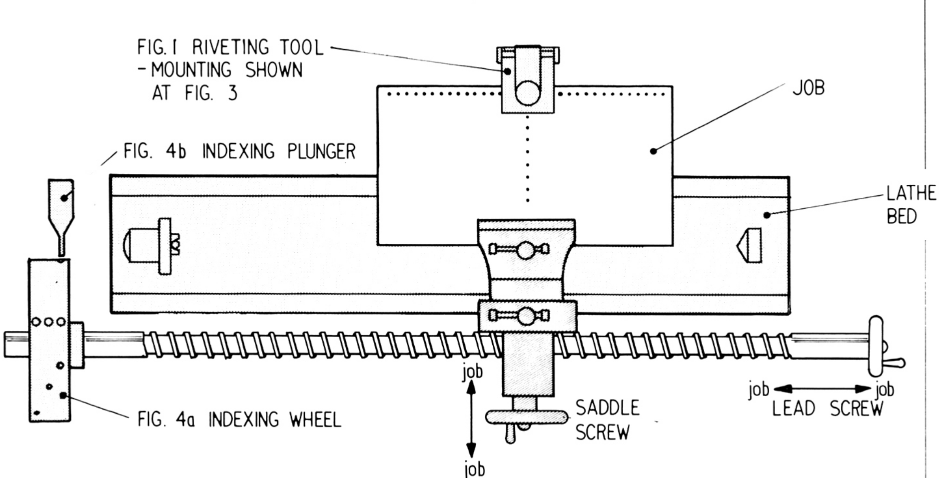
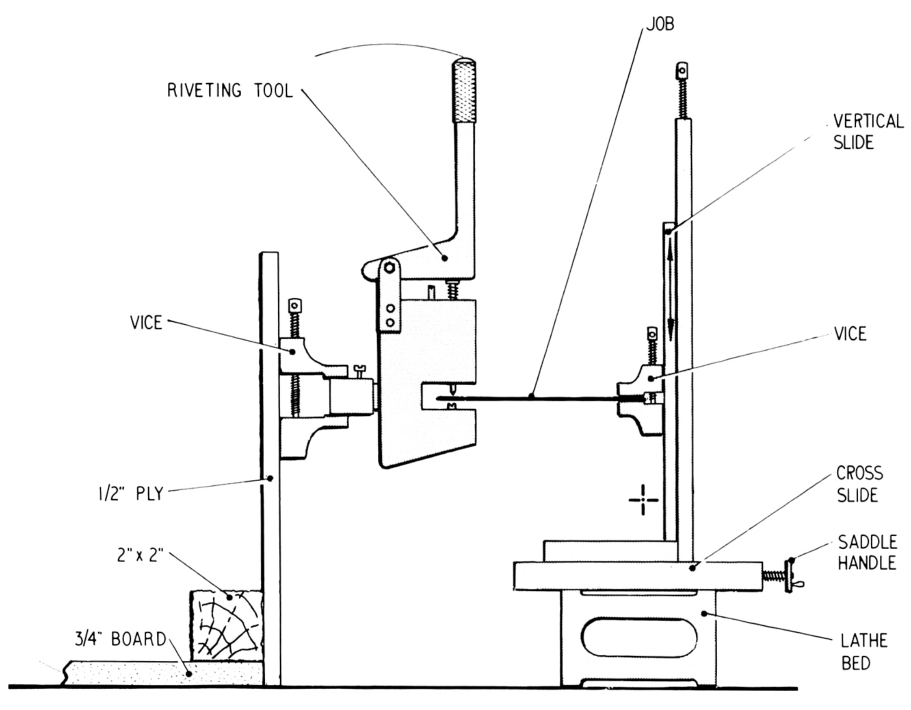


FIG. 3. TOOLING ARRANGEMENT (SIDE)



The interfacing of the riveting tool to the lathe bed was schemed within my brain box and, when put into practice, needed little or no modification. The scheme is shown in *Figs. 2 & 3*, drawn not to scale but, I trust, easy to follow. Perhaps the only thing not shown clearly in these views is the way in which the riveting tool is secured to the machine vice. If the tool has the tang on the end of it, a round hole in a square block is required to grip it between the jaws of the vice. On the other hand, if you don't intend to use the tool in the lathe's chuck, a flattened tang is quite adequate. The lathe's lead screw provides spacing for longitudinally-pitched rivet lines, lateral lines being spaced by the saddle screw in the 'traditional' way.

