Marie E, A Porter 0-4-0 in 4¾/5 in. gauge

by: DON YOUNG

Part 1 – The Chassis

For once introductions are unnecessary, for unconscious of what would ensue, I compiled the story of the LARGE LOCOMOTIVE of the same name, to the design of Oliver M. Johnston, as it appeared in LLAS No. 3 (May 1980). So any of our newer readers can avail themselves of this back number to avoid repetition.
I mentioned when announcing my humble design that MARIE E was a 'Beginner's Locomotive', which brought forth the question as to my reasons for such a label, particularly as some of you are building DON HUNSLET as your first SMALL LOCOMOTIVE, and by your letters are enjoying the experience. My definition of a Beginner's Locomotive is one of low work content, plus designed with a view to ease of manufacture, as an exercise in basic engineering. I think in this MARIE E meets my specification, though you the reader can be the best judge of this as the series unfolds.
I first looked at MARIE E in 3½ in. gauge, as this is the only worldwide standard and as such is attractive to me as the designer, there being no either/or dimensions to worry about. However, in this instance the end result was puny from a performance point of view and full of 'watchmaking'; no way was it a Beginner's Locomotive. At 4¾/5 in. gauge the whole thing fell into place and I must admit that my thought process stopped right there. As with HUNSLET though, there is a lot to be said for a 7¼/7½ in. gauge variant, though this time there is no Milner Engineering design from which to lift the details. If there is sufficient interest shown in these bigger gauges then I will fill in a few of the details, though at first, and second(!) look I have yet to find a dimension which cannot directly be increased by 50% to arrive at the larger Locomotive, other than rounding up the bar frame section to ⅝ in. square. Providing the builder does not mind a slight alteration in overall appearance, Don Young Designs can supply castings like Wheels, Dome and Sandbox from other existing designs, plus there will be no problem at all with the Fittings – we have you completely covered for these latter!
Back to 4¾/5 in. gauge, where Dennis Hill became interested in MARIE E very early in the project, and started to cut metal almost before the ink was dry on the drawings. That his MARIE E is now complete and running is the best boost to my morale there could be at the beginning of this series, for which my grateful thanks, but I must not steal his thunder and will leave Dennis to tell his own story in 'Builders Corner'.
A number of other builders are working ahead of the script, so this should make for a smooth passage, for experience has taught that the existence of a prototype does not remove every possible snag. Five years after my 5 in. gauge RAIL MOTOR No. 1 had been completed for instance, another of my 0-4-0 'quickies' that has proved popular, a South African builder told me it was impossible to set the valves as drawn; I was provided with details of the modifications required. Yet my original drawings checked out O.K. and when this builder called to see me a couple of years back I was able to show him my No. 1. He checked all the dimensions for himself; all was in order. Yet about 1 in 100 builders of RAIL MOTOR No. 1 report the same sort of snag, so this was not a single instance; this sort of thing is very baffling. In the case of MARIE E, Dennis Hill reports that valve setting occupied less than 30 minutes, when all was well, so I am off to a flying start. Talking of start, it is time I did just that with the series, so climb aboard and away we go.

Frames

The whole Chassis adorns the top L.H. corner of Sheet No. 2, not a very daunting prospect, especially when the frames are 18¾ in. finished lengths of $\frac{7}{16}$ in. square steel bar. Cut two 1⅝ in. blocks from the same material for the weighshaft bearings, then mark off one frame, clamp to the other and drill as a pair for both vertical and horizontal holes; fit the weighshaft bearing blocks and deal with these also.

Beams

It is difficult to obtain properly seasoned timber these days, so for the beams purchase a length of 1½ in. x 1 in. hardwood, this will be oak in the U.K. for preference, and leave outdoors under cover for as many months as you are able before planing to the required 1¼ in. x ¾ in. section; saw off to length and radius the front beam ends; my American friends will call this the pilot beam. Although it may sound crude, files are quite suitable for shaping wood, unclogging the teeth with a wire brush at frequent intervals, then finish with fine grade sandpaper.

Gussets

The gussets are from 1 in. x 1 in. x ⅛ in. steel angle, the bright variety with square root and corners if you can get it. Saw out to the shapes shown, clamp the inner pairs to the frames and clamp the beams in turn to the gussets. Lay the assembly on the lathe bed or surface plate to check for flatness, check for squareness across the frames as well, then drill No. 27 holes from the frames through the gussets. Remove the gussets, still clamped to the beams, drill the five fixing holes if not already attended to, these to suit your woodscrews, drill a pilot hole into the beam and screw home.

