78000, A.B.R. Class 2 'Mogul' for 5 in. gauge

by: DON YOUNG

Part 5 — The Cylinders

We come now to the main event of the evening, the cylinders, and it is worth spending a lot of time over them, for if you get them right first time, they will last the lifetime of No.78000 and beyond. In 1972, cylinders cast in iron were still in their infancy, at least amongst miniature locomotive builders in general, and that includes yours truly to a degree, as we were apprehensive of the rust bogey. Nowadays cast iron is widely used for cylinders, though I would still favour gunmetal for No.78000, simply because I do not envisage her as a Club locomotive handling passengers every weekend, but more of a 'fun' engine, though somebody is bound to prove me wrong — yet again! The cylinders for No.78000 also mark the start of my evolutionary process with piston valves that has since progressed through BLACK FIVE and E. S. COX to arrive at DONCASTER, though the fundamental principles remain, only the details having changed over the years, so builders of No.78000 can rest assured as to the right end results. Let me get down to their construction.

Cylinder Blocks

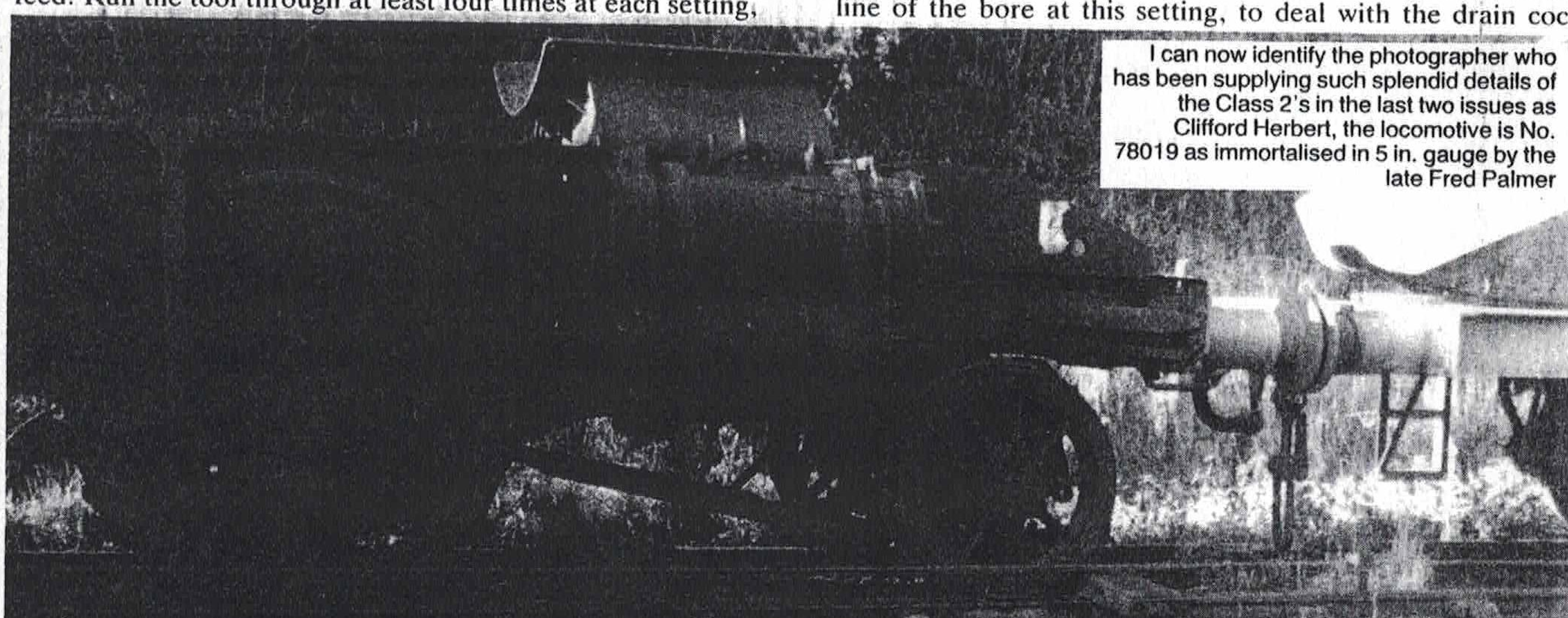
Drive hardwood blocks into both main and piston valve bores at one end of the castings and then assess the machining allowances provided; carefully mark out. I still prefer to use the 4 jaw chuck wherever feasible, and it certainly is to turn the bolting face down to line and face off the front face of each block, which hands them from now on, but now for a change of tactic.

Clear the boring table on the lathe and begin building up the block from said table with pieces of decent packing. The idea is to have the bolting face sloping, so that when the block is set up correctly, it will be possible to go straight from the main bore to that for the steamchest without altering the setting. Have the rear face of the block towards the headstock, fit a boring bar between centres and use same to trace out the marked off circles at both main bore and steamchest. It will take a lot of time to set up, but as a rough guide the steamchest bore is ¼ in. higher than the main one with the bolting face level, so you want roughly ¼ in. more packing under the main bore than at the steamchest. When satisfied, grip the boring bar carefully in the 4 jaw chuck, still between centres of course, and apply about 1/32 in. cut; speed will depend on the chosen material, but use the finest possible feed. Run the tool through at least four times at each setting, to avoid the possibility of any taper developing, and as you approach size, increase the passes per cut to six or more, listening for the hiss of the tool cutting that last whisker of metal until you arrive at a mirror finish. Move the cross slide on by 1.768 in. to deal with the steamchest bore, taking the same care as for the main one, it being if anything even more important.

Remove the boring bar and change to a fly cutter, which can be a round nose tool held eccentrically in the 4 jaw chuck, this to clean up the rear face of the block, so that it is perfectly square to the bores. This means that the block must overhang the boring table by a sufficient amount that you can arrive at the 3 in. dimension without striking the table with the tool, or I shall be in deep trouble! I would also number stamp the front faces as identification as to handling, so there can be no mistakes.

We have a basically machined block, now to start adding some of the finishing touches. You now have two datum faces which are perfectly square to each other, that for the rear cover and bolting flange, but we need a datum edge to tie the whole thing up, this being along the bottom of the bolting flange, the ½ in. dimension on the drawing detail. At least the block is now much easier to hold for machining, and of course when it was on the boring table, you needed strongbacks over the top of it, securing with long bolts down to the 'T' slots, for all we need now is roughly 4 in. length of ⅜ in. studding which will pass through either bore and secure to an angle plate. Rather than a strongback at the front cover face, it is worth making a special washer, this being a 1¾ in. disc from ⅛ in. steel plate, drilled centrally at 13/32 in. diameter, so that you apply pressure evenly, especially if gunmetal is your chosen material for the cylinders. Both the angle plate to the vertical slide and we can begin.

The first operation is to establish the datum edge and as the previous machining will have destroyed your careful marking out, you will now have to do this again. Now set the angle plate so that you can machine the edge at a single setting and deal with same with an end mill; thankfully there is not too much metal to be removed here. Checking this on my ML7 this morning, I had the bottom of the casting facing the headstock, when it was simple to move to the bottom centre line of the bore at this setting, to deal with the drain cock



I can now identify the photographer who has been supplying such splendid details of the Class 2's in the last two issues as Clifford Herbert, the locomotive is No. 78019 as immortalised in 5 in. gauge by the late Fred Palmer tappings. Mill a wee flat each end of the casting, to give a seating for said drain cock, then mark off, centre, drill and 'D' bit 5/32 in. diameter to leave at least 3/32 in. of metal between the bottom of the hole and the main bore, in fact err on the cautious side, as you can always slightly modify the drain cocks by shortening the thread.

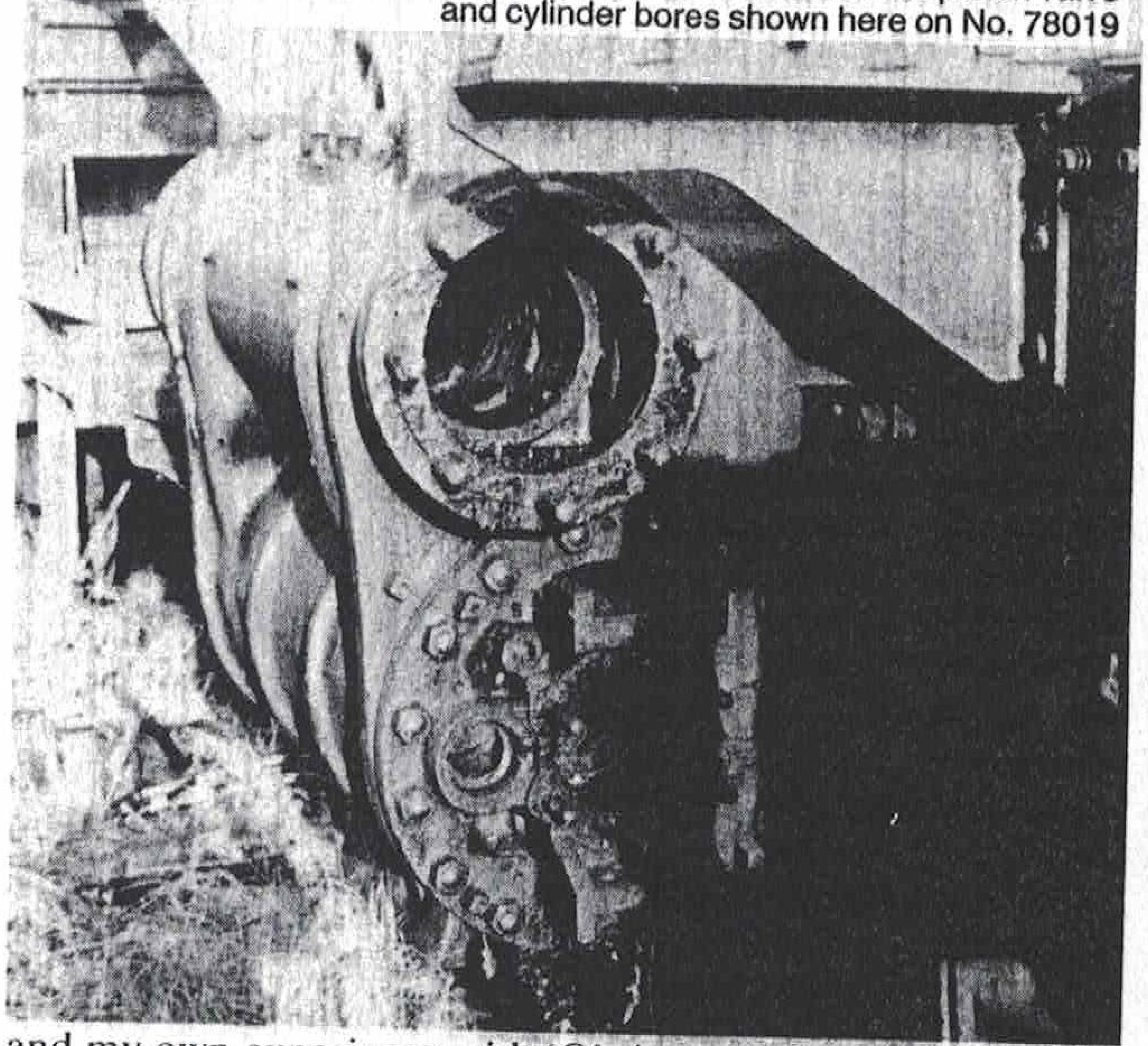
Tap each hole 3/16 x 40T, holding the tap in the 3 jaw chuck to make sure it goes in nice and square and later on you must remember to drill from the edge of the tapped hole No.51 at an angle towards the end of the bore, otherwise there will be red faces at the first steaming. Now turn the steam entry flange towards the headstock and although it is never easy to arrive at angles like the 65 deg. specified, Norman Lowe made the pattern sufficiently accurate all those years ago now that the face is as close to the nominal angle as makes no difference, so just face it off, centre and drill 1/4 in. diameter into the steamchest bore, removing all burrs.

Now turn the bolting face towards the headstock and if you fit the faceplate, to get the bolting face perfectly square, you just bring it up to said faceplate and tighten the stud at the main bore. Grip a 3/16 in. end mill in the 3 jaw and start forming the 7/8 in. long exhaust passages, in fact clean up the 3/4 in. wide cavity as you go. Once you are down to the bottom of the cavity, it will be easier to change to a 1/4 in. drill and carry on into the steamchest bore, finally forming into a slot with a 1/4 in. end mill; again remove all the burrs. The reason for having the bolting face perfectly square to the headstock is that we can now deal with the tappings to accept the cylinder flange. Bring this up and carefully position, firmly clamping into place, then spot through one of the No.34 holes, drill No.43 into the block to 1/4 in. depth and tap 6BA. In those earlier days I was terribly nervious of the block coming loose on its flange, this from full size experience of cylinders working loose from the frames, so it was belt and braces of socket screws and Loctite as further insurance. Nowadays I know a little bit better, and with 19 retaining screws, 6BA steel countersunk ones are more than adequate, so you can vary my original specification with confidence; carry on and deal with all 19 tapped holes. That takes the blocks as far as we can go for the moment.