INDEXING

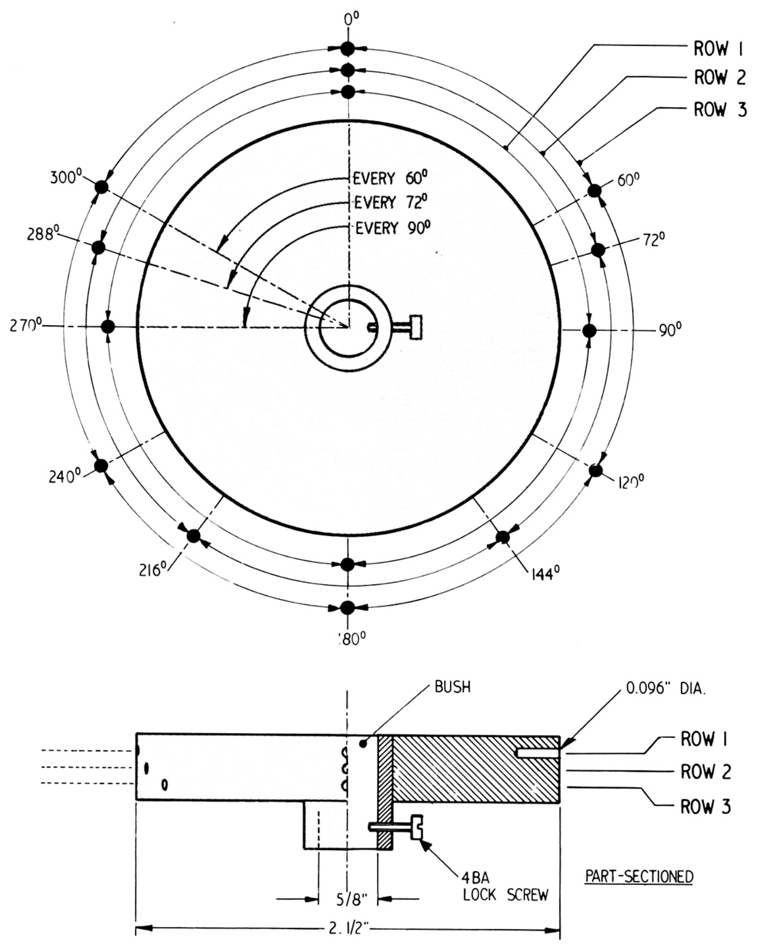
Now to explain the pitch (or indexing) of the horizontal lines. A cast iron pinion was rescued from a scrap bin. This, when all the teeth had been turned off and it had been bushed and bored to suit my 0.625 in (5/8 in) dia. lead screw, produced a 2.5 in dia. blank that was 1.125 in thick. Using a suitable gearwheel on the lathe head stock mandrel, this was indexed to produce an indexing wheel by drilling three sets of holes with a No. 41 (0.096) drill, as shown at *Fig. 4a*. These holes match the probe of the indexing plunger, shown at *Fig. 4b*, which itself fits in the root of the lathe's gear wheel using a mild steel peg.

The smallest increments of movement (90°, 72° or 60°) from the three rows of holes in the indexing wheel each give a different pitch. The pitch of the lathe's lead screw being 0.125 in (8 tpi), a full 360° rotation would produce a rivet pitch of 1/8 in (0.125 in). By moving at increments of more than one hole at a time, the number of pitches multiply to at least 12, as shown in the Indexing Tables. For example, if indexing at every hole of Row 1 (90°), then the rivet pitch occurs at an actual pitch of 0.03125 in. If indexing at every third hole of Row 2 (216°), the rivet pitch occurs at 0.0750 in. These pitches naturally scale up to modelling scales other than 4mm, the tables showing 7mm scale equivalents to give example.

The L & Y tenders had 3.5 in and 1.75 in pitch rivets. To represent these, I used Row 3 pitches of 3.169 in (120° increments) and 1.581 in (60° increments). You might prefer to use the Row 2 pitch of 3.800 in (144° increments) but, if doing this, then bear in mind the need to align alternate rivets on the tender flare (detailed below) and, for the 1.75 in pitch rivets, use instead the Row 2 pitch of 1.900 in (72° increments). To avoid possible confusion, I'll refer to these simply as wide-pitch and close-pitch throughout.