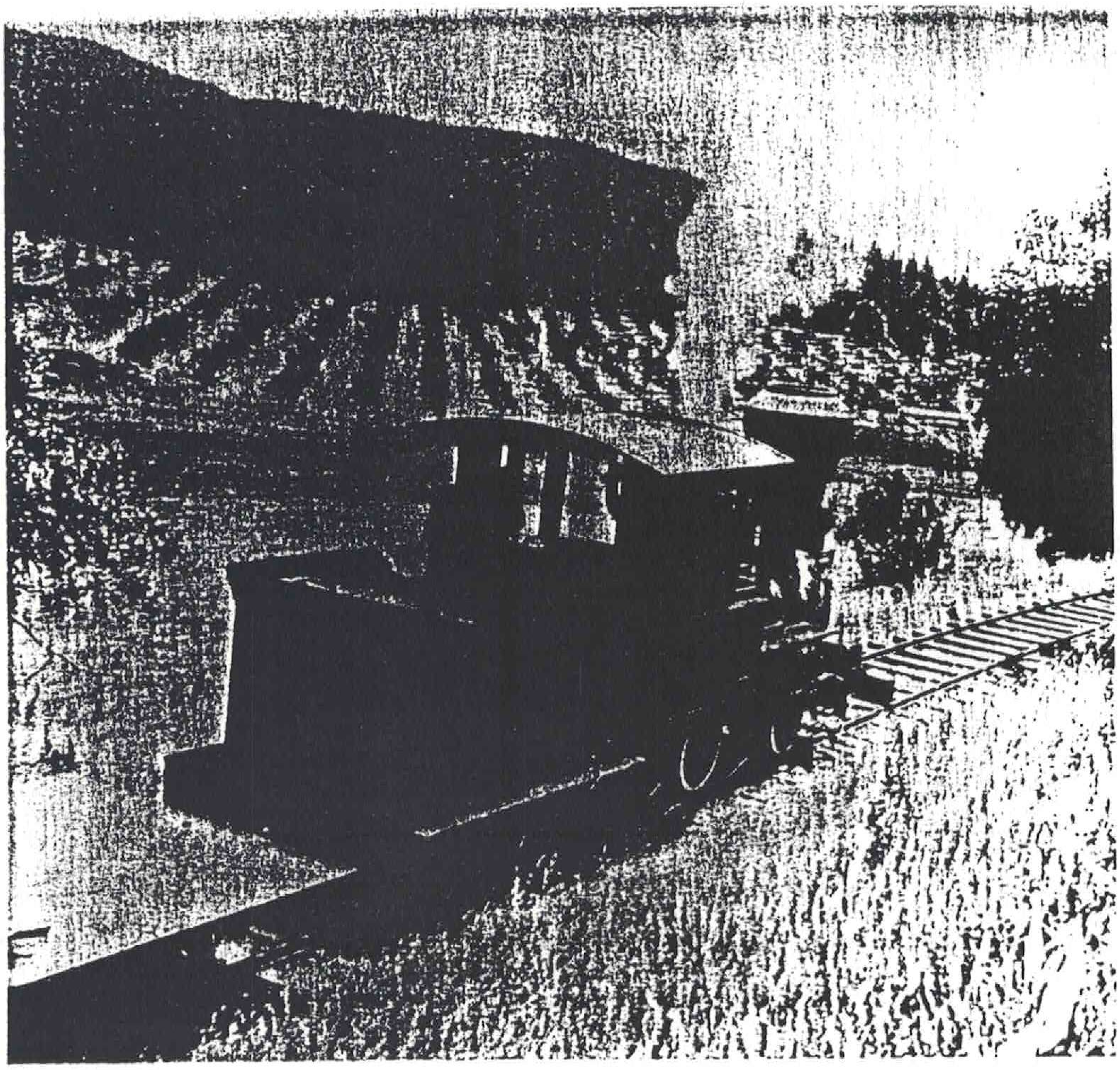
Equaliser Beam Stay

I should have mentioned earlier about frame spacing, and this is best achieved by making the equaliser beam stays. Saw these from ⅝ in. x ⅝ in. x ⅛ in. steel angle, square off to 4$\frac{9}{16}$ in. (4$\frac{5}{16}$ in. for 4¾ in. gauge) overall, clamp back to back, mark off and drill the two No. 27 holes, then clamp back to back again on the other face to mark off and drill the No. 11 hole, although this latter is not yet required. Now all you have to do is bolt the stays through any of the vertical holes in the frames to achieve the correct spacing.
The outer gussets have yet to be fitted, so clamp these to the inner pair, still attached to the beams, spot through and drill No. 27 for the frame fixings. Assemble the beams to the frames once more, with the outer gussets in place, then drill for and fit the woodscrews.

Drawbar Stay

We can stiffen the frame assembly with the drawbar stay, so cut a length from 1 in. x ⅛ in. BMS flat to match the overall width of the frames, clamp in place and drill the four No. 27 holes from the frames. Cut two blocks ⅝ in. finished length from ½ in. x ⅜ in. BMS bar, a 1½ in. length from ½ in. x ⅛ in. BMS flat, and clamp to the stay in the position shown. Drill four 3/32 in. holes for snap head iron rivets, but before rivetting over, remove the spacers, use 7BA bolts to fix the lower plate to the stay, and drill through at No. 11 for the drawbar pin.

I don't think much needs to be said about this pitcure by David Gooley; it should set builders of MARIE E dreaming!



Already we can begin to think about wheeling MARIE E, which in itself is very straightforward, thanks to Carl Purinton, founder of the Brotherhood of Live Steamers. For it was Carl who told me that he did not use springing on his Locomotives, as there was nobody on the footplate to feel the effects of a lack of springing. So for MARIE E I was able to think in terms of the classic 3-point suspension, the rear axle being fixed and the front axle pivotting about its mid point. By chance, less than 24 hours after Sheet No. 1 became a reality, I visited the Portsmouth M.E.S., Bill Edwards, who built my RAIL MOTOR No. 2 as his first attempt, was immediately taken by MARIE E and was the first to start construction. He was a little sceptical about the lack of springing, appreciating its importance to the track stability of his RAIL MOTOR, so as soon as the chassiss was wheeled it was taken to the Club track and sent hurtling around the track at high speed. There were no derailments and Bill is now convinced that this is a feasible form of suspension.

Wheels

I love turning wheels, so let us make those the next item to be tackled.

Chuck in the 3 jaw, by the tread, run at the lowest direct drive speed and first check that the wheel is running true. There should be no problem at all, for these castings are good, but if you are at all unhappy, change to the 4 jaw chuck and set to run true. That actually is the second operation, for the first task on picking up any castings is to assess the machining allowances provided; this will always pay handsome dividends! Face right across the back of the casting to remove the established machining allowance, then turn down the flange to $3\frac{11}{16}$ in. diameter, finishing the corner radius with a file. Next centre and drill through to 27/64 in. diameter and ream through at $\frac{7}{16}$ in.; complete all wheels to this stage. Take a drill of at least $\frac{1}{2}$ in. diameter, with taper shank to match your headstock, and saw apart at the top of the flutes; this will be much easier than you might imagine. Clean the headstock mandrel thoroughly, tap in the drill shank and turn down to a close fit in the wheel boss. Fit the faceplate, slide a wheel over the mandrel and bolt through the spokes to the faceplate; a large countersunk head screw, maybe with a washer under the head, is ideal here as it does not get in the way of the lathe tool. Face across the front of the tyre to the required $\frac{9}{16}$ in. overall thickness, then deal with the crank boss to finish 1/32 in. proud of the tyre. Tackle the tread next using a round nose tool so as to form the root radius at the same time; if there is any tool chatter, stop the motor and pull round by hand to get the required finish. Leave the tread about .010 in. oversize at this stage, but complete the flange to drawing, including the top radius. Repeat for the other three wheels. Leave the last one in place and take a final cut across the tread; leave the cross slide well alone and take this same finishing cut on the other wheels so they have identical tread diameter.

To drill for the crankpin we need a simple jig, so grip a $1\frac{3}{4}$ in. length of, say, 1 in. x $\frac{3}{8}$ in. BMS flat in the machine vice, on the vertical slide, and at $\frac{1}{2}$ in. from one end, centre and drill through in nice easy steps to $\frac{3}{8}$ in. diameter. Advance the cross slide by .813 in., centre again and open out in stages to $\frac{5}{16}$ in. diameter. Incidentally, this set-up is also best suited for drilling the frames, when if those No. 27 holes are not central in the $\frac{7}{16}$ in. bar, at least they are all on the same axis. Back to our jig, where the next job is to chuck a length of $\frac{7}{16}$ in. silver steel rod in the 3 jaw, after checking that it is a fairly close fit in the wheel boss, then turn down for $\frac{3}{8}$ in. length to $\frac{3}{8}$ in. diameter, a press fit in the piece of bar. Part off to leave a

$\frac{7}{16}$ in. length at the original $\frac{7}{16}$ in. diameter, press into the bar and our jig is complete.
Apply marking off fluid to the crank boss on each of the wheels and scribe on the centre line to position the crankpin, this on the outside of the wheel. Fit the drill jig, sight through the $\frac{5}{16}$ in. hole on to the centre line just scribed and position carefully by eye; this will be surprisingly accurate. Clamp the bar to the wheel, set up on the drilling machine table and drill through for the crankpin at $\frac{5}{16}$ in. diameter; repeat for the other wheels.
The leading wheels crankpin boss is relieved to give clearance for the coupling rod, so chuck in the 4 jaw and poke a length of $\frac{5}{16}$ in. rod in the crankpin hole. Grip a dial test indicator (d.t.i.) under the toolpost, bring up to the $\frac{5}{16}$ in. rod and set the wheel for the crankpin to run true, then machine the 1/32 in. recess in the boss as shown, this to complete the wheels.

Crankpins & Caps

The crankpins are plain lengths of $\frac{5}{16}$ in. bright steel rod, so first part off to length; between .005 in. and .010 in. above $\frac{3}{4}$ in. for the leading pair. Chuck a crankpin in the 3 jaw, centre and drill No. 34 to $\frac{3}{8}$ in. depth and tap 4BA. When turning, drilling, or tapping steel, always use plenty of 'cutting oil' and apply with a paint brush or similar. All the cutting and lubricating oil I use in the workshop costs not one penny, being the residue from the tins of oil used in the horseless carriage; you will be surprised how much would otherwise be wasted. Stand the can on a warm surface to reduce the viscosity of the oil, cut off the top with a can opener, and pour the contents into a jam jar; see what I mean!
For the crankpin caps, start with $\frac{1}{2}$ in. steel rod and reduce over a $\frac{1}{2}$ in. length to 31/64 in. diameter. Centre and drill No. 27 to the same $\frac{1}{2}$ in. depth, then change to a 90 deg. Rosebit, a very useful tool, and countersink to accept a 4BA screw; part off a $\frac{3}{16}$ in. slice then repeat the dose.
Degrease the crankpins and their mating holes in the wheels with petrol, better the Primer 'T' that Loctite supply in an aerosol can, apply a drop or two of Loctite 601, or 638 and reassemble; leave to cure. Most Loctite grades these days are 'superfast', which is alright for industry to cut production time, but for us SMALL LOCOMOTIVE builders it can be a curse. The curing time is temperature sensitive, so to give yourself more latitude, choose a cool evening rather than a hot summer day, this way you may get 10 minutes grâce instead of 10 seconds!