Cylinder End Covers

Front covers first, and they not being separately detailed, it gives me scope for their description. Chuck by the periphery in the 4 jaw, set the chucking spigot to run reasonably true and clean it up, then rechuck by same. Turn down the periphery to 1 15/16 in. diameter, assess the machining allowance for cover thickness and face across to be within said machining allowance. Now concentrate on the spigot over a 3/64 in. length to be a very good fit in the bore; it is not critical for the front covers, but good practice for the back ones which follow. Scribe on the bolting circle with a knife edged tool, pull out of the chuck far enough so that you can machine the front face, then part off. Mark off and drill the eleven holes No. 34 in the specified positions, and with no slide bars in the way, no countersinking is necessary, then offer up to the bore with the bottom pair of holes equi-distant from the drain cock tapping; spot through, drill No.43 and tap 6BA for hexagon head bolts. I am still thinking about those steam passages, but for the moment do remember to relieve the cover at the ends of same, otherwise you will block off the incoming steam, with more red faces!

Other than for initial setting up, we don't need the chucking spigot on the rear covers, so just use it to clean up the periphery of the cover and to lightly face it off, then grip by said periphery in the 3 jaw and part off the spigot. At this setting, tidy up the rear face of the cover as far as you are able, so that the bolt heads will sit on a nice flat surface, then face across the slide bar facing to size. Centre drill right through and ream to 1/4 in. diameter and we must deal with the 'O' ring housing. I have shown this to have square corners


Just about optimum proportions between the piston valve and cylinder bores shown here on No. 78019

and my own experience with 'O' rings as piston rod glands is that same is perfectly satisfactory, though you may vary same to 'O' ring data for housings, etc. As drawn, you simply countersink until a 7/16 in. 'D' bit will enter and then take it down to the specified 7/64 in. depth.

Next chuck a length of 1/2 in. steel rod in the 3 jaw, face and turn down to 7/16 in. diameter over a 3/4 in. length, a good fit in the 'O' ring recess. Further reduce over a 21/32 in. length to 1/4 in. diameter, again a good fit in the piston rod bore, then finally reduce over the end 1/4 in. length to 3/16 in. diameter and screw for a suitable nut; secure the embryo rear cover to this spindle. Face off to thickness as far as you are able, then concentrate on the spigot, getting it a very good fit in the bore. Mark on the bolting circle, then remove the nut and complete the facing off in the way of same. Mark off and drill the eleven holes, this time countersinking the trio in way of the slide bars. Offer up to the block, spot through, drill and tap 6BA.

Piston, Rod and Gland Plate

Checking the latest Reeves Catalogue a moment ago, it was to discover their standard section 'O' ring for 1/4 in. bore was 1/16 in., so be careful before you counterbore the rear cover to 7/16 in. diameter as you may well be looking for a non-standard 'O' ring today, one that will be prohibitively expensive! I was in fact looking to see if there was a suitable 'O' ring available to replace the soft packing specified for the piston, but I could find nothing, so we may as well keep to my original specification, if only to stop the queries coming my way!

Chuck a piston blank in the 4 jaw, clean up the chucking spigot, then rechuck by the latter in the 3 jaw. Face and turn down to about 1 15/32 in. diameter, rough out the groove with a parting off tool, then centre and drill through at 7/32 in. diameter. Follow up at Letter 'D' to 9/32 in. depth, then tap the next 3/8 in. or so at 1/4 x 40T before parting off to a full 9/16 in. thickness.

Next chuck a 5 in. length of 1/4 in. stainless steel rod in the 3 jaw, check that it is running perfectly true with a d.t.i., changing to the 4 jaw if there is any doubt, then face and screw 40T over a 9/32 in. length. Screw the embryo piston to same, face it off to thickness, which will pull the piston hard onto the thread, then turn down the outside to a good sliding fit in the bore. Although the piston packing is nominally 1/4 in. square, and we can at least use the advantages of PTFE impregnated yarn over the graphited type, do not machine the packing groove 1/4 in. wide x 1/4 in. deep or you will be in trouble. Instead, make the groove ¼ in. wide but only a full 7/32 in. deep, removing all burrs so the piston is still a nice sliding fit in the bore. We don't want to pack the piston as yet, otherwise it will be a nuisance every time we want to fit or remove same, but when the time comes, take a length of packing and hammer it down to rectangular section. Wrap it around the groove, assess the correct length required and cut off squarely with a very sharp knife.

Ends of bores full size were bell mouthed and it is often stated that the reason for this was to assist in fitting the piston rings. The real reason as far as I was concerned was to allow the cylinder to be bored out without the need for new covers; nobody gave much thought to the fitter! With soft packing, bell mouthed bores are a hindrance rather than a help, so I have always omitted them, the procedure for packing being as follows. Work the packing into the groove as far as you are able, and this means really working at it. Now enter the piston in the bore, keep pushing the packing down with a blunt screwdriver or similar instrument as you push the piston in, and at the very end likely you will shear off a tiny bit of the packing. This did worry me initially, but as the years passed and no piston ever required repacking, I have forgotten all about it, that is until I came to pen these notes!

The gland plates are either cut from 2.5mm brass sheet, or turned from ⅞ in. diameter bar. Whichever material you choose, chuck, centre, drill and ream through at ¼ in. diameter, then scribe on the bolting circle, marking off and drilling the four No.51 holes before completing the profile. Poke a length of ¼ in. rod through the rear cover, bring up the gland plate, spot through, drill and tap the cover 10BA to ⅛ in. depth and secure with hexagon head screws

Assemble piston and rear cover to the cylinder block and bolt the whole lot to an angle plate with the rear cover facing the headstock, and this time you can make use of the ½ x 32T tapped hole in the cyinder flange for attachment to the angle plate, plus a clamp if you prefer. Chuck a large diameter end mill in the 3 jaw, bring it up to the piston rod, then move it away by 9/16 in. initially and deal with one side bar facing. Check the dimension as far as you are able, then gradually move in to the required ½ in., which is ⅝ in. away from the centre line of the piston rod; repeat at the opposite facing. Likely you will not get a perfect end result here, but if you are at all worried, then err on the small side of the specified 1¼ in. dimension, then you can add shims between the facing and the slide bars, just like we did in full size.

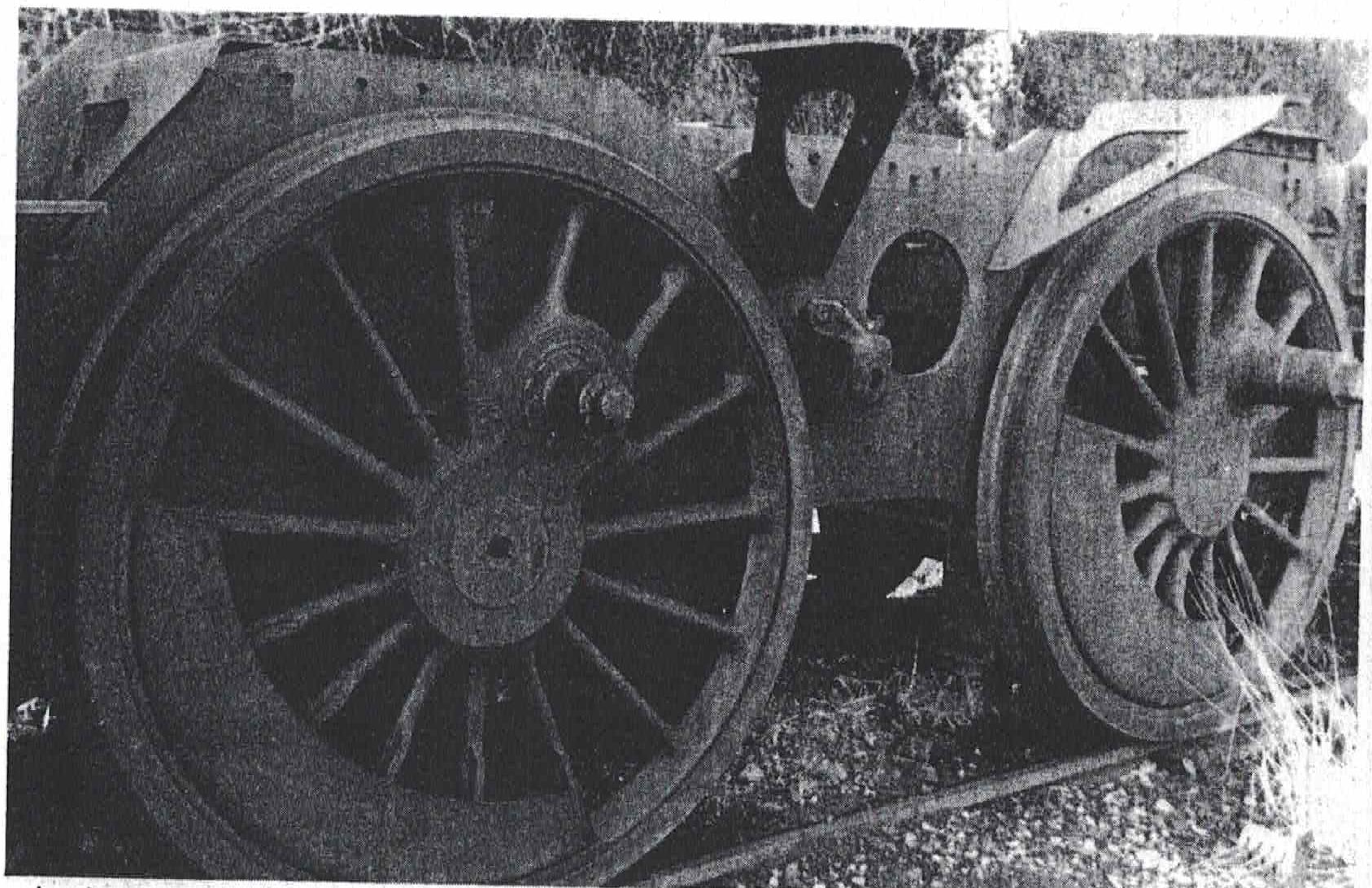
Those steam passages can be put off no longer and if you look at DONCASTER you can see that to make life simpler there are belts machined into the steamchest bores as an aid to drilling, whereas No.78000 is still in the LBSC era in this respect, though the maestro always managed well enough, and so shall we! There is quite a little latitude with the steamchest bore, for as long as we keep clear of the steam entry and exhaust things will be steamtight, though this is not a licence for sloppy work, or you will regret it. File a flat at the entrance to the bore as shown on the end view, to come between the cover fixings. Centre pop deeply in one position only, then set the block up in the bench vice, soft clams please, so that you estimate you will be drilling the passage vertically, then you don't have to worry about any odd angles. The required angle, at least for the inner hole of the pair, is approximately 30 deg., but you can easily draw this out and stick the bit of paper on the outside of the block as a further guide. Drill initially a No.42 hole, noting its exit carefully, when we can correct any small error. Countersink the end of the No.42 hole so that an ⅛ in. end mill will enter, when it will make its own hole rather than exactly follow the No.42 one, as would another drill, so you can make some correction. If the hole is still not in exactly the correct position, change to a 5/32 in. end mill in the hand drill and repeat, but if it is OK, then simply put the No.22 drill through. For the second hole, you can poke a length of 5/32 rod in the first one as a sight, but do correct any errors as for the first one.

Steamchest Liner

We now come to the single item most critical to the success of your No.78000 out on the track, so take your time to get things right the first time around. The material requirement is a 4¼ in. length of 1½ in. diameter bar of the chosen material, the extra length to provide a chucking piece. Grip in the 4 jaw, gingerly face the outer end for except with the largest lathe there is bound to be a big overhang, then centre and bring the tailstock into play; turn down to about 1 7/16 in. diameter as far along as you are able. Rechuck by the machined end, lightly face the other, centre and again bring the tailstock into use. Turn down to 1⅜ in. diameter over a 3¾ in. length, then concentrate on getting the outer bare 3 in. down to around 1 13/64 in. diameter. Next mark off those two 5/32 in. wide grooves as the start of the steam ports, cutting them with a parting off tool down to 31/32 in. diameter. Back to the whole 3 in. length, to get close to the required 1 3/16 in. diameter, then just ease the initial 1/16 in. or so until it just enters the steamchest bore, keeping the workpiece nice and cool so that the expansion coefficient does not become a problem; hopefully we shall be using this in our favour in a moment. Ease the turning tool back and then bring it up to within .00075 in. of its previous setting, it sounds highly technical, but really it is ¾ of one graduation on the micrometer collar on the cross slide, no problem even on my 30 year old machine; apply this cut right along the 3 in. length, and if you have external micrometers both internal and external in the 1-2 in. range, you can check out the result, otherwise do not bother. Likely the corner between the 1 3/16 and 1⅜ in. diameters will have a wee radius on it, for most turning tools seem to work better with a radius on them rather than an absolutely sharp corner, then you simply ease the back end of the steamchest bore with a file to a matching chamfer, then the shoulder of the liner will come right up to the block and not leave a tiny gap; now for the bore.