I did make one small error in the matching of the rivet pitches on one of the tender sides, which you may have noticed – I'll explain this later. As for the pitch sizes not being exact, I don't think actual pitch errors of 0.0022 in and 0.0044 in are visibly wrong! They look right to me, and to others who have seen them. I opted for the indexing wheel because I feared problems in matching closely-spaced lines of closely-spaced rivets. The indexing wheel makes it so simple that a child could emboss a line of equally spaced rivets, provided

FIG. 4a. INDEXING WHEEL



INDEXING TABLES

INDEX ROW NUMBER	INCREMENTS OF INDEXING°	ACTUAL PITCH" CORRECTED TO 4 DEC. PLACES	SCALED-UP PITCH" CORRECTED TO 3 DECIMAL PLACES Exact 4mm	Exact 7mm	Approximate 4mm	Approximate 7mm
ROW 1 4-HOLES	90	0.03125	2.375	1.361	2.375 2. 3/8	1.375 1. 3/8
	180	0.0625	4.750	2.714	4.750 4. 3/4	2.750 2. 3/4
	270	0.09375	7.125	4.071	7.125 7. 1/8	4.125 4. 1/8
	360	0.1250	9.500	5.443	9.500 9. 1/2	5.500 5. 1/2
ROW 2 5-HOLES	72	0.0250	1.900	1.089	1.875 1. 7/8	1.125 1. 1/8
	144	0.0500	3.800	2.177	3.75 3. 3/4	2.125 2. 1/8
	216	0.0750	5.700	3.266	5.750 5. 3/4	3.250 3. 1/4
	288	0.1000	7.600	4.354	7.500 7. 1/2	4.375 4. 3/8
	360	0.1250	9.500	5.443	9.500 9. 1/2	5.500 5. 1/2
ROW 3 6-HOLES	60	0.0208	1.581	0.905	1.625 1. 5/8	0.875 0. 7/8
	120	0.0417	3.169	1.811	3.125 3. 1/8	1.750 1. 3/4
	180	0.0625	4.750	2.714	4.750 4. 3/4	2.750 2. 3/4
	240	0.0833	6.333	3.619	6.250 6. 1/4	3.625 3. 5/8
	300	0.1042	7.917	4.524	7.875 7. 7/8	4.500 4. 1/2
	360	0.1250	9.500	5.443	9.500 9. 1/2	5.500 5. 1/2

a slight pitch error is acceptable. Using another list of pitches, you might get it exact by using a calibrated wheel on the lead screw, which is fitted to my lathe and is ranged from 0.001 in to 0.125 in increments of 0.001 in, kindly done for me by a fellow member of the Manchester Model Railway Society. However, note that the Indexing Tables are already corrected to a mere four decimal places!

EMBOSSING THE TENDERS

I used five pieces of 0.010 in nickel silver for the sides and ends of both tenders. Four of the pieces were each for a tender side, the fifth was for both ends, which were embossed as one piece. The side pieces were about 0.125 in longer and 0.5 in wider than required; the 0.125 in enabled me to use a vernier slide caliper to mark out (off the job) the starting positions of the horizontal lines of rivets, and similar marks were made for the vertical lines. The piece for the two ends was large enough to enable me to cut the ends out after embossing all the rivets. Once all these pieces are ready, the job can be installed in the tooling.

A tender side piece is gripped in the machine vice by its 0.5 in of spare height. Before finally tightening the job in the vice, it is paralleled to the lathe bed by sighting a 6 in steel rule against the free (bottom) edge of the tender side to the lathe bed. Check the paralleling again, after the vice has been clamped up. I would have used a dial gauge but, what with all the clutter on the lathe bed, there wasn't room to fit one! The set-up, meaning the tender side held firmly in the machine vice, was moved around the lathe bed using the lathe's lead screw and saddle screw. The set-up is moved past the first rivet position towards the lathe's headstock. It's then wound slowly back to the first rivet position and, by judicious adjustment of the set-up's position, the nearest pitch hole in the indexing wheel is aligned with the plunger pin, at which point the pin drops snugly into the hole. To avoid accidentally snagging the saddle handle, so moving a line of rivets out of line, it should be locked. The lock can be simply a toolmaker's clamp and wood packing, as I used. I wasn't going to ruin things for the sake of a few minutes and a simple lock!