Axles

For the axles a 12 in. length of $\frac{1}{2}$ in. bright mild steel rod is required. Saw off two lengths and face them to $5\frac{3}{4}$ in. ($5\frac{3}{8}$ in. for $4\frac{3}{4}$ in. gauge) overall. Chances are your 3 jaw chuck is sufficiently accurate to turn the wheel seat concentric with the journal; you can quickly check this with the d.t.i. If any problem, change to the 4 jaw and set to run true with said d.t.i., with about $\frac{7}{8}$ in. protruding from the jaws. Centre the end of the axle quite deeply, this was virtually universal practice full size, then carefully turn down over a 19/32 in. length to $\frac{7}{16}$ in. diameter, a close fit in the wheel boss; repeat at the other end of the axle. Degrease and apply a wheel to each axle with Loctite 601 or 638 and this is as far as we can go for the moment as there are some other pieces to be made and fitted before the other wheels meet their axles.

Eccentric Sheave

The next job, the eccentric sheaves, are pure turning from $1\frac{1}{4}$ in. diameter bright steel bar, length around $3\frac{1}{2}$ in. Chuck in the 3 jaw, centre and bring the tailstock into use. Starting at the tailstock end, cut grooves with a parting off tool down to about $\frac{5}{8}$ in. diameter, first to leave $\frac{3}{16}$ in. at the outer end, then four lengths of a full $\frac{1}{2}$ in. so that they will clean up to the required sheave thickness. We next need a parting off tool with a 7/32 in. wide blade, ground perfectly flat so that the groove can be formed at one pass. Experienced builders will make this from a piece of tool steel, but beginners should look around for a proprietary one suitable for your needs. Tackle the $\frac{3}{16}$ in. wide end piece for a start and reduce to $1\frac{1}{8}$ in. diameter, which dimension can be arrived at with sufficient accuracy with calipers, as this piece will become your gauge for the mating straps later on. Feed on plenty of cutting oil to get that lovely 'frying tonight' sound, though the smell is not so pleasant(!) and make a note of the cross slide reading at the completion of the cut. Now move on to the sheaves themselves and deal with each in turn to arrive at the same groove diameter; part into individual sheaves. Clean up to the required overall $\frac{1}{2}$ in. thickness, to leave a 3/64 in. thick flange, then mark the 7/32 in. eccentric throw onto one sheave and set in the 4 jaw. Turn to produce the $\frac{13}{16}$ in. diameter boss, taking light cuts, then centre, drill and ream through to $\frac{1}{2}$ in. diameter to suit the axle. Undo two jaws only to release and tighten the same two jaws to continue with the rest of the sheaves. Complete by drilling and tapping 5BA for a cup point socket grub screw for securing to the axle later on.

Driving Axlebox

The driving axleboxes are very straightforward and bolt directly to the frames. Start with a length of $1\frac{1}{2}$ in. x $\frac{1}{2}$ in. BMS bar and saw off two pieces $1\frac{3}{8}$ in. long. Chuck in the 4 jaw, face one end on each piece, then chuck together and complete to $1\frac{5}{16}$ in. overall. Mark the axle centre on one piece, chuck the pair again in the 4 jaw, centre, drill through and bore out to an odd end of $\frac{5}{8}$ in. diameter steel as your gauge; this can now be used as a 'button' to align the two boxes for the remaining machining.
On to the machine vice and vertical slide, again as a pair, to mill the $\frac{1}{16}$ in. deep recess to leave a $\frac{1}{16}$ in. flange to 'grip' the frames. Rotate through 180 deg. and mill away the side flanks so that the outer fixing bolts need not be overlong. Get a couple of very small grease nipples, Tecalemit used to do one screwed 4BA, and tap the boxes to suit. If you don't fancy turning up the bronze bushes, Messrs. Whiston stock the oil retaining variety, which are ideal for our purpose, though you may have to cut them to length; this applies to all the bushes detailed. Press these home, drill the grease hole into the bore, and we are ready to erect.
Take one axlebox and clamp firmly to the frame, flange outside, and position as close to drawing as you are able. Drill through the outer holes at No. 27, spot the middle one, drill this latter No. 33 and tap 4BA; secure with hexagon head bolts. Slide in the driving axle, fit the second axlebox and clamp in place, then check for free turning of the axle. When all is well, drill, tap and secure this axlebox in turn.
Nothing attaches to the driving axle by reason of it passing through the ashpan, the reason I should have given for grease lubrication, so we can fit the second driving wheel immediately after we have completed the coupling rods. There are all sorts of quartering jigs, none of which have I ever used; all my Locomotives so far have been set by eye. However, there is a reasonably simple way of achieving the desired result in a more scientific manner, using a surface plate, a scribing block, and an engineer's square. Choose a cool evening, degrease the axle end and wheel boss, apply Loctite of the 601 or 638 variety and assemble. Sit on the surface plate and use pieces of packing to stop the wheels rolling about. Use the scribing block to set one crankpin reasonable horizontal to the axle centre and the square to set the other at 90 deg. to same; it makes no real difference if the right or left crank leads, though if you do want an instruction for this then put the L.H. one in front.

Leading Horns, Axleboxes, and Stays

The leading axleboxes are from 1 in. square BMS bar, so cut a 1½ in. length and face the ends square in the 4 jaw. Find the centre of one end by the 'X' method, scribing lines to opposite corners, and set to run as true as possible in the 4 jaw, then drill through and bore out to ⅜ in. diameter as for the driving boxes. Back to the machine vice and vertical slide to mill a 1/16 in. recess in one face, leaving a ⅛ in. thick flange at each end. Rotate through 180 deg. and repeat the process, when you can saw into individual boxes and face off to ⅝ in, overall thickness. To complete the boxes, press in the bronze bushes and we can move on to the horns.

A 'stick' casting is provided for the horns, being very easy to machine. First chuck in the 4 jaw and machine the top surface, then reverse in the chuck and machine the bottom face to give the correct 1¾ in. dimension; the working face can either be dealt with in like manner, or you can revert to the machine vice and vertical slide to end mill to the required finish. Whatever method you choose for the working face, tidy up the non-working surfaces at the back, plus the ends of the top and bottom lugs, with an end mill. Back to the 4 jaw chuck and face across both ends of the casting, then saw off the first individual horn. Face off the sawn end, cut another horn and repeat until you have the set of four. Pack a horn from the chuck body so that the face left to be machined is clear of the jaws, then face off to 7/16 in. thickness. At the same tool setting and using the same packing piece, face the other three horns to identical thickness.

Clamp a pair of horns to an axlebox, the flange of the latter being inwards, and clamp the whole in turn to the frames. Locate as accurately as possible, position in this instance being more critical than for the driving axle, and spot through from the frames. Drill the outer holes through at No. 27, the inners at No. 33 to ¼ in. depth, and tap 4BA; secure with hexagon head bolts. There is a very easy way to complete the assembly to be free-running, though we have need to start the coupling rods to achieve this.

Take two 9 in. lengths of 1 in. x 5/16 in. BMS flat and at 13/32 in. from one edge scribe a line the full length. At ⅜ in. from each end, scribe vertical lines to roughly represent the centres of the bosses. Clamp one of these embryo rods to the pair of axleboxes fitted to the one frame, packing the leading axlebox down by 5/16 in. to align with its driving partner. The 'cross hairs' you have provided with those scribed lines will allow you to find the centre of the axle holes very easily to the accuracy you require. Drill through from the bushes at ¼ in. diameter and repeat for the second coupling rod, when they will be of identical length between centres.