Before releasing the tailstock, erect your fixed steady on the lathe bed and bring it into contact with the liner at a suitable point towards the outer end of same, greasing well as very necessary lubrication as it will take some time to complete the bore. Change to the tailstock drill chuck and drill right through to as large a diameter as possible, likely ⅝ in. and of course you fit these larger diameter drills directly into the tailstock barrel. Change to a boring tool and of course this means the carriage must have been clear of the fixed steady from the outset, to bore right through to around 23/32 in. diameter. We now have to relieve the outer end to ⅞ in. diameter over a ⅜ in. length and this is fairly easy as we can see what we are doing. Take careful note of the final readings both on the cross slide micrometer collar and the lead screw handwheel as they are vital to the next operation. For we now have to wind the carriage on by exactly 2¼ in. and then open the rest of the bore out to ⅞ in. diameter towards the headstock, and don't worry at all about going beyond the final length of 3⅝ in., go right to the end of the bar. Midway between the two end relieved portions is a ¼ in. wide steam entry belt which is to 15/16 in. diameter. If you leave the lead screw engaged at all times, you will be able to wind the carriage back to this point and deal with this recess, its actual diameter only being nominal, for most importantly it is the place to drill the ¼ in. steam entry hole without damaging the liner in way of the piston valve bobbins. If you do not possess the luxury of a ¾ in. diameter reamer, and in any case it must be in superlative condition or it will cause more problems than it solves, then simply bore out to size, which can be a few thous either side of the exact ¾ in. dimension; for we shall be making the valve to suit.; it is the finish on the liner that is vitally important, though we shall be proving in a moment

This view reminds me that we have the pleasure of wheel turning to come in the next session!



that even your very best turning is not too hot! Part the liner off to length, reverse in the chuck and face off, when we must deal with the actual steam ports.

Mark off the eight positions on the circumference of the liner at the steam port belts and centre pop each, drilling about No.27 so as not to touch the side walls of the grooves. Now it is a question of filing out to 5/32 in. square ports, a square Swiss file is indicated here, passing the file right through a pair of ports and concentrating on that closest to you first, then turning the liner through 180 deg. and dealing with its partner. It is not absolutely critical to get each port measuring 5/32 in. around the circumference, you will be able to see by eye if they look square, but axially it is vital that the 5/32 in. dimension be adhered to, which means the groove width was critical, as is filing exactly to the sides of said grooves as your register, indeed you will see very little by looking up the liner bore unless you have a dentists's mirror/light.

Now we come to the nail-biting bit, that of getting the liner into the steamchest without a lot of aggro, though this is where the domestic department can come in very handy. In the old days, one was reduced to either pressing or pulling the liner into place, and I will describe how to do this as a last resort in a moment. But most of you will possess a freezer in this day and age, if not a freezer compartment in the fridge, together with a gas or electric oven. Put the liner in the freezer overnight and when the joint of meat goes in the oven, give it a cylinder block for company for a few minutes, say at 180°C. Use oven gloves to remove the block and slide in the liner fresh from the freezer, but be quick about it before the temperature begin to equalise and liner comes up solid half way through its bore. If you have such misfortune, do not despair, for we can solve the problem with 'steam age' equipment.

Centrepiece of the equipment is a 7½ in. length of the same 3/8 in. studding that we used to hold the cylinder block to the angle plate for its later machining, and with any luck both pieces will come out of a foot length of studding, plus the two nuts can be used again. We now need two special washers, so chuck an odd end of 1½ in. diameter bar, face, centre and drill 13/32 in. diameter to 1 in. depth. Next turn on a 7/8 in. diameter spigot over a 3/32 in. length, an easy fit in the liner end, and part off at ¼ in. overall. Face again and turn another 3/32 in. long spigot, this time to an easy fit in the 13/16 in. diameter steamchest hole; again part off at ¼ in. overall.

As we are taking things more gently this time, instead of the earlier 'quickfire' method, have a look at the cylinder section and you will see that the liner is relieved at the end of the steam passages, so you can file on a flat to emulate this. It matters not if you forget to do this, for after pressing home, all you have to do is run the 5/32 in. end mill up each passage to remove the local obstruction.

Enter the liner into its bore, feed the studding through, fit the end washers, then the nuts and begin tightening the latter to pull the liner into place. Approaching completion, reverse the washer at the front end, otherwise you will tend to crush the liner when it comes into contact with the spigot. We now have to extend both steam entry hole and exhaust slots though the liner, the entry hole is plain drilling and we know the set-up to deal with the exhaust slots, so complete these and remove all burrs. If you do have a ¾ in. reamer, just run it through the liner again and we are ready for the valves.

Valves

The valves are from cast iron or bronze bar as you choose and the initial diameter wants to be around 7/8 in. Chuck in the 3 or 4 jaw, face, centre and bring the tailstock into play and you want at least 2 in. protruding from the chuck. Start by reducing the full length to around 25/32 in. diameter, allow ½ in. for the first bobbin for reason which I will describe in a moment, then concentrate on getting that central 7/8 in. portion down to 7/16 in. diameter, the length being critical as it affects valve events. Over the end 1/8 in. gradually reduce towards ¾ in. diameter until it just fits into the end of the liner, then part off a bare 3/16 in. slice and re-centre; start parting off again at a very full 1½ in. overall to reveal the two valve bobbins. Go back to the original setting at which you turned the bobbin end to a fit in the liner, which really indicates you start parting off both pieces ahead of this operation, then pull the tool out by .0005 in. so that the valve becomes almost a driving fit in the liner; I know it sounds cruel! Drill No.10 to 15/8 in. depth, clean up the ends of the bobbins to 1½ in. overall length with 5/16 in. thickness of head, then part off.

What saves the valves from being ruined is a liberal coating of molybdenum disulphide grease, a "Rocol" product that prevents both seizing and scuffing. Sit the cylinder block upright on a very firm surface, get a length of hardwood dowelling, and drive the valve right through the liner; if you have got the fit right then this first pass will take some effort.

For a description of No. 1210, see Page 8 of LLAS No. 39

Do not despair, clean off all the grease and apply another good coating, then repeat and by about the eighth time the drive fit will have become a heavy push one. I should have said that before you started to fit the valve to the liner to inspect your best machined surfaces with a strong magnifying glass; the hills and valleys you see I promise will frighten you! Look again now and you will see those hills and valleys have disappeared, leaving a mirror finish, one that with proper cleanliness and lubrication will last the lifetime of the engine, and beyond.

Valve Spindle

After that little exercise, the valve spindle will come as light relief, a 4⅜ in. length from 3/16 in. stainless steel rod, screwed in the lathe for 2¼ in. at one end and held in place with brass nuts and locknuts.

Front Steamchest Cover

The front steamchest cover is from 1½ in. bar, brass, or steel as you prefer. Chuck in the 3 jaw, face and turn down to 13/32 in. diameter over a 25/32 in. length with a small round nose tool and radiussing the outer end, then part off at a full 1⅝ in. overall and rechuck by the spigot. Face off to length, turn on the rest of the outer profile, then drill and bore out to ⅞ in. diameter and ⅝ in. depth; complete by scribing on the bolting circle at 1⅛ in. diameter. Mark off, drill No.44 and countersink as shown for screws, then offer up the end of the block and you can use an odd end of ⅞ in. diameter bar as alignment, to spot through, drill and tap 8BA to about 5/32 in. depth.

Rear Steamchest Cover

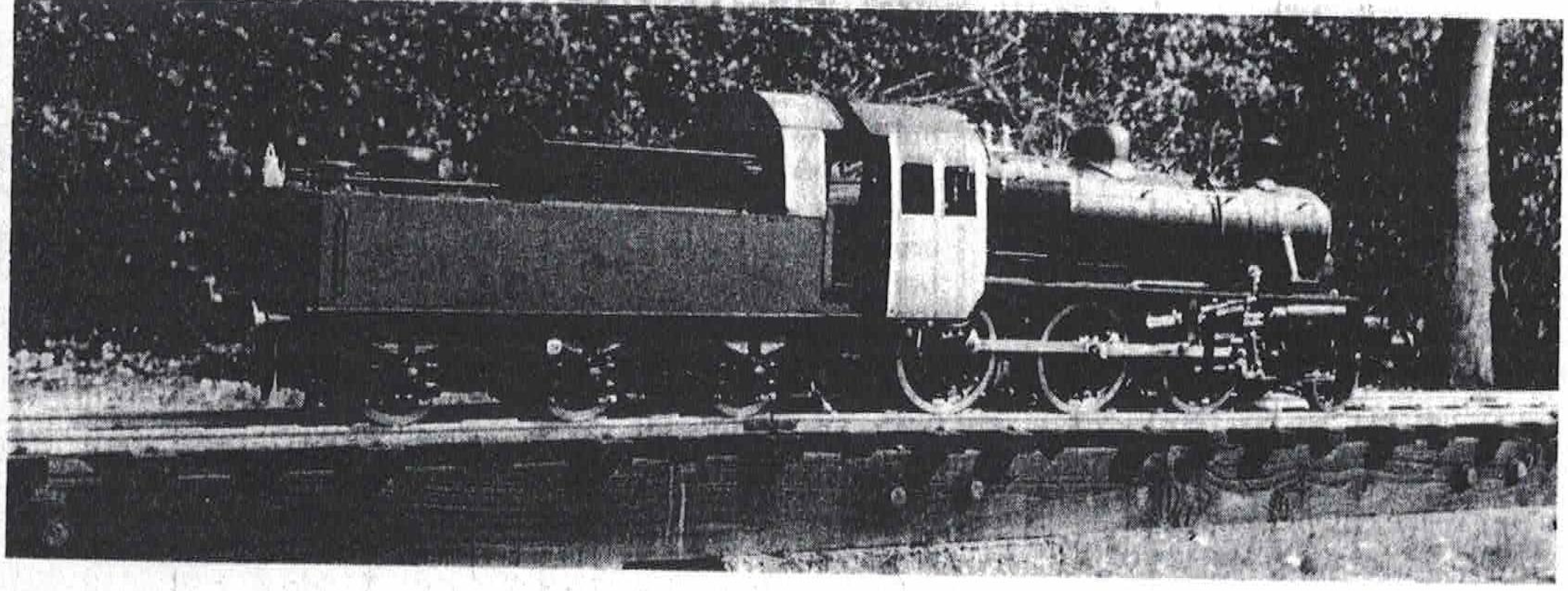
Just one more item to complete another marathon session, and it is not the easiest!, though the first bit is straightforward. Also as this is a fabrication, then gunmetal or bronze must be used in all cases for the actual cover.

Chuck a length of 1½ in. diameter bar in the 3 jaw, face, centre, drill and ream 3/16 in. diameter to at least ⅝ in. depth. Follow up with a 9/32 in. drill and 'D' bit to 11/32 in. depth and tap 5/16 x 40T. Turn down to 1 15/32 in. diameter over ⅝ in. length, then turn on the 1 in. diameter spigot over the end ⅛ in., rounding the sharp corner. Start parting off to expose the 7/32 in. thick flange, reducing only to about 15/16 in. diameter over the 3/16 in. length as shown, then part right off. Chuck an odd end of ½ in. steel rod, turn down over a ¼ in. length to 5/16 in. diameter and screw 40T; fit the embryo cover to same. Now complete the 3/16 in. spigot to ⅞ in. diameter, a good fit in the liner end. Scribe on the bolting circle at 1 7/32 in. diameter, mark off for the six holes, but don't drill them as yet.

Next chuck a 1½ in. length of ½ in. square steel bar as truly as you can in the 4 jaw and turn down over a ½ in. length to .375 in. diameter, this is important. Reduce the outer ¼ in. to 5/16 in. diameter, open the 40T die out a little and screw the end to be a tightish fit in the end cover. Remove to the machine vice and mill two opposite side flanks to exactly match the .375 diameter, then we can use this as a building jib for aligning the valve crosshead guide supporting pieces that we have to tackle next.

For each cover we need two 2 in. lengths from 1¼ in. x 5/16 in. brass bar. Mark the profile off on one piece of brass, the excess metal at the front end to match the cover later on, then clamp together. Mill as much metal away as you can, particularly at the valve crosshead guide faces to keep them nice and square, and only resort to saw and files when you can no longer grip for milling. Next carefully mark out, drill and tap the four 8BA holes, tapping to about 3/16 in. depth at this stage. The inside face is complete, but we now have to relieve the outer one to drawing and this is where brass comes in handy, for we can sweat to a large chunk of same so that we can grip in the machine vice. Do this operation of milling gradually, taking care not to heat or put too much pressure on the soldered joint, then warm up and clean off all the excess solder in conclusion. We now have to fit the supports to the end of the cover, so saw them out roughly to a fit, then file each one, using the gauge to correctly position them at ⅜ in. apart.

Next take a piece of 1 in. x ⅛ in. BMS flat, square it off to 1¼ in. length, then mark off and drill four No.44 holes to coincide with the 8BA tapped ones in the supports; bolt the whole firmly together. Our screwed jig no longer fits, so grip it in the machine vice again, and this time mill the third face so that when you sit it on top of the plate just made, you arrive at the ¼ in. dimension down the face of the supports; clamp the whole assembly together and silver solder the joints. Pickle and clean up, check the positions of the holes and drill them through the cover flange, then offer up to the steamchest liner, to spot through, drill and tap 8BA; we have won!



Dr. Bill Naunton whose completed Class 2 is depicted here is partly responsible for my No. 78000 series in that he wrote of problems he was experiencing in the Southern Federation Newsletter, one that has obviously now been solved. Hopefully my series will eliminate problems before they arise for other No. 78000 builders, or I shall have failed

78000, A.B.R. Class 2 'Mogul' for 5 in. gauge

by: DON YOUNG

Part 6 — Progressing the Frames

By 1972 the density of detail on my drawings is such that I had to take two bites at Sheet No. 4, but with any luck at all I shall now have a clear run to complete No. 78000 in three issues, as I have a whole host of exciting designs yet to be described in LLAS. Let me continue the theme from last time in getting the frames spaced the correct 4⅛ in. apart, starting with the front buffer beam.