The very first and most important rivet can now be embossed and identified using a piece of tape, as this is the reference hole for the first horizontal line and the first vertical one. When moving to a new horizontal line, return and pass the reference hole and then return slowly to it, thus taking up any slack in the lathe's bed mechanism. After that, unlock the saddle handle and move on to the next horizontal line, confident that the riveting will be in line with the line above. Before embossing that new line, the saddle handle lock is applied again.

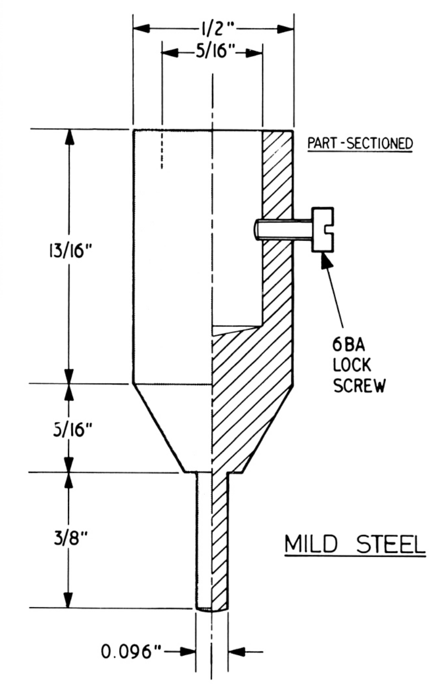


FIG. 4b. INDEXING PLUNGER

The first line is a horizontal one of wide-pitch at the top of the tender side for the flare piece. This line isn't visible from outside the tender but is there as a reference for the flare, which I'll explain shortly. This is followed by the vertical line of close-pitch rivets, started from the reference hole after first taking up the slack. Work by adding the saddle reading to a separate list of pitches.

Next, the whole set-up is moved to present the far end for its vertical line of close-pitch rivets, embossed as before. Then, the two vertical lines in the middle of the wide-pitch rivets are embossed. Returning to the reference hole and with the saddle handle locked again, it comes the turn of the first line of horizontal close-pitch rivets. This done, unlock again and adjust the set-up ready for the bottom and final line of close-pitch rivets, which are embossed with the lock on.

RIVETING THE FLARE

The tender flare is actually a separate piece which, on the prototype, is riveted to the tender sides and rear. This caused a little brain-searching before coming up with a solution. The wide-pitch rivets had to be in line with

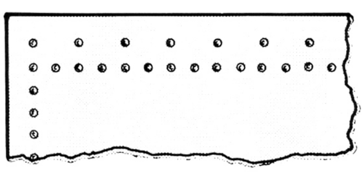
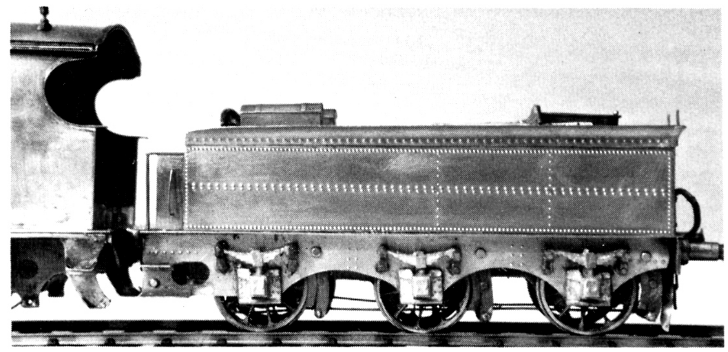


FIG. 5. TENDER

alternate close-pitch rivets of the lower lines, as shown at *Fig. 5.* The top line of wide-pitch rivets on the tender provide a reference for the flare position.

The flare, made from the nickel silver sheet, is cut out in flat form with an extra inch of material at its top. The flare (only) is first rolled to profile with the bottom edge ready cut to shape. It is then embossed with a line of wide-pitched rivets and, after removing it from the set-up, the inch of spare material is cut away to leave a finished flare. When laid over the top line of the tender's wide-pitch rivets, the flare, with every rivet over an alternate rivet of the tender's close-pitch line immediately below, is in the correct position. With a wipe of solder cream and a hot iron, it is fixed in place. Once I had this done, I was home and dry.