Clamp the second leading axlebox to its horns, clamp in turn to the frames, then poke lengths of ¼ in. rod through both leading and driving pairs of axleboxes. Slip on the coupling rods, adjusting as necessary, then fix the second pair of leading horns to the frames. The hornstays are plain 2 in. lengths of 7/16 in. x ⅛ in. BMS flat, the cross ties 4 9/16 in. (4 5/16 in.) long from ⅜ in. x ⅛ in. flat. Clamp firmly to the horns, check the leading axlebox is free to move, then drill right through at No. 27 in four positions and secure with 4BA nuts and bolts.

Coupling Rods

We must now carry on with the coupling rods so that we can completely wheel the engine and for this we need a 12 in. length of bright steel angle, say 1¼ in. x 1¼ in. x 3/16 in. section. Along one face drill a series of holes at about 2 in. centres and of a size to suit the 'T' bolts for fixing to the vertical slide table. On the other face we need two ⅜ in. holes at 7¾ in. centres so that we can bolt the embryo coupling rod in place. Bolt the angle to the vertical slide and set level; I achieve this by using a length of ground stock across the lathe bed and simply winding down the vertical slide until the angle comes in contact with same. Bolt the rod in place, chuck a large diameter end mill in the 3 jaw, and starting from the edge of one boss, remove 1/16 in. of metal as shown. You will have to move the angle along the vertical slide table as no SMALL LOCOMOTIVE builder's lathe to my knowledge has a cross slide travel in excess of 8 in., though this is no problem as you simply reset, gradually bring the end mill to the work again and carry on machining. Reaching the second boss, you have to machine right across it, so put a clamp over the very end of the bar, this is why it is over-long, and mill up to the clamp. Turn the rod over, put 1/16 in. packing between angle and rod where the metal has been removed, and repeat the process to achieve the stepped ends as per drawing.

Next apply marking off fluid and carefully scribe on the profile of the rod. Bolt again to the angle and mill along the straight line closest to the chuck, using a ⅜ in. end mill. Rather than turn the rod and have to set up all over again, the other edge of the rod can best be tackled with a Woodruff key cutter, Reeves can supply this most useful tool, when you will have removed the majority of the metal which was superfluous to our requirements. At this stage there will be a lot of burrs and sharp edges; carefully remove these with files so that the rod is safe to handle.

Those end bosses we can partly machine, so take another piece of the 1 in. square steel bar and drill a ¼ in. hole through it. Loctite a stub of the ¼ in. axle material into same, to protrude by about ¾ in., then grip this mandrel in the machine vice, on the vertical slide. Fit a ¼ in. end mill in the 3 jaw, slide the coupling rod over the mandrel, advance the rod onto the end mill, a very little at a time, and pull the rod around the mandrel towards you, never the other way. Most of us learn the wisdom of that statement the hard way at some stage, so be warned! You now have to complete the rod profile with files, drill the oil holes and press in the bushes flush with the inner face.

Erect the driving axle, then the leading one to include the eccentric sheaves, when you can apply Loctite to the last wheel, correctly orientating it by fitting the coupling rods. When the Loctite has cured and the wheels turn, they are bound to be a trifle stiff; grip a 5/16 in. drill in the bench vice, slip a rod end over it, poke a length of 1/16 in. steel rod down one of the flutes and rotate the coupling rod to ease metal from the bush. Do this to all the bushes, when the wheel should turn sweetly, even when you raise and lower a leading axlebox independent of its partner; this requirement is essential to the wellbeing of MARIE E on the track.

Equalising Gear

Having tried displacing the leading axleboxes by hand we can now provide the equalising gear which will carry out this function for us when running; it is all very simple. The equaliser beam is a 4½ in. (4¼ in.) finished length of ¼ in. x ¼ in. BMS bar. Clamp between the two equaliser beam stays which we have already made, mark off for the No. 11 fulcrum hole and drill right through. For the fulcrum pin, chuck a length of 5/16 in. steel rod in the 3 jaw and turn down for ⅜ in. length to 3/16 in. diameter, a nice sliding fit in the No. 11 hole just drilled. Lightly chamfer the end of the pin for ease of entry into said hole then part off to leave a 3/32 in. thick head. Fit the pin and cross drill 1/16 in. diameter for a split pin. Assemble to the frames and the beam is in contact with the frames at both ends; we must mill away the 1/16 in. step at each end so that the beam can operate properly. If the track on which you will run is very uneven, increase the step to 3/32 in., or ⅛ in. as a maximum. To connect from the top of the leading axleboxes to the underside of the equaliser beam we need two push rods 1⅝ in. lengths of 5/32 in. mild or silver steel rod, though lengthen to suit if the steps in the equaliser beam were increased. You can now assemble all the pieces made so far and try the chassis on your track.

Connecting Rod

The connecting rod is not next in line in logical sequence, but having just tackled the coupling rods, these are so similar that we may as well get them out of the way; also I can correct the missing dimension! Take two 8½ in. lengths of 1 in. x ⅜ in. BMS bar and scribe a line 13/32 in. above one edge. At ¾ in. from one end, scribe a vertical line, then move on 7⅜ in. and scribe another; this is the centre distance. Drill one hole ½ in. diameter and the other 5/16 in. diameter, drill two 5/16 in. holes at the same centres in your piece of angle, bolt the rod in place, the angle in turn to the vertical slide, and set level.

First use the end mill as for the coupling rods, to reduce the thickness to ¼ in. away from the big end boss, then carefully mark out the profile. This time the rod profile is tapered along its length, so release the bolt holding the big end in place and adjust the rod until the end mill follows the bottom line; remove metal to line. Angle the rod the other way and use the Woodruff key cutter to machine the top away to line. Radius the ends over mandrels then complete with files. Press in the bronze bushes, central in the rods, drill the oil holes, then turn up the crosshead pins to drawing, from 7/32 in. mild or silver steel rod.

Cylinders

We now have a fairly long session ahead of us, making the cylinders, in fact once these are out of the way our chassis will be almost complete, so let me hurry on. All the castings come from my 'standard' 3½ in. gauge Great Western Railway designs, and as Churchward was greatly influenced by American practice, their use is thought rather apt. They do need packing away from the frames to achieve sufficient clearance, but the cylinder flange has proved extremely useful in other directions, not being simply a packing piece.

Grip the cylinder block in the 4 jaw chuck and first machine across the bolting face to achieve that 29/32 in. dimension to the centre of the bore. Next turn the casting and face across one end, then reverse in the chuck and set with the bore running true, packing about ⅛ in. clear of the chuck body to allow the boring tool to pass right through. For ease of setting, drive a hardwood bung into the core hole, file across the end of the casting to give 'bright' metal, then mark on the bore centre. With dividers, scribe a circle at 1 1/16 in. diameter then clamp a scriber under the toolpost and set the cylinder such that the scriber follows the circle; this will be found surprisingly easy, and accurate.