Front Buffer Beam and Rubbing Plate

Early in my literary career I made strong assertion that the LBSC method using angle for the buffer beams was unbeatable and I remember with a smile how Martin Evans drew my attention to said remark when I began to deviate from angle to flat bar beams! At least I have remained loyal to the late maestro at the front of No. 78000, so I just hope that approximately the right section material is still available, the alternative being 1½ in. x ⅛ in. BMS flat. Square the angle off to 8 in. overall, mark off and drill all the holes as specified, then scallop the bottom corners on the same front face before shaping the top face to drawing. Although it is possible to machine the slots to accept the mainframes, I still find it quicker to saw and file to an odd end of frame material as your gauge, so mark off, fit two hacksaw blades in the frame and saw down between the scribed lines. Using a key cutting file, file carefully down to the inner line, then open out to gauge to be a tight fit.

The fixing angles are 1⁷⁄₃₂ in. lengths from 1 in. x 1 in. x ⅛ in. bright steel angle, with one face reduced to ⅞ in. width. Fit that piece of frame material in the slot, then clamp the angle to it and the buffer beam, to drill through and fit ⅛ in. soft iron snap head rivets, hammering well down into those countersinks.

The rubbing plate is from 1¼ in. x ³⁄₁₆ in. BMS flat, so start with about a 3 in. length and mark out on the end of same. First drill a row of ⁷⁄₃₂ in. holes and open out to form the ¼ in. slot, and of course you can do this with the material gripped in the machine vice on the vertical slide. Now you have to relieve by ³⁄₃₂ in. to form the ³⁄₁₆ in. land as shown, which is bread and butter for an end mill, after which you can saw off to ¹⁵⁄₁₆ in. overall and tidy up the ends, completing with a radius at the corners. Offer up to the beam, drill through the six No. 51 holes, but before rivetting in place, deal with the slot in the beam to match the rubbing plate.

Pony Truck Support Stay

Just one more part to hold the frames the required 4⅛ in. apart and it is the trickiest of them all, though we shall win, especially as we now know the fundamentals of steel fabrication. Start by squaring off a 2²⁹⁄₃₂ in. length of 2½ in. x ⅛ in. steel flat. Next square off two 1 in. lengths of ½ in. x ¼ in. BMS bar as a pair, reducing the thickness by milling or turning down to ⁷⁄₃₂ in. to start forming the lugs for the side control springs. Clamp together, mark off and drill the ¼ in. hole, radius around a mandrel with an end mill, holding securely with a 'Mole' wrench, then grip in the machine vice and mill the inner edge to sit on the support stay, completing with the outer profile. Sit on the stay with ¼ in. rod and spacers to arrive at the correct 2¼ in. distance apart, clamping in place, though this can wait until we are ready for the brazing operation.

The end plates are 1⅛ in. squared lengths from 1½ in. x ⅛ in. steel flat, the top plate a 3²⁹⁄₃₂ in. length from the same material which requires the rear profile reduced to drawing. Hold the pieces made so far together with a few 8BA round head brass screws. For the spring plunger tube, chuck a length of ¾ in. diameter steel bar, face, centre, drill and ream ½ in. diameter to about 1⅜ in. depth before parting off a 1¼ in. slice. We now need three webs cut from 1 in. x ⅛ in. flat to complete the fabrication, two to hold the plunger tube central and the other a short piece between tube and stay, again holding in place with some 8BA screws; braze up as previously described, then clean and apply a coating of zinc after filing off the screw heads.

Back to the machine vice and vertical slide to first deal with the two end plates by end milling to arrive at the 4⅛ in. dimension, keeping the plunger and spring lugs nice and central. We now have to shape the bottom edge of the stay and it is quite involved, so saw away as much excess material as you are able, then back to the machine vice to deal with those lugs, then the flat surfaces, completing the sloping edges with a file.

Plunger and Side Control Pin

For the plunger, chuck a length of ⅞ in. diameter drawn bronze rod in the 3 or 4 jaw, face and turn down to ½ in. diameter, a nice sliding fit in the tube, over a 2⁵⁄₃₂ in. length, and do run the ½ in. reamer through the tube ahead of this as the brazing will have slightly distorted the hole. Centre, drill and 'D' bit ⁵⁄₁₆ in. diameter to ⅝ in. depth before parting off at 2⅜ in. overall, reversing in the chuck to clean up the head to ³⁄₁₆ in. thickness as shown. The side control pin consists of a 2⁹⁄₁₆ in. length of ¼ in. steel rod which fits the pair of lugs, after which you drill right through at No. 60 for 1mm spring dowel pins, though don't fit the latter as yet.

Axleboxes, Spring Pins and Plates

The gunmetal axlebox material is cast solid in pairs and first we must arrive at the correct section of 1½ i. x ⁵⁹⁄₆₄ in., either by milling or turning in the 4 jaw. Next we have to produce the slots to match the horns, so grip in the machine vice and mill a ½ in. wide slot to ⅛ in. depth, gradually opening out to ⅝ in. width to arrive at the correct flange thicknesses. This means making a note of the vertical slide micrometer collar readings when the last cuts were taken, so that you can now rotate the bar through 180 deg. and repeat, this time trying the axleboxes in their horns as you approach the 1¼ in. dimension. Saw into individual axleboxes, stamping them to be in pairs, then turn them down to 1¹¹⁄₃₂ in. overall. Again these lengths want to be matched, so do them in pairs in the 4 jaw.

Break off for a moment to partly deal with the axlebox keeps, again I can supply gunmetal castings for this from DONCASTER, though they are not listed. Arrive at the correct ⅞ in. x ²¹⁄₃₂ in. section, sawing into individual keeps and squaring them off to ⁵⁹⁄₆₄ in. overall length. Mark out for the keeps on the axleboxes, grip them in the machine vice and mill until the keeps are a good fit, again stamping the keeps to match their axleboxes. Clamp together, turn the boxes through 90 deg., to mark off and drill No. 31 for the pair of ⅛ in. retaining pins, which I see are not detailed, being plain 1¼ in. lengths.

We now have to bore out the axleboxes, still in pairs, so mark the axle centre on one box and chuck as a pair in the 4 jaw, then centre and drill right through to around ¹¹⁄₁₆ in. diameter. Change to a boring tool and if you do not possess a ¾ in. reamer, merely bore out to an odd end of bright steel round bar as your gauge, then at least all the bores will be the rechuck to face off. Screw to the trailing crankpin, then cross drill either for a 3/32 in. taper or spring dowel pin.

Now for the leading crankpins, which call for a little patience, so chuck the ½ in. rod again and start by reducing to a press fit in the crank boss over a 9/16 in. length, parting off at a full 25/32 in. overall. Reverse in the chuck, face to length, centre and drill No. 48 to 7/16 in. depth, then drill 3/8 in. diameter and 'D' bit to 5/64 in. depth. Again transfer to the machine vice, this time to mill the 5/32 in. wide slot, and you can start this by drilling a couple of No. 25 holes before changing to a 5/32 in. end mill to complete; tap the remains of the No. 48 hole at 7BA.

For the cap, chuck a length of 5/8 in. diameter steel bar, face and ease the diameter a few thous over a 3/8 in. length, then turn the outer 5/32 in. down to 3/8 in. diameter, a tight fit in the end of the crankpin. Transfer again to the machine vice, this time to start forming the spigot to fit the crankpin, though you will have to complete with files to a very tight fit. Such is vital to the well being of No. 78000 out on the track, for if that crankpin cap can revolve just a thou, then it will do so, the 7BA retaining bolt will slacken, and disaster will ensue, that I guarantee! Back to the 3 jaw, to part off at a full 7/32 in. overall, then rechuck by the 3/8 in. spigot and face off to length. Now centre and drill through at No. 41, following up with ¼ in. drill and 'D' bit to 3/32 in. depth. The means of holding the cap to its crankpin is a socket head screw, so if you have no 7BA ones by you, vary the tapping to suit what is available, going for instance to 6BA rather than 8BA. Use the cap when pressing the leading crankpins into the wheel boss. Before we can wheel the engine we need the side rods, so on we go.

Coupling Rods

With care you will be able to get the leading coupling rods out of 1¼ in. x 3/8 in. section BMS bar, so mark them off carefully. We shall though be drilling back from the axleboxes in the frames so that rod and axle centres coincide, very necessary for free running, so try a length of ¾ in. diameter bar in the axlebox bores and if at all slack, turn down from 7/8 in. bar to be a tight fit. Face off of course, then centre and drill 5/8 in. diameter to 1 in. depth, parting off a 7/8 in. bush; repeat. A third bush will be required for the rear coupling rod, this one with ½ in. bore but otherwise identical to the other pair. Fit the bushes for a leading coupling rod, bring up said rod and clamp firmly in place, check the 'crosshairs' from your marking out and when satisfied, drill through at 5/8 in. diameter. Check your marking out again against the pair of holes, and if there is any error, coat the rod and mark it out afresh.

We now need a foot length of bright steel angle of section around 1½ in. x 1½ in. x 3/16 in. that is perfectly square and once you have such a piece then keep it for all future rods. In one face, drill 3/8 in. holes at roughly 3 in. pitch so that you can bolt it directly to the vertical slide table and move it along in stages so that you can cover the full length of the rods. in the other face and at approximately 7 5/32 in. centres, drill further 3/8 in. holes and bolt the rod in place using plain washers. We now have to remove 3/32 in. of metal from the inside face all the way along except at the front boss, so grip a ½ in. end mill in the 3 jaw and do just that, changing to a clamp when you reach the rear fixing bolt. Turn the rod over, pack it up 3/32 in. away from the front boss and mill this face also to arrive at the 3/16 in. thickness back to the rear boss. This machining will have destroyed your marking out, so repeat again and this time chuck a Woodruff key cutter to deal with the 9/32 in. wide flute, though choose a No. 606 Woodruff cutter which is only 3/16 in. wide and deal with the flute in several bites. Still using the Woodruff cutter, deal with the top edge of the rod furthest away from you, changing to an end mill to tackle that facing the chuck to arrive at the 3/8 in. dimension; remove all burrs and sharp edges.

We now have to deal with the third hole for the knuckle pin, which means we should have started with a 9 in. length of bar, so grip by the 3/8 in. portion in the machine vice, chuck an odd end of 5/8 in. diameter bar in the 3 jaw and align the driving crankpin boss with same. Now you can move on .813 in. by micrometer collar on the cross slide, to centre and drill through at 3/8 in. diameter. Change to an end mill to remove 1/16 in. of metal to start forming the tongue, then turn the rod over and repeat. Using the mandrel and end mill technique, we can radius a part of each end boss, though be careful not to remove the oil boxes, resorting to saw and files to complete.

The rear coupling rods start as 7½ in. lengths from 1 in. x 5/16 in. BMS bar, so mark off the rod, then grip in the machine vice to centre and drill through the knuckle joint at Letter J, then radius over a mandrel with an end mill. Although the fork end can be formed using a slitting saw in an arbor, gripping the embryo rod in the machine vice, I think you will find it quicker and easier to resort to hacksaw and files in the same way as we dealt with those slots in the front buffer beam, fitting to place over the tongue on the leading rod.