The tender sides and rear ends were mitred and soldered up in my usual way, published in



Close-up of tender side, showing rivet detail on side and flare.

the September 1978 issue of the old *Model Railways.* This matches the flaring sides to the end of the tender without trouble.

FURTHER APPLICATIONS

The riveting tool can be used to emboss detail for purposes other than showing rivet or bolt head detail. Here are three more uses for the riveting tool, which may encourage you a little further and perhaps solve a problem or two that's long baffled you!

The cabs on two L & Y 0–8–0 locomotives I was building needed a row of ventilation holes in the spectacle plate, which was very close to the cab roof. With the riveting tool in the three-jaw chuck and the spectacle plate held in a vertical slide on the saddle, I embossed a line of equally spaced 'rivets'. Each rivet was then drilled No. 71 drill (0.026) to give a beautifully neat row of 2 in scale holes – no marking out or centre-popping was required.

When making the back heads for these two locomotives, I wanted to represent the sliding bar (*Fig. 6*) for the regulator. A strip of 0.125 in wide 0.010 in nickel silver was held at one end by the vertical slide on the saddle, and the riveting tool was affixed to the three-jaw chuck. 'Rivets' were embossed at the reading in *Fig. 6*, adding them up for each move. After drilling each rivet with a 1/64 in drill, pins of 0.016 in dia. were soldered through to attach it later to the back head, with two other pins of the same size to represent the two handles. With the bar filed down to as near 0.023 in as possible, using the pin shanks as a guide, the result is a straight bar with the holes at the correct spacing. I doubt if I could mark one out with the same accuracy as the riveting tool achieved.

Also, again on the L & Y regulators, was a small plate riveted to the back head acting as a bearing for the regulator lever handle. *Fig. 7* shows its dimensions in 4mm scale. How was I to make two of these? With my lathe-mounted riveting tool, it was easy! They were made from a strip of 0.007 in nickel silver, the rivets and centre hole all being embossed in the one process and equally spaced by the saddle screw. The 1/64 in centre hole was drilled out and filed to size whilst held at one end and, later, the now-drilled and riveted plate was nipped off to length.

THE PUNCH LINE

The minor error in the riveting, to which I referred earlier, is that the lower line of horizontal wide-pitch rivets starts off one below the other but then goes slightly out of pitch. This is something that neither I nor, apparently, anybody else had noticed previously, or maybe they were too polite to say so. Eight years is a long way back to remember but I do recall once having some trouble with the lever on the riveting tool; I must have moved the tool by the odd thou or so to get this result. The other three sides (two tenders!) are alright – just my luck to have this one photographed! A grab handle can also be seen adrift, quickly cured once back at home.

In my wagon-making days, after painting and lettering, I would always put a finished wagon in front of a mirror and then look at it through another mirror. This showed any errors in true perspective. I should have given the tender this test!

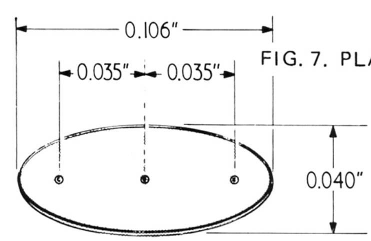


FIG. 7. PLATE

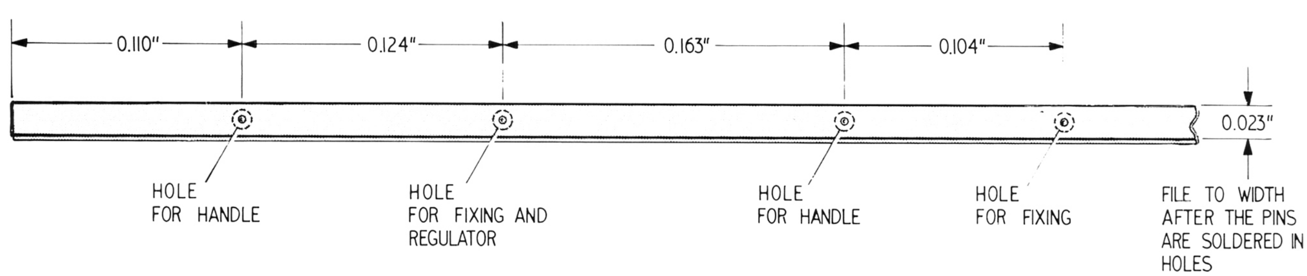


FIG. 6. REGULATOR LEVER

Drawings by Monty Wells.