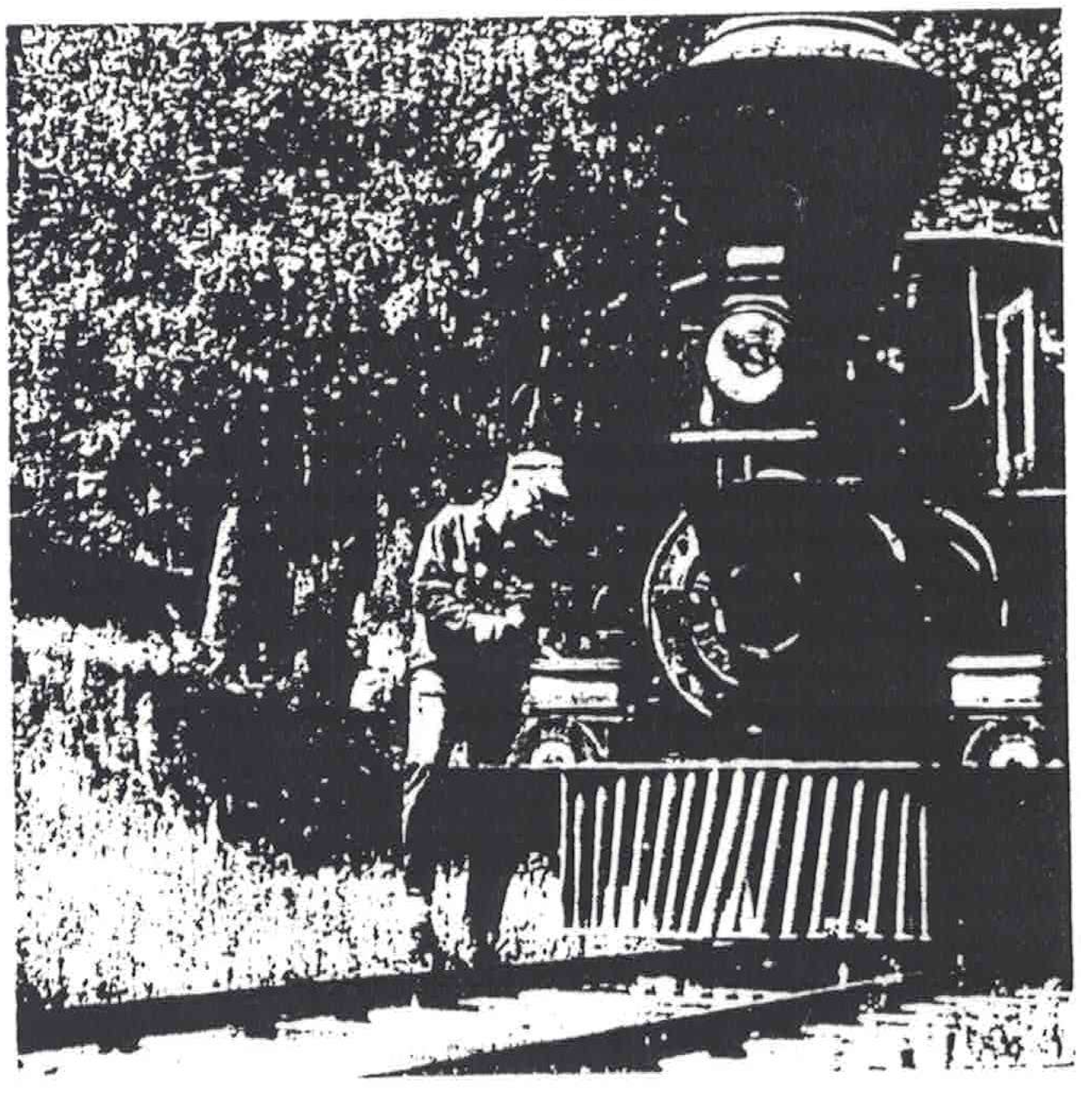
Drill out the bung and then change to a boring tool, one long enough to pass right through the block, and the largest size that will enter the core hole in the casting, this latter in the cause of tool rigidity. Although a 'fancy' boring tool with detachable bits is very useful, the plain tool with ½ in. square shank that is the Myford 'standard' will give the most excellent results. The first cut should be as heavy as the lathe will comfortably cope with, using a fine automatic feed, then reduce to 1/32 in. cuts, or less, increase speed to around 300 r.p.m., and allow the tool to pass both ways through the bore at each tool setting. Approaching finished size of 1 1/16 in., a dimension which you can check with calipers, reduce the cut to around .005 in. and allow four traverses per cut, this to get the bore nice and parallel. Sometimes a much better finish can be obtained by applying paraffin with an old paint brush, depending on the crispness of the gunmetal; check this out before you reach the finished bore size. Face off the end of the casting to achieve the correct 2⅜ in. overall length, making this the back cover face as it is perfectly square with the bore. Bring the other block up to this stage, handing it so that the back cover face comes in the right place to make a pair.

We now come to the only awkward job on the whole engine, machining the inclined port face. First scribe around the block and if you are adept with a hacksaw, remove some of the metal to reduce machining time, plus make life easier for your lathe. Builders in the U.S.A. using MARIE E castings purchased from our good friends Power Model Supply Co. will be able to ignore that last instruction as these blocks should be cast with the inclined port face. One thing I fervently believe in is a minimum number of involved setting operations, as saving both time and frustration, and this influences the type of machining specified, as we shall see shortly.

Fit an angle plate to the vertical slide and set level, cut a 1½ in. square from 3/16 in. steel plate and drill a ⅜ in. hole through its centre. Stand the cylinder block on the angle plate, poke a ⅜ in. bolt up through the bore, it wants to be around 3½ in. long, slip the plate over the top and complete with a nut. Turn the bolting face towards the 3 jaw chuck, open said jaws and bring the block hard against same to ensure that the bolting face is square across the lathe axis. Next mark off the exhaust outlet tapping; centre and drill this 11/32 in. diameter to 11/32 in. point depth before tapping ⅜ in. x 32T. Lift the vertical slide table by .625 in. to bring the steam inlet into line for attention, drilling this 9/32 in. diameter to 5/16 in. point depth and tapping 5/16 in. x 32T. We are going to use the ⅜ in. x 32T exhaust tapping to bolt to the angle plate, so screw a length of ⅜ in. steel rod at 32T and make a nut to suit from an odd end of hexagon bar. Fit to the angle plate with the portface towards the headstock and measure from the vertical slide table to the marked portface line to set roughly square across the lathe axis. That single bolt is hardly sufficient to hold the block for the sort of machining operations that I propose, so cut a couple of 1¼ in. lengths of bright steel angle to abut against the ends of the block, with a hole drilled in each to suit slots in the angle plate.

The specification now is to fly-cut the portface, which sounds rather exotic, but in fact involves nothing more than an ordinary round nosed tool and the 4 jaw chuck. Grip the tool in said chuck so that it sweeps a circle to overlap the portface set the tool in motion clear of the job and carefully advance the block onto the cutter; lock the carriage and machine right across. Advance the block by about .005 in. at a time, checking occasionally that the tool is not working loose in the chuck.

Ollie Johnston oils MARIE E ready for another run on the Deer Lake Park and Julian R.R.



As you approach completion, make any minor adjustments necessary so that the portface will finish to line. If the bore is slightly displaced, that 1 1/16 in. dimension will be difficult to achieve; as long as there is clean metal in way of the fixing studs all will be well and any gap can be filled with Isopon P38 or similar on final assembly. Using the fly-cutter technique, the portface should machine to a very good finish; you can try feeding on a little paraffin, but beware the tool swing!

With the block still in place, use an engineers square to mark on the positions of the ports; this is where we shall save a lot of time. For the steam ports, drill a row of No. 37 holes to 1/4 in. point depth, clear of the scribed lines; two rows to the same depth in the exhaust port. Staying with the exhaust port, change to a 3/16 in. end mill and complete nearly to line all around to 1/4 in. depth, then change to a 3/32 in. end mill for the final cut. These small end mills are extremely flexible, so run the lathe at top speed, apply a cut of a few thous only and let the end mill take its time, otherwise you will not get a straight port edge, especially if the end mill digs into a corner. Having got used to the end mill, you can take it with confidence into the more restricted steam ports, again cutting a groove in the centre to full depth and then carefully opening out to a piece of 1/8 in. thick material as gauge. One thing I did learn during my apprenticeship at Doncaster was how to use a hammer and chisel, so I would chip the corners of the ports square to drawing. As the probability exists of damaged ports if this were to be a general instruction, the advice is to leave well alone.