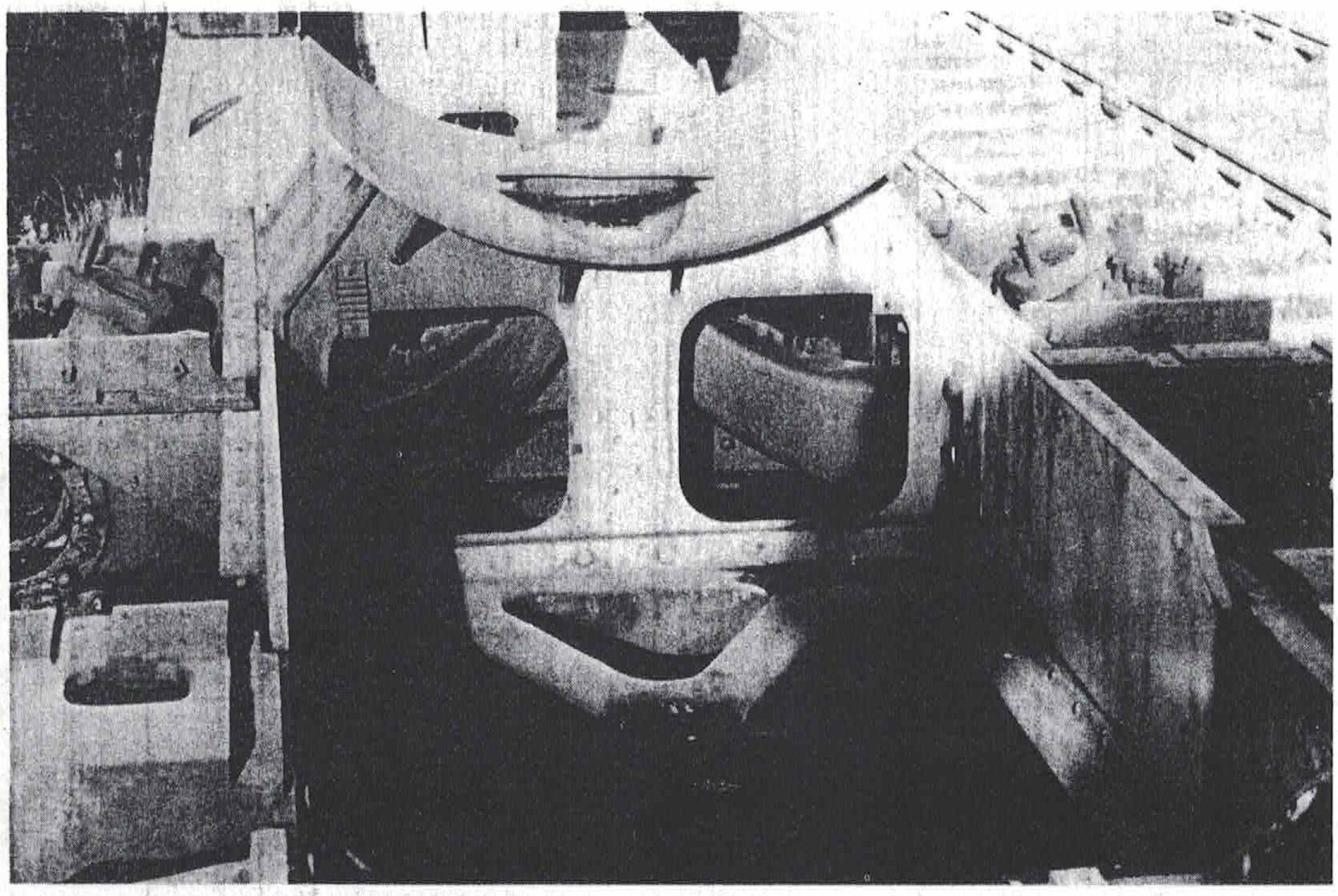
Knuckle Pin and Rod Bushes

We now require the knuckle pin and its bush, so we may as well have a turning session and deal with all the bushes at one fell swoop. A length of ¾ in. drawn gunmetal rod is the ideal and I am able to supply same should any builder find the need, when it can be chucked in the 3 jaw. Face and turn down to .628 in. diameter over a 5/16 in. length for the driving bushes, then centre and drill ½ in. diameter to 7/16 in. depth before parting off at a full 11/32 in. overall, then reverse and clean up. For the trailing pair, first reduce to 5/8 in. diameter over a ½ in. length, then further reduce to .503 in. diameter over the outer 11/32 in. before you centre and drill 3/8 in. diameter to ½ in. depth. Part off at a full 3/8 in. overall, reverse and clean up.

For the leading pair of rod bushes, turn down over a 3/8 in. length to .628 in. diameter then centre and drill ½ in. diameter to 3/8 in. depth and part off a 7/32 in. slice, again cleaning up. That brings us to the knuckle pin bush, for which turn down to .378 in. diameter over a ¼ in. length, centre and drill 9/32 in. diameter to ¼ in. depth, part off a full 5/32 in. slice and clean up. By now you will be wondering why I have added a couple of thous to the outside of all the bushes. It is simply that I have found in practice over later years that making bushes a really severe press fit keeps them in place thus they never move in service, so press them into the embryo trailing coupling rods and run the drill through the bore again; later drill through at No. 51 as an oil hole.

For the knuckle pin, chuck a length of 9/32 in. silver steel rod, face and turn down to 3/16 in. diameter over a 5/32 in. length, screwing 2BA; part off at 15/32 in. overall. Assemble the pairs of rods, use lengths of 5/8 in. diameter bar to align the front rod to the axle centres, clamp the rear one in place and drill through at ½ in. diameter; complete the rod in similar fashion to its front partner. Press in the bushes, deal with the oil holes and before we reach the track there is one other vitally important operation to carry out.

Due to the lack of the driving crankpins, we cannot actually assemble all the wheels to their axles yet, but I must assume all the crankpins have been fitted so as not to forget this vital instruction. Press one wheel on to each axle, or of course secure with Permabond, then bring up the second wheel to the leading axle and mount between centres in the lathe. With scribing block and engineers square, quarter this pair of wheels as well as you are able, though I will always do this by eye, then push home that second wheel. Erect in the frames, fit the driving wheel on its axle, bring up the pair of leading coupling rods and fit the second driving wheel, checking that the wheels turn sweetly without binding, then go on likewise



This view looking forward to the smokebox saddle shows the exhaust steam pipes contained in same; note the attachment of the horizontal stretcher
Photos of No. 78019 by Clifford Herbert

to the trailing pair. That is OK as far as it goes and all axleboxes must be packed hard down onto their hornstays whilst the wheels were being fitted. Now release the axleboxes and try moving just one of them to the top of its horn and you will find the coupling rods prevent this, so if your brand new engine ran over a low joint on the track it would derail; such is certain. We therefore have to destroy your best workmanship by easing the fit of the coupling rod bushes. Grip a ½ in. drill point upwards in the bench vice, fit a rod over same and drop a length of ⅛ in. rod down one of the drill flutes. Pull the rod around the drill, that ⅛ in. rod will jam, and you will be able to pare a little metal from the bush. Only a little please, changing to ⅜ in. drill for the rear bush, until you can lift each axlebox independent of the rest and the wheels still turn sweetly. If you omit this process, No. 78000 will quickly do it for you, though in the process she will be at grave risk!

Connecting Rod

The connecting rods start from 9 in. lengths of 1 in. x ⅜ in. BMS bar, so mark them out and drill ⅜ in. and ⅝ in. holes at 7⅝ in. centres. Back to that angle fixture to drill a ¼ in. hole for the small end of the rod, then bolt firmly in place. The first operation is to remove 1/16 in. of metal from each side of the rod right back to the big end boss, packing up by said 1/16 in. when you deal with the second, outer, face; mark the rod out again. With a Woodruff key cutter, machine the .025 in. deep flute right down the centre of the rod, then set the rod over to arrive at the taper furthest away from the headstock, when you will be able to use the key cutter to deal with that edge of the rod. Now set the rod over the opposite way to complete the flute, when you change to an end mill to deal with its mating edge. If at any time you feel there is too much metal to mill away, then use a hacksaw to rough out the profile.
That lump at the small end is an oil box full size, the rod being milled away to form a reservoir, a separate cover being fitted and the rod peened over to trap the cover in place. All we need do here is mill to form the flat portion, drill and tap as shown to represent full size practice, then radius both ends of the rod over a mandrel with an end mill, completing with saw and files.
I said earlier that I would deal with all the bushes at one fell swoop, then omitted to look right at the two detailed under the connecting rod; tackle them as previously described.

Motion Plate and Expansion Link Trunnions

Continuing the fabrication theme, we now come to the motion plates and an immediate decision. Look at the section at the radius rod slot and you will see that the main member can either be machined from 5/16 in. steel flat for the outer stiffener to be integral, or that edge can be a part of the fabrication, and I must say I favour the latter method. Carefully mark out, saw and file to line, then grip in the machine vice to mill the ¼ in. slot for the radius rod before drilling the six No. 44 holes. You can make the slide bar lugs from 3/16 in. thick material if you wish and then machine to suit said slide bars, though if you arrive at a dimension slightly greater than the required 1 9/16 in. over the jaws then a shim or two will solve the problem. Saw out the top plate and file to line, then set the main member up on a flat surface, adhering strictly to the 3/16 in. dimension, filing the main member until the top plate sits flat; secure with a couple of 6BA round head screws. Now you can add the frame fixing flange and that sloping portion of stiffener at the outside before brazing up, then back to the machine vice to mill the frame fixing flange. We really require both crosshead and slide bars before erecting the motion plates to the frames, and as the crossheads are detailed on Sheet No. 6 this is another job we shall have to leave until the next session.
The expansion link trunnions we can make and erect and on reflection I would now specify these from 1 in. x ¼ in. BMS bar. Mark them out, drill and ream the ⅜ in. hole, then saw them off at full length and clamp together with an odd end of ⅜ in. silver steel rod to align the reamed holes. Mill across the base to arrive at the 15/16 in. dimension, then offer up to the motion plate with ⅜ in. silver steel mandrel and ⅝ in. distance spacer, to spot through, drill and tap 8BA as shown. You now have to complete the profile so saw and file away as much metal as you are able, then grip with a 'Mole' wrench and radius the bearing end over a mandrel with an end mill, filing the flanks to match. The fancy hole can be dealt with by drilling through at 5/16 in. diameter and finishing with a file, then change to an ⅛ in. end mill to remove 1/16 in. of metal at each side to reveal something like the webs I have detailed, just so the end result is pleasing to your eye.

Slide Bar

Earlier this morning, Steve Titley rang me to discuss the first steaming of the PADDINGTON he has been building, when the worst problem that arose was the 'firing' of the cast steel crosshead to the gauge plate slide bars. I told him to use molybdenum disulphide grease as lubricant, but Steve had already beaten me to this, though to his comment that the working surfaces were OK, it was the wee lips on the crosshead that had been the trouble, I don't think he was too happy when I told him to use a file to ease the fit! I say all this because you now have to decide whether to use mild or chrome vanadiam steel for the slide bars, and I very much favour the latter.

We shall require four 6 in. lengths from ½ in. x ⅜ in. section and this is one job where a horizontal milling machine would be an advantage, when we could gang mill the bars as was full size practice to expose the stiffening web, gaining literally barrow-loads of swarf in the process! However, the machine vice and vertical slide will come to our rescue, to first reduce the width to 7/16 in. as per drawing. Now clamp the embryo slide bar directly to the vertical slide table, hence the extra length, to end mill down each side to expose the stiffening web, and if you have an end mill by you with a radius ground on the end of the cutting teeth, this will provide a radius between bar and web as per prototype. Leave the bar portion a little over the specified 5/32 in. thickness as the heavy milling will likely have made the slide bar banana shaped, but before turning over to clean it up to size, saw and file away the excess web. Saw and square off to length in pairs, then mark off and drill the two holes at the rear cover end, noting that the bars are now handed by said web.

You need the crosshead to offer the slide bars up to the rear cover, to spot through, drill and tap the cover 6BA, using shims if necessary to get the crosshead sliding freely between the slide bars. Bolt the cylinders in place, then bring up the motion plates, fixing them to the outer end of the slide bars before drilling through from the frames.

Weighshaft Bearing

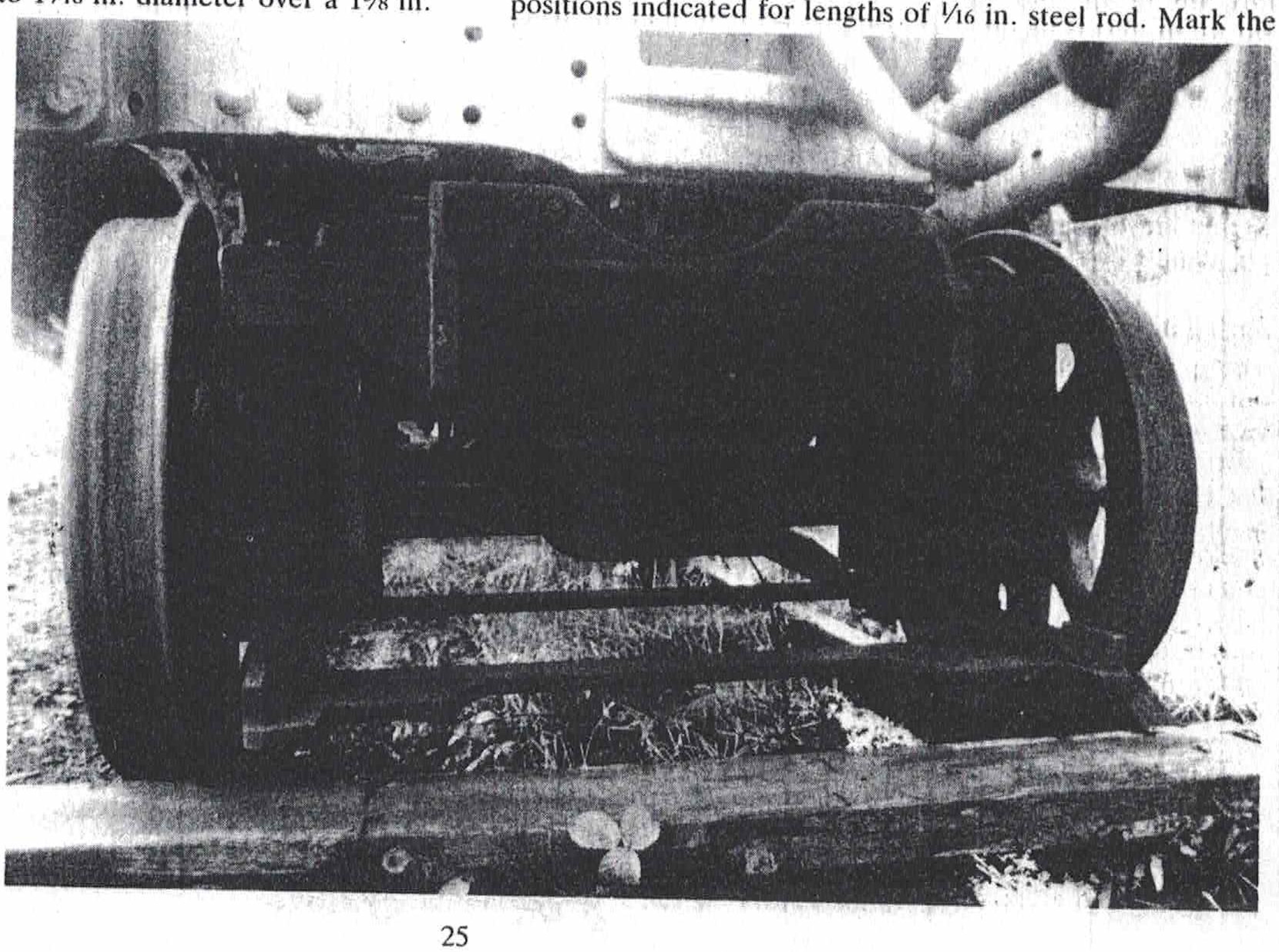
For the weighshaft bearing, chuck a length of 1¼ in. diameter steel bar in the 3 jaw, face, centre and bring the tailstock into play before turning down to 1 3/16 in. diameter over a 1⅝ in. length. Further reduce the outer 1 3/32 in. to 19/32 in. diameter, adding a wee radius with a file, then concentrate on the next 5/32 in., getting it a nice tight fit in the ⅝ in. hole in the mainframes. Centre, drill and ream ⅜ in. diameter to 1⅝ in. depth, then part off at a full 1⅜ in. overall, reversing to clean up the flange to ⅛ in. thickness. Offer the pair of bearings up to the frames, use a length of ⅜ in. silver steel rod to check alignment, then spot through, drill No. 47 and tap 7BA for hexagon head bolts.

PONY TRUCK

The rest of this session is devoted to completing the pony truck and my design owes less to E. S. Cox than to Robinson and American practice, though it fits neither description exactly! With full equalised springing, an equalising beam would come forward from the front pair of coupled wheels and transmit load to the pony truck frame. This I have replaced with a simple spring loaded plunger, the actual spring being critical to arrive at the correct loading on the pony truck, though it is supplemented by the axlebox springs, so do experiment once you get to the track. I have also introduced a measure of side control by use of springs, though being positioned high up, they would affect the ride of the pony truck if made as strong as I would have liked; the system does work though and well, so maybe I am being too critical of my design work?

Axleboxes and Keeps

Requirement for the axleboxes is an approximately 2½ in. length of cast gunmetal stick that will machine to 1 in. x ¾ in. section; arrive at this then mill the 7/16 in. wide slots for the horns to 3/32 in. depth. This time we shall fit the horns to the axleboxes, so no fit to worry about. Back to the 4 jaw to face off one end, then turn on the raised portion and use a ball nose tool to produce the spherical indent for the spring beam ball end; reverse and repeat. Saw into individual boxes, face off to length, then mark out for the keep, gripping in the machine vice to mill said keep recess. The keeps can either be from a gunmetal cast stick, or an odd end of ⅝ in. square brass bar; mill down to a good fit in the axlebox, then saw off and face to length, drilling through No. 52 at the two positions indicated for lengths of 1/16 in. steel rod. Mark the



This front view of the pony truck is again slightly different from my own specification, mainly as in 5 in. gauge I have to allow for additional side movement

Lubricator Drive Arm and Pin

The drive arms are best fabricated, for which we require a wee jig. The base of same is a 1¼ in. length from, say, ½ in. x ¼ in. BMS flat, so grip in the machine vice and at ¼ in. from one end, on the centre line, drill No. 13 then move on 9/16 in. to drill a second hole at No. 43; press in ½ in. lengths of 3/16 in. and 3/32 in. silver steel rod and coat the whole jig with marking out blue.

Next chuck a length of 5/16 in. steel rod in the 3 jaw, face, centre and drill No. 12 to ⅝ in. depth, parting off two 5/32 in. slices. The arm is from ⅜ in. x ⅛ in. BMS flat, so first mark off and drill the No. 41 hole. Roughly file on the 3/32 in. radius, completing with an end mill over a mandrel, then saw off the parent bar and scallop this end so the two pieces precisely fit the jig; braze up. Clean off and file the flanks of the arm to blend into the boss, then offer up to the expansion link pin and drill through No. 52 for a 1/16 in. spring dowel pin.

We know how to fabricate small pins from those we made for the valve gear, so the lubricator drive pins will cause us no problem, and at the same time you may also like to deal with those for the brake hangers.

Lubricator Drive Rod

Although the side running boards don't yet exist, at this point in time we have to position the lubricators on same mainly for ease of piping to the cylinders, when we can arrive at the correct length of drive rod, the lubricators only being secured to the running boards by means of the clack; no other fixing will be necessary.

The fork ends are from ¼ in. square steel bar, so drill No. 41 for the pin, then move on 3/16 in. to cross drill ⅛ in. diameter to start forming the slot, one which you will complete with saw and files to suit the two arms. Radius the end over a mandrel with an end mill, file the flanks and saw from the parent bar. You may just be able to grip the fork end in the 4 jaw to turn on the 5/32 in. diameter end to match the rod, otherwise leave it until after brazing, when you will be able to grip by the rod itself to clean up, completing with files; erect and check operation of the lubricators.

BRAKE GEAR

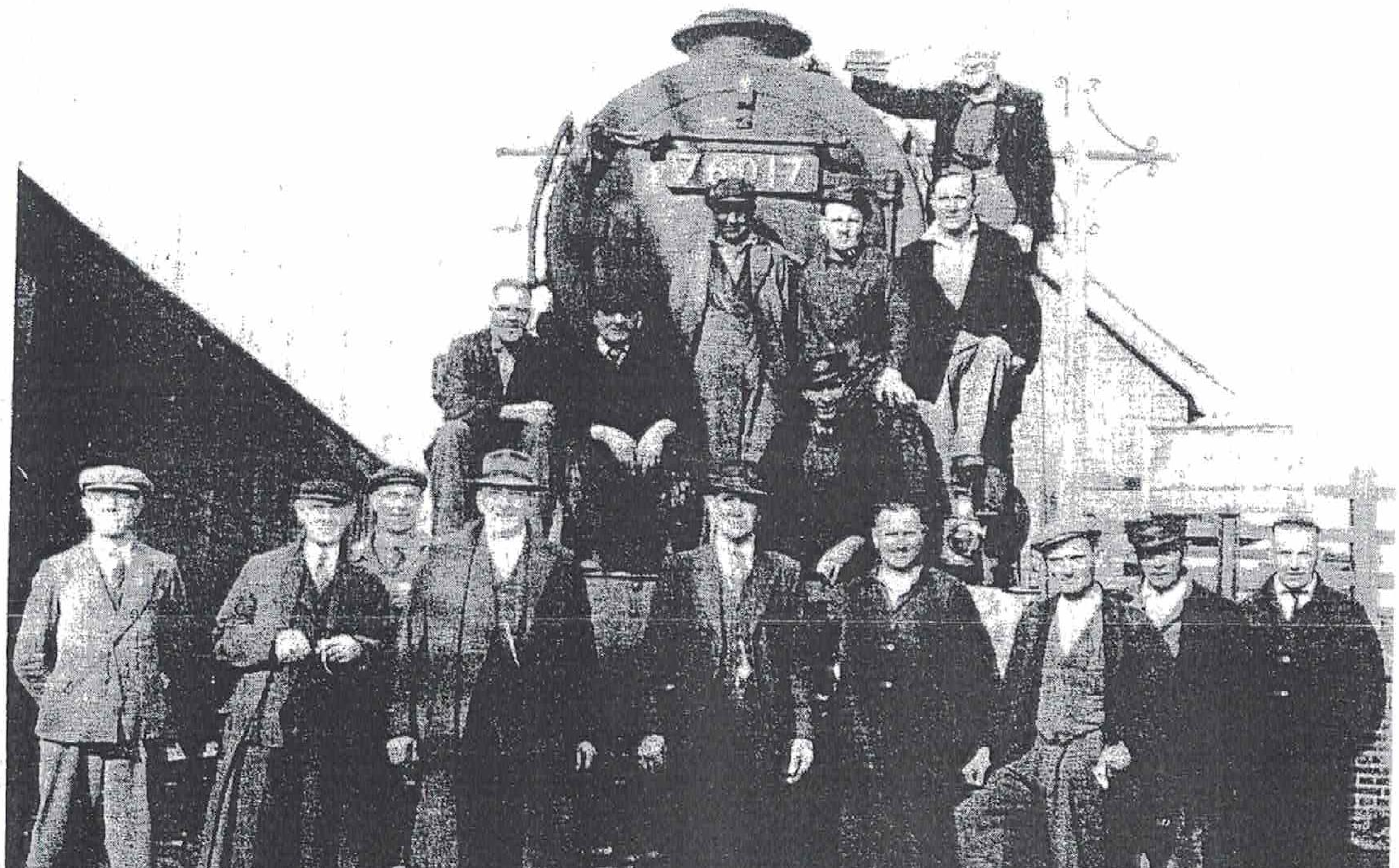
Most of the brake gear will have to await the final session next time, but we can at least make a start with the brake hanger and bracket.

Brake Hanger and Bracket

For the brake hangers, we require yet another simple jig, in fact it can pay dividends if you spend some time looking at the various details to see if a composite jig can be employed. For this one we need a 3¼ in. length of the ¾ in. x ¼ in. BMS bar as the base and at ¼ in. from one end, drill No. 23, then move on 2¾ in. and repeat; press in ½ in. lengths of 5/32 in. silver steel rod and coat the jig with marking out blue.

Chuck a length of 5/16 in. steel rod in the 3 jaw, face and turn down to 9/32 in. diameter over about a ¾ in. length, then centre and drill No. 22 to ¾ in. depth, parting off ¼ in. slices and repeating until you have 12 end bosses. Fashion the hanger from ½ in. x ⅛ in. steel flat, scalloping the ends to suit the bosses which are sitting in the jig, pack the central portion up by 1/16 in. and braze up. Clean up and paint with a black undercoat as this best represents 'raw' steel. Mark off and drill a No. 30 hole in the jig at the brake block pin position, then use as a drill jig for all the brake hangers to complete.

There are many ways of tackling the brake hanger brackets, but as one who usually favours fabrication, this time I am choosing to machine from ¾ in. x 5/16 in. section BMS bar just to ring the changes. Mark a bracket out on the end of a piece of bar and first cross drill the three specified holes. Saw away below the No. 22 brake hanger pin hole and tidy up with files, before completing the radius over a mandrel with an end mill, leaving a 5/32 in. thick flange. Now grip the bar in the machine vice to mill the ¼ in. wide slot to accept the brake hanger, then turn the bar round to mill away above this slot to arrive at the 3/32 in. dimension and again a 5/32 in. thick flange; saw away from the parent bar. All that remains is to tidy up the flange profile to drawing, then erect to the frames, and that is as far as we can go in this session.



The story behind this pictures would fill this issue if told! I have said many times about not being able to recall No. 76017 at Eastleigh. This photograph was taken after No. 76017 had been successfully extricated from the sand drag at Whitchurch by my Shedmaster at Eastleigh. Mr. Reg Meggett and sent in by Denys Pack. It still doesn't solve the mystery for me, but it did serve to reintroduce me to Mr. Meggett after an interval of 45 years. It is a picture full of memories, for here are my friends and colleagues from an extremely happy period of my life, the centre of which was Bert Waring seen here in Wellington boots, a man who always led from the front.

78000, A B.R. Class 2 'Mogul' for 5 in. gauge

by: DON YOUNG

Part 8 — Conclusion

Completing the Brake Gear

This final session is going to start off in relaxed manner, for much of the remaining brake gear has already been described. As instance, the complete brake cylinder as being one of my pet 'standards' was covered for POM-POM as recently as LLAS No. 40 thus only requires the briefest mention. I see that for No. 78000 there is a detail for the brake cylinder top cover, cut from .005 in. thick brass shimstock, obviously to prevent rust from the drag box above from glueing up the works, though the zinc coating applied to said drag box is just about sufficient insurance against same. The only other point of note is that the push rod is shortened from the ⅝ in. dimension for POM-POM to ½ in. for No. 78000; that was easy!

When dealing with the tender brake gear details in Part 3 of the series in LLAS No. 37, the engine brake beams and pull rods were also described, which brings me on to the brake shoes.

Brake Shoe

I actually enjoy 'wood butchery' and this is probably a reason why an engine like MARIE E with her wooden cab and tender underbody appeals so much to me. Early on, I also started making patterns with equal confidence, only to discover they were in the main far too precise for my limited skills, thus without Norman Lowe I would not be a castings supplier today. I did, however, manage to produce one brake block ring pattern and it covers several of my designs, including No. 78000, there being a fairly generous machining allowance. As a first step, grip in the 4 jaw or 'dog' to the faceplate to bore out to size and face across the outside, relieving by 1/32 in. to reveal the ¼ in. thick shoe. Rechuck by the bore to face off to ⅜ in. overall thickness, then relieve this second face by 1/32 in. as before. Mark off and drill the No. 30 hole for the brake shoe pin, saw off into individual shoes, slot to suit the brake hanger and I am afraid the rest is saw and file to complete the profile; erect.

Brake Shaft and Trunnion

For the brake shaft, chuck a length of ⅜ in. steel rod in the 3 jaw, face and turn down to 5/16 in. diameter over a ¼ in. length. Part off at a full 1¼ in. overall, reverse in the chuck, face off to length and complete the second journal.

The brake arms to attach to the shaft start life as a length of 1¼ in. x 5/16 in. BMS bar, so first mark off and drill the pair of No. 22 holes, plus the ⅜ in. one to suit said shaft. I have neglected the machine vice and vertical slide of late, but here the set-up comes into its own again to reduce the main portion of the arms down to 3/16 in. thickness. Mark on the profile, saw away most of the surplus, though still attached to the parent bar, then cross drill No. 22 to start forming the fork end at the push rod, completing with saw and key cutting file. Radius over a mandrel with an end mill, saw from the parent bar and complete, to include the No. 50 hole for the return spring. Erect to the brake shaft and braze together, then clean and coat with oil.