Our blocks are rapidly approaching completion, in fact, apart from a fair number of tapped holes, only the passages require attention. For these latter, start by filing a chamfer in the position shown at each end of the bore and centre pop at a full 1/8 in. centres. The passages are a full 3/4 in. long, which gives a margin for error, so scribe a light line on the bolting face to represent the axis of these holes. Grip in the bench vice, hang a bolt on the end of some lightweight cord, and use as a plumb-bob to set the hole axis vertical. Now drill a pilot hole at 1/16 in. diameter into the port. If there is any error countersink the outer end of the hole, chuck the 3/32 in. end mill in the drill and use this to correct the defect; it will not follow the original hole as another drill would. If you still have a problem, use an 1/8 in. end mill for final correction. To form a slot from the two individual holes, use a dental burr, though if great care is exercised the end mill will achieve the same result. At this point we must lay the blocks aside and make progress in other directions.

Cylinder Covers

The front covers are easy, so let us get them out of the way next. Chuck by the rim in the 3 jaw and clean up the spigot, then rechuck by the latter. Turn down the periphery to 1 5/8 in. diameter and face right across, then concentrate on the step to get this a nice push fit in the bore; it does not matter if you do not achieve this specified fit, but it is the best possible practice for the rear cover to follow, where said fit is vital. Change to a knife edged tool and scribe a circle at 1 3/8 in. diameter for the fixing bolts, then tidy up the outer face before parting off the spigot. Mark off and drill the six No. 27 holes, offer up to the block, spot through, drill No. 33 to 3/16 in. depth and tap 4BA.

Turning to the rear covers, chuck by the rim and face off the slide bar boss, including removal of the spigot. Centre and drill right through at No. 3, follow up at 11/32 in. to 1/4 in. depth and 'D' bit to 5/16 in. depth before tapping 3/8 in. x 32T; poke a 7/32 in. reamer through the remains of the No. 3 hole. Bring the other cover up to this stage then chuck an odd length of 5/8 in. rod, face turn down for 7/32 in. length to 3/8 in. diameter and screw 32T; fit a cover to this holder. Turn down the rim, face and produce the step exactly as for the front cover, then deal with the fixing holes. We shall deal with the slide bar seating later on, but you can drill and tap the cylinder block to fix the cover.

Piston & Valve Rod Glands; Piston & Rod

The piston and valve rod glands are simple turning; I would start to produce the 'C' spanner slots with a hacksaw and complete with a key cutting file to about 3/32 in. width, now for the piston and rod.

Grip the piston blank in the 3 jaw chuck and clean up the spigot, then rechuck by this latter. Face the end then centre and bring the tailstock into play. Turn down to around 1 1/8 in. diameter, then with a parting off tool. rough out the groove for the square packing, again leaving metal to be removed later. Fit the tailstock chuck, that most useful accessory, and drill right through at 3/16 in. diameter. Follow up at No. 3 to 7/32 in. depth, tap the remains of the 3/16 in. hole at 7/32 x 40T, then part off to a full 7/16 in. thickness.

For the piston rods the requirement is two 12 in. lengths of 7/32 in. stainless steel rod; the reason for these long lengths will become clear later. Turn to a point at one end then reverse in the 3 jaw chuck and check with a d.t.i. that the rod is running perfectly true; use the 4 jaw to achieve this if necessary. Face off then use a tailstock die-holder to screw 40T for 1/4 in. length. Screw the piston to the rod and then turn down to 1 1/16 in. diameter, a nice sliding fit in the bore; this operation will also tighten the piston onto the rod. Face off to thickness and then concentrate on finishing the groove, which latter wants to be the same width as your packing but a good 1/64 in. less in depth than the section to provide a bit of 'squeeze'. Don't pack the piston as yet, but here is the way to do it correctly, so that I do not omit description later on in my excitement! Wrap the packing into the groove and cut to length with a sharp knife so that there is no gap. Enter the piston in the bore and with a piece of flat brass, work the packing down into the bore, pushing in the piston as you go. Sometimes it is difficult to get the very last bit of packing into the bore, in which case tap the piston with a wooden mallet, when the excess will be severed. Pack the gland and we can move up to the steamchest.

Steamchest

As always, check the machining allowances, but this time be extra careful to check that the boss will clean up in the position shown, not the same spot as on the casting. Chuck in the 4 jaw and face across, then reverse and face again to the required 11/16 in. thickness. Three of the four external surfaces can also be faced off, or you can mill them in the machine vice on the vertical slide. Now for the important fourth face, the one with the valve spindle boss. Mark this off, scribe a 1/2 in. circle on the boss and set this to run true, using a scriber as for the cylinder bore, chucking of course in the 4 jaw. Face the boss and turn down to 1/2 in. diameter, continuing on and facing the steamchest wall. If you are worried by the stand-out from the chuck, centre drill the boss and bring the tailstock into use. Change to the tailstock chuck and drill through at No. 14, follow up at 9/32 in. diameter to 5/16 in. depth and tap 5/16 in. x 32T. To complete, mark off and drill the seventeen No. 34 holes, then clean up the inside with files.

Steamchest Cover

I much prefer to cut these from brass plate, but for the casting, chuck by its spigot and face right across. Saw off the spigot, grip in the machine vice on the vertical slide and mill the four edges to match the steamchest; you may clamp the pair of items together to achieve this. To machine the upper face, pack off from the back of the vice so said face is clear of the jaws, then use the largest end mill available to clean up to thickness.

Still in this position, find the centre by the 'X' method, centre, drill through at No. 22 and tap 3/16 in. x 40T for the oil connection from the hydrostatic lubricator kit called for on Sheet 1. Drill the 17 holes from the steamchest, then offer the latter up to the cylinder block, spot through, drill the block No. 43 to 1/16 in. depth and tap 6BA for 1 in. long hexagon head bolts.

Whilst drilling holes in the blocks there are a couple more in the portface area to be dealt with. The first is the steam inlet, so mark this off and drill a 3/32 in. diameter pilot hole down to the steam entry tapping. Again rectify any error using an end mill held in the drill chuck, as for the passages, then open out to No. 11. The other hole is to connect from the exhaust port to its tapping, so centre pop in the inner corner of this port and again drill 3/32 in. diameter initially. Open out in stages to 1/4 in. diameter, keeping clear of the port edges.

Valve, Buckle & Valve Spindle

Chuck the valve in the 4 jaw and carefully machine the working face, then reverse and clean up to the required 1/2 in. thickness. Mark out the valve so that the cavity is central then back to the machine vice and vertical slide to mill the two side flanks to 7/8 in. width. Next mill to length, then turn the cavity towards the chuck and tidy this up to size with your 3/32 in end mill. Reverse in the vice and pack out from the back of the body until you can mill right around the upper spigot to arrive at the 11/16 in. square; this again must be centralised to avoid breaking into the cavity. The buckle is like a mini-steamchest and is dealt with in identical fashion, the last operation being to clean up the inside to a nice sliding fit over the 11/16 in. square just milled on the valve. The valve spindle will cause no problems, when all can be assembled.

Exhaust Fitting & Cylinder Flange

The exhaust fittings are plain turning, so let us deal next with the cylinder flange. Cut from 1 1/4 in.x 5/16 in. BMS flat and face off in the 4 jaw to 2 1/8 in. overall; they can be machined as a pair. Mark off and drill all the holes, including the four at No. 27 from the frames. Use the exhaust fitting to fix the cylinders to the flange, poke a 5/16 x 32T tap into the steam entry and erect to the frames, clamping in place with the No. 27 holes aligning. Now you can do the final adjustment by lining up the extended piston rod point with the centre of the driving axle, easing the 21/64 in. steam entry hole if necessary to achieve this. When satisfied, spot through the four No. 27 holes into the block, drill this latter No. 34 to 1/4 in. depth and tap 4BA. The correct steam entry is by way of two Don Young Designs 1/4 in. male Unions fitted with bronze nipples, these latter in bronze so there is no fear of their melting when you silver solder in the steampipes.