For the trunnions, although they could be bent up from 1¼ in. x ⅛ in. BMS flat, I recommend they be machined from 1¼ in. x ½ in. steel bar, starting with a 6 in. length. Mark a trunnion off on each end of the bar, grip in the machine vice on the vertical slide to mill the section; drill the 5/16 in. hole, radius the end over a mandrel with an end mill, then complete the profile. Saw away from the parent bar to leave an overthick flange, then turn up the doubler discs from ¾ in. diameter steel or brass bar, clamping in place and brazing together; clean up. Bolt the trunnions back to back through the 5/16 in. hole, grip the whole in the machine vice and mill the flanges to both ⅛ in. thickness and to be a pair. Build up the relevant parts of the brake gear on the bottom of the drag box as shown, spot through, drill and tap the twelve 6BA holes, bolt in place and complete with the specified return spring.

THE SMOKEBOX

The smokebox is not only the last major feature of No. 78000 to be tackled, but also the most vital, for on the draughting depends the success of the engine and by 1972 I was well aware of this. It also allows us to complete the chassis by manufacture of the smokebox saddle.

First though we require the smokebox shell, which must be rolled up from 1.6mm steel or brass sheet, the joint being brazed. I am almost certain that Reeves provide such a service but my attempt to check ahead of typing this sentence came to nought as John Crisp, Alec Farmer and Robin Butler were not available. Chuck the tube by its bore in the 3 jaw and if you use a 4 in. diameter chuck then the tube can be passed part way over the body, to square off one end. You can try to lightly clean up the bore over about a ¼ in. length, though driving in the end fitting later on will have the same effect. Reverse and square off to finished length when we can delay the smokebox saddle no longer.

Smokebox Saddle

Whilst fabrications in steel will no longer hold any terrors for builders of No. 78000, access to bending rolls is almost essential to ensure the flange mates with the smokebox shell to an acceptable degree, home made bending rolls being perfectly OK provided the flange is rolled hot, so start with a 9 in. length of 4⅛ in. x ⅛ in. steel flat. After rolling, trim away the excess at each end, then mark off and drill the 28 holes specified at No. 34, followed by the ⅝ in. hole for the blast pipe which is centrally located. The side plates are bent up from 3½ x ⅛ in. steel flat, the bottom edge being scalloped to clear the exhaust union. Clamp to the frames and trim the top edge to suit the flange and arrive at the 1⅛ in. dimension. Use a cardboard or plastic template for the front and back plates, transferring to 3mm steel sheet when satisfied, then use a few 8BA brass screws to assemble the bits for brazing, cleaning up and applying a coating of zinc to prevent rusting. The way I have described manufacture calls for no machining at the side faces between the frames, any wee gap in conclusion being taken care of with shims, though of course you can spread the side plates slightly when adding the ends and then mill to your frame gauge. Erect the saddle to the frames and use lengths of 3/16 in. steel bar sitting on top of the frames to support the underside of the flange to arrive at the 5/16 in. required height, clamping in place and spotting through before tapping 6BA from the frames.

Bring the saddle up to the smokebox shell, the front edge of the latter wants to be 15/16 in. ahead of the flange, to drill through a couple of the No. 34 holes and bolt firmly together before going on to deal with the remaining 26 holes. Very likely you will find that the shell does not sit axle centre on one box, chuck as a pair in the 4 jaw, to centre, drill through and bore out to ½ in. diameter to achieve an easy running fit. Turn the 1/16 in. raised face on the outer box, then release the pair and deal with its partner. All that remains now is to relieve the flanges so that the wheels can rise and fall independently as for the coupled axles.

Top and Bottom Plates

I note that Reeves list a 3⅝ in. x ⅛ in. sheared section mild steel flat which is ideal for our purpose, so mark out, drill the specified holes, then saw and file the profile. The top plate is from 2½ in. x ⅛ in. steel flat; first mill away ⅛ in. to arrive at 2⅜ in. width, then mark out and again drill the holes. Saw and square to 4⅛ in. overall and we have to make and fit the side control lug. At 9/32 in. from the end of a length of ½ in. x ¼ in. BMS bar, drill ¼ in. diameter then open out into a 5/32 in. long slot with an end mill, at the same time easing the slot out to 17/64 in. width. Radius the end over a mandrel with an end mill, which indicates you do this whilst there is a plain ¼ in. hole, then saw off and square to 11/16 in. overall. Clamp to the top plate, don't bother about a temporary fixing screw, and braze up, then clean and apply a coating of zinc.

Horns and Frame Assembly

For the horns, saw four 1⅜ in. lengths from ½ in. x ⅜ in. BMS bar, grip as a quartet in the machine vice and reduce the width to 7/16 in. to fit the axleboxes, then mill the ends to arrive at 1 11/32 in. overall; that was easy!
Clamp a pair of horns in place over each axlebox, fit to the axle and bring up the top and bottom plates, clamping over these in turn. Turn is the operative word, for when the axle turns sweetly you can spot through from the plates, drill the horns No. 47 to ¼ in. depth and tap 7BA; ease the axleboxes in their horns if there are any tight spots.

Spring and Pivot Pins

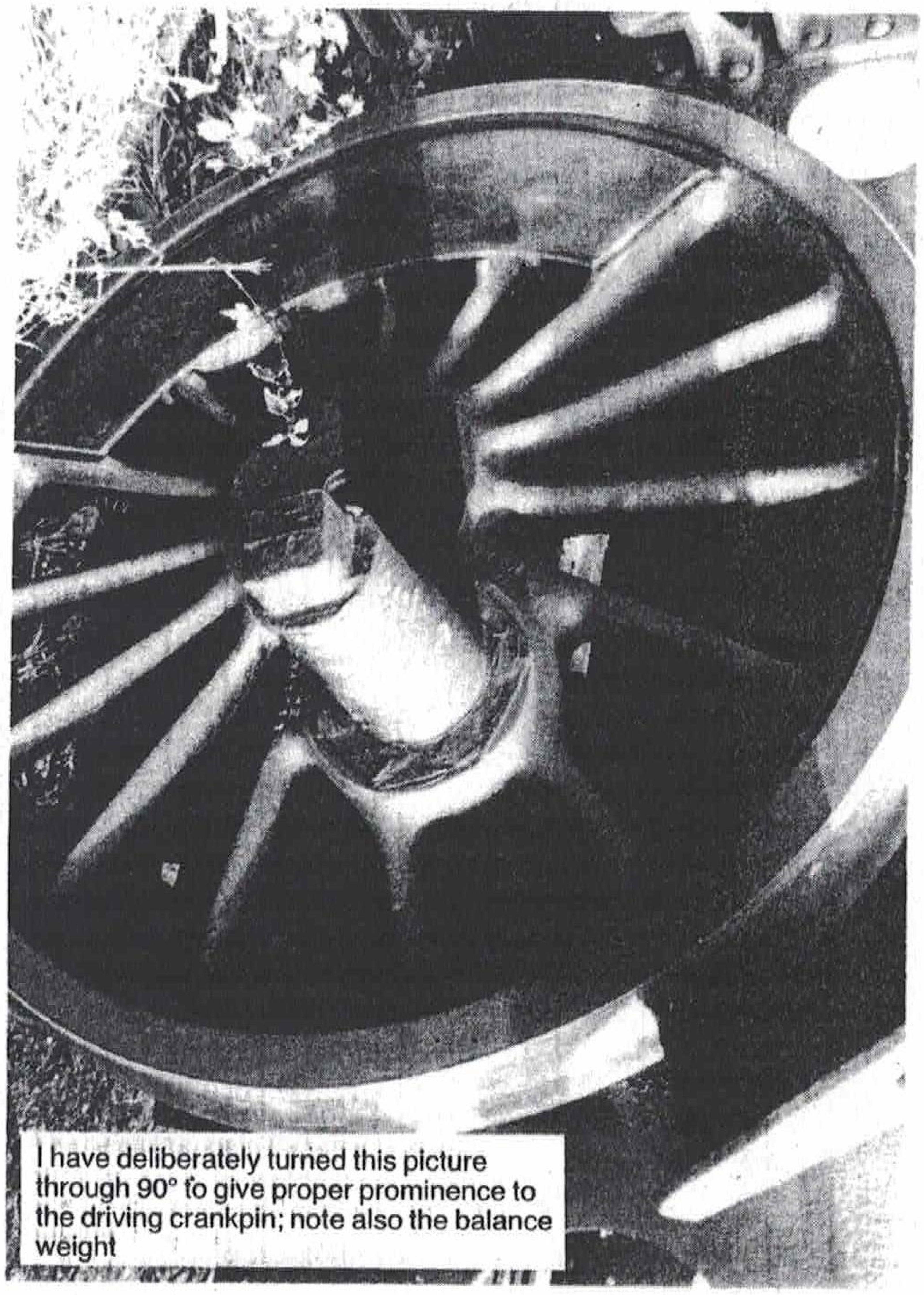
For the spring pins, chuck a length of 3/16 in. steel rod, face and screw 2BA for ⅜ in. length, then part off at 1 59/64 in. overall; repeat another three times. For the pin heads, chuck a length of 9/32 in. steel rod, you will almost certainly have to turn it down from 5/16 in. material, to centre and drill No. 13 to 1 in. depth, parting off four 7/64 in. slices. Press the heads onto the ends of the pins, braze them for additional security, then chuck by the shank and clean up the heads to drawing, removing all excess spelter.
The pivot pin can be made in like fashion, though as there is only one of them and the 5/16 in. diameter wants to be an easy fit in both yoke and stay, it will be just as easy to machine the pin from ½ in. steel rod.

Spring Beam and Ball End

The spring beams start from ⅜ in. square steel bar, so mark out for the three holes, grip each piece in turn in the machine vice and drill the pair of outer No. 11 holes. Move to the centre to drill No. 22 and tap through at 3/16 x 40T; now mill the two sides down to 5/16 in. to keep the holes nice and central. Turn the bar over to reduce the ends to 3/16 in. thickness as shown, then file on the rest of the profile before you radius the ends in the usual manner.
I see in 1972 I specified the ball ends from ¼ in. stainless steel rod, though mild steel will suffice. Chuck in the 3 jaw, face and turn down to 3/16 in. diameter over a 13/32 in. length, then further reduce the outer 3/32 in. to 5/32 in. diameter before screwing 40T. Centre and drill No. 60 to ⅞ in. depth before parting off at a full 13/16 in. overall. Reverse in the chuck and clean up to length, then add the spherical radius to match the axlebox; screw hard into the spring beams. Assemble all the pieces made thus far, including the springs as specified, when we can turn our attention to the yoke.

Yoke and Stays

Quite an involved fabrication on which to approach the close of this session, but with the pony truck assembled and erected to its support stay, at least we can check a lot of the dimensions to ensure the first yoke we make is the last! Start with a 6 in. length from 4½ in. x ⅛ in. steel flat and mark out, leaving extra length on the two lugs to fit to the bottom plate at this stage. If you drill some 5/16 in. holes in the areas where metal is to be removed, you will be able to mill much of the profile, bolting the embryo yoke directly to the vertical slide table, though packed off same to avoid ruining said table. It makes a change from sawing and filing, plus you can use an end mill to produce the scallop for the pivot boss, the latter being plain turning. Although you can bell-mouth the 5/16 in. hole, an ordinary clearance fit is perfectly OK and gives a bit more freedom when entering curves. Grip in the bench vice and bend those two lugs to approach the 29/32 in. dimension, checking against the assembly that all is well, then saw off the excess at the lugs, tidy them up, mark off and drill the eight holes. The facing strips you will have to fit to place, securing with a few 8BA round head screws. Set up on the brazing hearth and if you have any bother in locating the pivot boss, it is worth taking time to make up a jig to hold it firmly in place. This jig can be from another 6 in. length of the 4½ in. x ⅛ in. steel flat, first drilled through from the end lugs, then with a 5/16 in. hole under the boss. Turn up a 29/32 in. long spacer and bolt the boss in place; braze up, clean and zinc spray.
Offer up to the bottom plate, clamping in place and checking the action of the complete pony truck before drilling through the No. 34 holes, and please note I now specify drilling the yoke first rather than the reverse instruction on the drawing details. To complete this marathon session, bend up a pair of stays from ⅜ in. x ⅛ in. steel flat to fit yoke and top plate, clamping in place and drilling through; next time its the valve gear!



I have deliberately turned this picture through 90° to give proper prominence to the driving crankpin; note also the balance weight

78000, A B.R. Class 2 'Mogul' for 5 in. gauge

by: DON YOUNG

Part 7 — Rods and Motion

At the end of the session, our chassis will be complete save for a few items of brake gear, so let me hurry on without further delay.