Smokebox Saddle & Bottom Plate

That virtually completes the cylinders, so let us move on to the smokebox saddle, a very pretty gunmetal casting that requires only a minimum of machining. The saddle itself merely needs some small attention with a half round file to accept the 4 in. o.d. boiler/smokebox tube and to sit snugly thereon. Next grip in the 4 jaw chuck and face across the bottom, taking very light cuts, this to achieve the 1 1/4 in dimension.

The remaining work is best done in the machine vice on the vertical slide, so next cut and fit a piece of hardwood packing inside the saddle, so the vice jaws can be tightened without distorting the casting. Mill the two end faces to a close fit between the cylinder flanges, then concentrate on the two steps to get these a close fit between the frames, to ensure the whole assembly is very rigid. Remove the cylinders, leaving the flanges in place, fit the saddle, spot through, drill and tap the fourteen 6BA holes for countersunk screws.

Cut the bottom plate from 2 1/8 in. x 1/8 in. strip to be a tight fit between the flanges and deal with these fourteen fixing holes also; use 6BA screws if you are at all worried about breaking through the saddle walls. Those last couple of paragraphs have meant a great leap forward and there are not many pieces left to be made now to complete this first marathon session.

Crosshead

Experienced builders will make their crossheads with 1/16 in. steel side plates and braze same to the piston rod boss, but my specification here is for machining from 1 1/4 in. x 1/2 in. BMS bar. First mark off all the holes, drilling those six No. 34 right through as a first step and countersinking the back face. Next drill No. 3 for the piston rod to 3/8 in. depth, then drill right through at No. 27 at the crosshead pin, following up at 7/32 in. diameter for 3/8 in. depth. Roughly saw out the bottom profile, then chuck a length of 7/32 in. rod in the 3 jaw, centre, drill No. 33 to about 3/16 in. depth and tap 4BA. This is our mandrel for milling the bottom radius, this as for the coupling rod ends, the crosshead being held from sliding off the mandrel by a 4BA bolt. Next grip in the machine vice, on the vertical slide, to mill a slot from top to bottom up to the piston rod boss. Use a 1/4 in. end mill, or 5/16 in. once the slot is near to size, and open out to 3/8 in. to a piece of requisite thickness material as your gauge. Saw off to length, or rather height, mill the top edge to line, fit packing in the slot and then mill away above the piston rod boss to complete; the 1/8 in. taper pin hole will have to wait awhile.

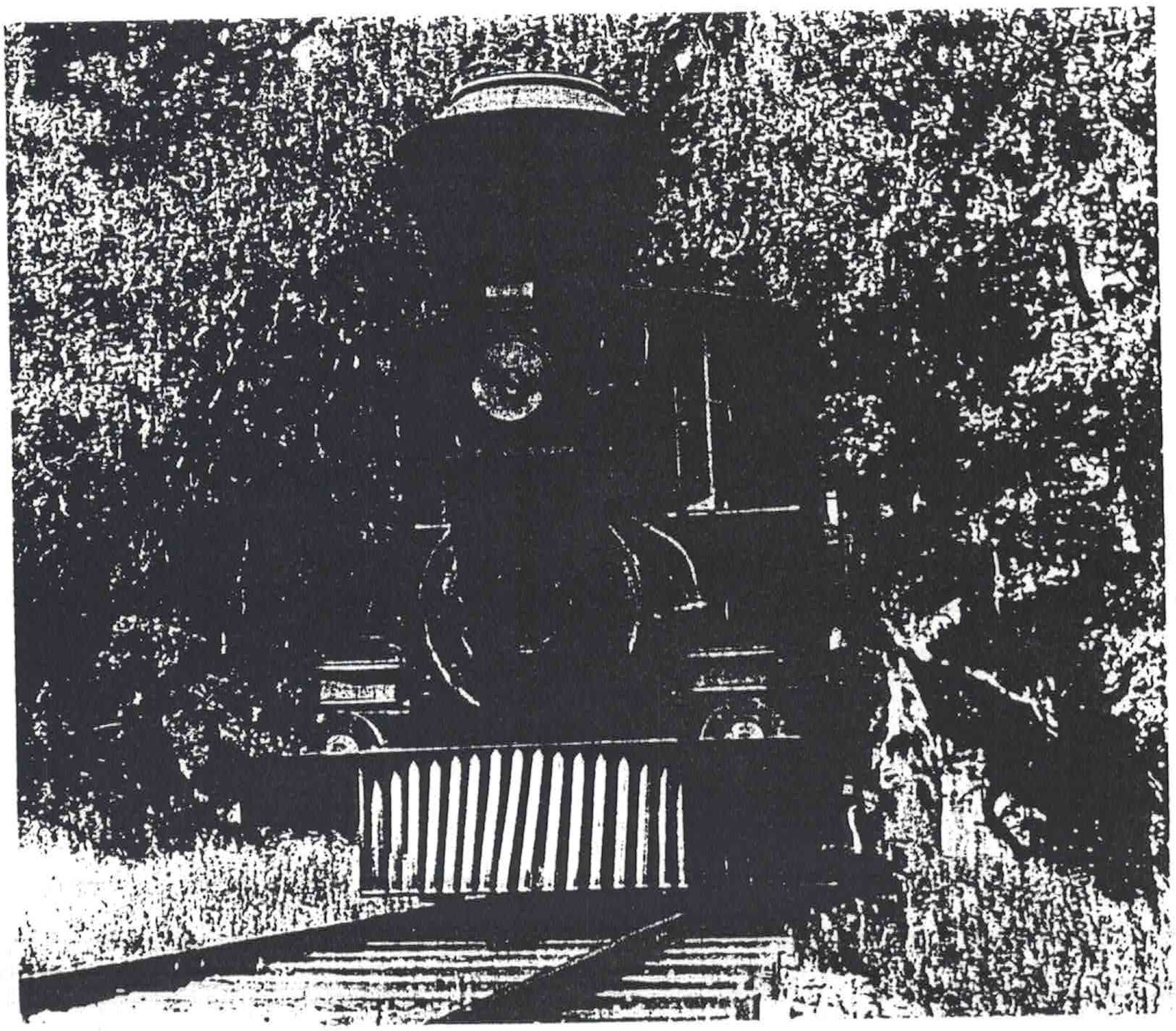
Slide Bar & Slippers

Messrs. Whiston stock 3/8 in. x 3/16 in. brass bar and this is ideal for the slippers, so saw off four lengths and square off to 1 1/4 in. overall. Cut the slide bars initially 4 3/8 in. long, square these off also and drill the No. 27 hole, when we can move on to machine the slide bar boss on the cylinder rear cover.

Bolt the complete cylinder to the angle plate on the vertical slide once more, using the exhaust tapping for fixing, and set square across the lathe axis; this time you can use a d.t.i. along the piston rod as an additional check before cutting down to about 3 3/8 in. long. Fit the crosshead and clamp a pair of slippers to the slide bar. Mill across the slide bar facing on the rear cover and clamp the slide bar to it; now you can check how much more metal has to be removed to bring the top slipper down flush with the top edge of the crosshead. Remove this metal at the rear cover, offer up the slide bar, spot through, drill the boss No. 34 to 1/4 in. point depth and tap 4BA; secure with a hexagon head bolt. Remove the complete unit from the angle plate, clamp over the cross-head to hold the slippers firmly in place and drill through at No. 34 from each side the four ends holes, securing with 6BA countersunk screws, nutted on the outside. Check for freedom of movement, easing the slipper faces slightly if necessary, then deal with the other two holes.

Next job is to fasten the crosshead to its piston rod, once we know the correct position, so erect the cylinders to the frames and fit the connecting rod. Turn the engine to front dead centre, then push the piston rod further forward until the piston strikes the front cover; scribe where the piston rod enters the crosshead. Turn to back dead centre and push the piston further until it strikes the back cover, checking that the overlong piston rod does not foul the connecting rod first; scribe another line at point of entry to the crosshead.

I have more front end shots of MARIE E than any other and no wonder, she is impressive viewed that way! Readers will note the discrepancy between the Diamond Stack on my drawing and the Congdon pattern now on MARIE E; Ollie preferred the Diamond but had to change because of the risk of lineside fires.



Scribe a third line equi-distant between the first pair; this is the correct point of entry of the rod into the crosshead to give equal clearance for the piston at each end of its stroke. Cross drill at No. 41 and follow up with an $\frac{1}{8}$ in. taper pin drill or reamer, finishing with a taper pin which for the moment must be finger tight only.

Slide Bar Stay

The outer end of the slide bars is supported by a simple angle stay, which is straightforward after all that has gone before. Shape the end of the slide bar as shown on Sheet 1, checking that free movement remains, then tap the slide bar and secure with a hexagon head bolt.

Eccentric Rod & Straps

We cannot complete the valve gear in this session, although our chassis will be more than 85% complete, but we can make three of the major items, starting with the eccentric rods and their straps. The straps are gunmetal castings which first require chucking in the 4 jaw, not out of the window I hope!, to face off both sides to 7/32 in. thickness, a nice fit in the sheave groove. Carefully mark off the joint, saw in halves, then grip in the machine vice on the vertical slide, this to clean up the joint faces with an end mill. Reverse the front portion and mill the face to accept the eccentric rod flange, this to the $\frac{3}{4}$ in. dimension. Bring the two halves of the casting together and clamp in the machine vice to deal with the fixing bolt holes, pushing the last face to be machined hard against the back of the vice. Lightly end mill the lugs so the fixing bolt heads will sit properly, then mark off and drill right through at No. 44. Follow up at No. 34 to a bare $\frac{1}{4}$ in. depth then tap the remainder 6BA, holding both drill and tap in the 3 jaw chuck. Separate the pieces and run the No. 34 drill through the back piece to give a clear hole, then fasten together with 6BA bolts; throughout I am assuming you will use bolts with hexagon heads one size smaller than standard – they look so much neater as well as giving the very necessary clearances.

Fit a wooden bung in the core hole, scribe across the joint and scribe in the centre line in the other axis, to find the centre of the strap; scribe a circle at $1\frac{1}{8}$ in. diameter. We now know how to set jobs up to run true on a scribed circle, so carry on and drill out the bung, then bore out to that piece that we produced as a gauge when making the sheaves. Assemble over the chosen sheave, when all should be well; you can now complete the profile with files. Drill the No. 30 oil reservoir to $\frac{3}{16}$ in. depth, then separate the halves, centre pop and drill back at No. 60 from the bore into the oil reservoir, removing any burr with a larger drill, just twiddling it around with your fingers.

For the eccentric rods first cut four $3\frac{1}{2}$ in. lengths from $\frac{5}{16}$ in. square BMS bar. Mark off and drill the No. 31 hole at one end, then turn the bar over and drill No. 12 at the end of the fork. Back to that length of square angle attached to the vertical slide, when you can clamp the eccentric rod in place to mill away the main portion to leave the 3/32 in. thickness; this is the reason for the overlong material. Grip in the bench vice and make two saw cuts down to the No. 12 hole to remove most of the material, then complete the slot with a key cutting file to a piece of $\frac{3}{16}$ in. material as gauge.

Take a piece of, say, $\frac{1}{2}$ in. square bar and drill a No. 31 hole right through; press in an $\frac{1}{8}$ in. silver steel pin to leave about $\frac{1}{2}$ in. protruding. To press this type of pin in accurately, I take a short length of $\frac{5}{16}$ in. rod, about $1\frac{1}{2}$ in. long, chuck in the 3 jaw and drill a No. 30 hole to $\frac{1}{2}$ in. depth. Slip this over the pin and life becomes a lot easier. Take a strip of emery cloth, wrap around the projecting pin and remove enough metal so that it slides into the No. 31 hole in the rod, then grip in the machine vice and use as a mandrel to end mill the radius at the fork end. Cut off the rod to a full $2\frac{3}{16}$ in. from the centre of the No. 31 hole, end mill this square and then profile the rest of the rod with files.

For the end flanges, cut four 3/4 in. lengths from 1/2 in. x 1/8 in. BMS flat, lay on your brazing hearth, which can be a piece of asbestos millboard, and pack to be level. Mix up some Easyflo flux to a stiff paste and apply liberally at the joint, then heat up with your torch and apply Easyflo No. 2 spelter, or equivalent specification of course. Allow to cool, wash off and wirebrush clean; I will cover the subject of silver soldering more fully when we reach the boiler in our next session.

Back to the machine vice and vertical slide, to grip the rod and end mill the flange to the correct 5/8 in. x 7/32 in. section, this to mate with the strap. We now have to reduce the thickness of the flange, but before doing so we need a simple jig. Take a 5 in. length of, say, 1 in. x 3/16 in. BMS flat and drill two No. 31 holes at 3 /1/32 in. centres; if you grip the bar in the machine vice on the vertical slide then you will be able to advance the cross slide by 3.031 in. to achieve this very accurately. Press 1/2 in. lengths of 1/8 in. steel rod into these holes and emery cloth one of the pins to accept the eccentric rod. For the other end, chuck that gauge you used for the eccentric straps in the 3 jaw, centre and drill through at No. 31. You can either press this over the second pin, or ream at 1/8 in. diameter to be a sliding fit.

Assemble the rod and strap on the jig, when you will see the amount of metal to be removed from the flange; deal with this by end milling. If you do happen to remove too much metal then a shim can be inserted to restore the status quo, just like full size. To complete, drill the flange No. 41 for the two fixing bolts, carry on into the strap for about 5/32 in. at No. 47 and tap 7BA; assemble with hexagon head bolts.

Lifting Link, Valve & Reverser Levers

For the remaining parts to be made we need similar building jigs, again using 1 in. x 3/16 in. BMS flat, each 3 in. long. In the first piece drill a No. 31 hole, advance the cross slide by 1.438 in. and drill No. 13; for the second piece the same holes are at 1.250 in. centres. Press in lengths of 1/8 in. and 3/16 in. steel rod with about 3/8 in. stand-out.

The lifting link uses the long centres, so chuck a length of 5/16 in. bronze rod in the 3 jaw, face, centre, drill No. 13 to about 7/8 in. depth and ream at 3/16 in. diameter; part off two 3/16 in. slices for the end bosses. For the link, take a length of 1/4 in. x 1/8 in. BMS flat, grip in the machine vice, centre, drill through at No. 31 and ream 1/8 in. diameter. Radius the end over the mandrel from the eccentric rods, file the side flanks, then cut off to give a good joint with the end boss when fitted to the building jig. We now have to silver solder the two pieces together, but must be careful not to braze the whole to the jig. To prevent this disaster occurring, coat the jig liberally with marking off fluid. Assemble the pieces, apply Easyflo flux at the joint and then apply heat and Easyflo No. 2 in turn. Remove the completed link from the jig before it cools right off, otherwise you will have a problem as the expansion/contraction is uneven between link and jig.

The valve and reverser levers require slightly different treatment; first turn up the end bosses, then drill and ream a 1/8 in. hole in a length of 1/2 in. x 1/8 in. BMS flat. Assemble and scallop the joint at the end of the lever to suit the boss, then braze up. To complete, file the flanks of the lever to drawing and radius the end over your mandrel; Sheet 2 is complete!

This photograph by David Gooley of Paramount, California was taken with an eye to beauty. LLAS readers would have cut that tree down to reveal the hidden Locomotive detail!