Crosshead, Pin and Drop Arm

The crosshead centre starts life as a 1⅞ in. length from 1¼ in. x ⅝ in. BMS bar, so first reduce the section to the required 1$^1/_{16}$ in. x $^9/_{16}$ in. before marking out. Centre, drill through and ream to $^3/_{16}$ in. diameter for the crosshead pin, then follow up at 7.0mm or Letter J to $^5/_{16}$ in. depth and ream this portion at $^9/_{32}$ in. diameter. The next job is to machine the $^9/_{32}$ in. wide slot to accept the connecting rod and if you do not have a 2 in. diameter cutter by you, then use a ¼ in. end mill in lieu and open out to $^9/_{32}$ in. to be central. All these operations should be undertaken in the machine vice on the vertical slide, so now turn the embryo crosshead centre so that you can complete the slots top and bottom to accept the slippers. We now have to deal with the boss to accept the piston rod, so chuck in the 4 jaw, face, centre and drill 6.3mm or Letter D into the $^9/_{32}$ in. slot. Now turn on the $^9/_{16}$ in. diameter boss over a $^7/_{32}$ in. length, face off to arrive at the $^9/_{32}$ in. dimension shown to the main body of the crosshead, then with a round nosed tool, remove as much metal as you can down to the specified ½ in. diameter before completing this part of the profile with files. Next chuck the centre to turn on the $^1/_{16}$ in. raised face as shown to $^9/_{16}$ in. diameter, and being symmetrical, this operation does not hand the crossheads, then complete the rear profile.

For the crosshead slippers, I can supply some lovely cast gunmetal stick which is ideal for the purpose, so first arrive at a section of approximately ⅝ in. x ⅜ in. Still in the machine vice and with a ⅜ in. end mill, deal with the $^9/_{32}$ in. wide spigot to the $^5/_{32}$ in. dimension to be a good fit in the crosshead centres. Cut into individual slippers and square them off to length, then grip by the spigot in the machine vice and first mill the outer edge to arrive at the specified $^{11}/_{64}$ in. dimension, then the inner edge to give a width of $^{19}/_{32}$ in. overall. We must now tackle the groove to suit the slide bars, so mill a slot with the ⅜ in. end mill, deepening and widening it a little at a time and checking against the crosshead centre, assembling the whole on the piston rod and trying between the slide bars. Remember what I said previously about being able to adjust the slide bars with shims, but the more accurate your machining, the less fitting will be necessary. When satisfied, mill away the excess tongues to arrive at the $^3/_{32}$ in. dimension as shown.

Before we can braze up the crossheads, we need the drop arms, and now the crossheads have been handed by the fitting of the slippers, so bear this in mind. The drop arms are from ⅝ in. x ⅜ in. BMS bar and if you use, say, a 6 in. length, then you will be able to mark one out at each end. Drill the ¼ in. hole, radius over a mandrel with an end mill, then deal with the pair of No. 52 holes. Now grip in the machine vice on the vertical slide to deal with the steps and as much of the profile as you are able, dealing with each drop arm in turn, and taking readings at the final cuts so that the second arm can be machined identically. Saw away from the parent metal, complete the profiling, then drill down No. 51 into the ¼ in. bore and tap 8BA as shown to complete.

Offer up to the crosshead centre, with the slippers in place, to drill through and fit $^{19}/_{64}$ in. lengths of $^1/_{16}$ in. silver steel rod as dowelling, to positively locate the drop arms for brazing. Allow to cool and drop in the pickle for about a minute, then clean up to remove all excess flux, polish and coat with oil.

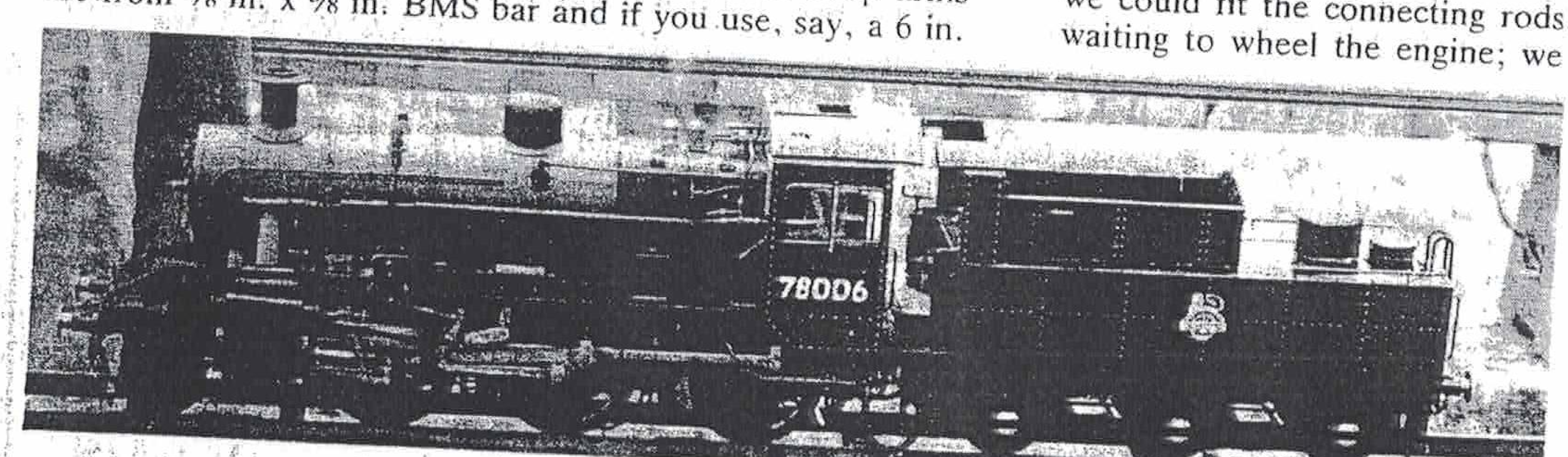
The crosshead pin is simple turning from $^9/_{32}$ in. silver steel rod, though I see from Reeves latest catalogue that what was readily available in 1972 is not so in 1990! The alternative is to turn from $^5/_{16}$ in. rod and if you resort to mild steel, then caseharden for the extra service life that this will provide.

Taking the 'bumps'

Ease the fit of the crossheads over their respective piston rods to a light drive fit, bring up the slide bars and position them so that the crossheads are a nice sliding fit, then deal with the motion plates to complete that part of the assembly. Pack the driving axle up to its normal working height, erect the connecting rods, then turn towards front dead centre at one side, only I very much doubt if you will achieve this position, as the extra length of piston rod provided as insurance should ensure that the piston 'bumps' against the front cylinder cover before you reach dead centre. Push the piston rod further onto the crosshead to achieve this, and this may also involve shortening said piston rod, then scribe a line where the rod enters the crosshead. Now turn to back dead centre, remove the front cylinder cover and tap the piston until it strikes the back cover, again shortening the piston rod if this is indicated; scribe on a second line at the point of entry of the rod into the crosshead. Now draw a third line equidistant between the first two and enter the piston rod by this amount into the crosshead; now drill through crosshead boss and piston rod at an angle of about 45 deg. for a taper pin, but don't drive said taper pin right home as yet.

Return Crank

In taking the 'bumps' I made the, wrong!, assumption that we could fit the connecting rods, but of course we are still waiting to wheel the engine; we can move towards this by



The fine rivet detail is particularly noticeable on No. 78006 built by Gordon Ross.

dealing with the return cranks, which are from ¾ in. x ¼ in. BMS flat. As for the drop arms, if we use a fairly long length of bar we can machine one at each end of same, so mark out, drill and ream a 3/16 in. hole which we will later tap 7/32 x 40T and radius over a mandrel with an end mill. Before we radius the end though, we have to move on 1.265 in. by cross slide micrometer collar to drill a ¼ in. hole as a start to forming the square. Next cross drill No. 34 and for the ⅛ in. taper pin, then bolt the embryo return cranks to the length of angle that we used when dealing with the side rods, to arrive at the 5/32 in. thick relieved portion as shown. It is just possible to radius around the ¼ in. hole to form that bit more of the profile, but it is a tricky business and just as easy to complete said profile with saw and files. Slit down to the ¼ in. hole with a hacksaw and I know of no other way bar filing to complete that ¼ in. square, so take it a little at a time and use a wee wedge in the slit, just to open it out a fraction when you try the return crank over the end of the crankpin.

Crankpin Setting Jig

Start the jig by gripping a short length of ¾ in. square BMS bar in the machine vice and drilling through at ½ in. diameter at a full ½ in. from one end. Move on .563 in. by cross slide micrometer collar, to drill a second hole at No. 13, into which you press a 2 in. length of 3/16 in. silver steel rod. The main locating pin starts from ¾ in. diameter steel bar, so chuck in the 3 jaw and turn down over a 1½ in. length to 11/16 in. diameter, a good fit in the driving wheels. Further reduce to ½ in. diameter over a ¾ in. length to be a press fit in the jig, part off at 1⅜ in. overall and press home. Assembly a return crank to its crankpin, securing firmly in place with both through bolt and taper pin, slip the jig into the wheel centre and then orientate the return crank as per drawing before pressing the crankpin home, aligning the 3/16 in. pin in the jig with the reamed hole in the return crank; now you can tap the latter at 7/32 x 40T.

Valve Crosshead, Guide and Spacer

The whole assembly is rather tricky, but at least with the valve crosshead we start off with a straightforward item. First arrive at the correct section of 9/16 in. x 11/32 in., then mark off and cross drill No. 13 for the vale gear pin. Square off the outer end to suit said hole, then deal with the 3/16 in. slot with an end mill. Now saw and square off to length and if you do this in the machine vice you will be able to go straight on at that setting to drill and ream the 3/16 in. hole for the valve spindle.

For the guide pillars, or spacers, chuck a length of 5/32 in. steel rod in the 3 jaw, the steel wants to be of good quality though it need not necessarily by the silver variety, to face and turn down to .086 in. diameter over a 7/32 in. length, screwing 8BA. Expose the next ¼ in. of material from the chuck and use a round nose tool to produce the fancy shape before pulling out more rod and parting off at 23/32 in. overall. It is likely you will have difficulty gripping the embryo pillars in the 3 jaw, so chuck an odd end of ⅜ in. rod, face, centre and drill No. 50 to about ⅜ in. depth. Follow up at No. 43 to ⅛ in. depth and tap the remains of the No. 50 hole at 8BA; fit a pillar. Turn the outer end down to .086 in. diameter to leave a ¼ in. long central portion, locking the carriage so that you can repeat the dimension for the remaining 7 pillars, then screw 8BA to complete.

The guides are 1¼ in. finished lengths from ⅜ in. x ⅛ in. chrome vanadium steel flat, many catalogues refer to this material as gauge plate. Mark off one guide, clamp them together and drill right through No. 44 in the two positions. Now we have to mill the land to suit the valve crosshead, so deal with each guide in turn, concentrating on the lower ones first and trying to place, remembering that you can always use shims in emergency to correct any small error, but trying to avoid this. Once you are satisfied, clamp the guides to the rear steamchest cover to drill through and tap, securing with the pillars, then carry on and complete the top guides, final proof of your success being that the valve crosshead slides smoothly when connected to its spindle; now you can drill through and secure with a taper pin.

Combination Lever

Our first item of valve gear also involves the most machining, but this is a good place to make a start, for things get easier later! It is also the most heavily loaded part of the valve gear, hence the specification of good quality steel, which I would now amplify as chrome vanadium as available from Whistons and we need two 4¼ in. lengths of ⅝ in. square section. There is one decision to be made before we start and I should have mentioned it at the time we tackled the drop arms. All those years ago I specified that the most heavily loaded parts of the valve gear be bronze bushed, which means the valve gear is easily refurbished when wear occurs, though the larger holes necessary to accommodate the bushes does somewhat weaken an item such as the combination lever and some builders may well prefer to leave these three holes at 3/16 in. diameter, hardening the levers to reduce wear. Whatever your decision, grip the bar in the machine vice and using the cross slide micrometer collar, accurately position the holes to your chosen size. Transfer the mebryo combination levers to the angle you just used to hold the return cranks, to start milling away the section a bit at a time to expose the finished shape, though such as the bottom oil boss you will have to complete with files. Radius the bottom end over a mandrel with an end mill, then mark out the rest of the profile, and I reckon this will be best arrived at with saw and files, though of course you can deal with the lower portion as a miniature connecting rod, fluting with a Woodruff key cutter as very much an 'optional extra'. Although the purpose of the protrusions at the top of the lever full size were for oil boxes, in miniature to repeat the feature would seriously weaken the lever, thus they have been omitted, so all you have to do is drill the lower boss and I suggest this be around No. 57, carrying on through the bush if fitted; in this I am ignoring my drawing instruction about hexagon headed brass plugs!

Union Link

After the piles of swarf produced in arriving at the combination levers, it would be nice to get the union links out of ⅜ in. square BMS bar, though the more cautious of us will be using 7/16 in. square. Start by marking off for the valve gear pins, and if you employ the machine vice then you can arrive at 1.000 in. centres by the cross slide micrometer collar, ending up with a pair of accurately positioned 3/16 in. reamed holes. Cross drill 3/16 in. diameter to start forming the fork ends, then saw and file to the drop arm and combination lever as your gauge. It is hardly worth setting up to 'waist' the centre of the link, plus in any case you will have to complete the section with files, that is unless you are reducing from the original 7/16 in. thickness. Now radius the ends over a mandrel with an end mill, then reduce the central portion to ¼ in. width to complete.

Valve Gear Pins and Collars

Although we shall require several lengths of valve gear pins, ones which we shall have to arrive at by checking to place, at least their construction is identical. Start by chucking a length of 3/16 in. silver steel rod in the 3 jaw; face and lightly chamfer the end. Measure the length of pin, remembering to include 5/64 in. for the head, and part off at this length. For the head, chuck a length of ⅜ in. steel rod, face and turn down to 11/32 in. diameter over a ½ in. length, then centre and drill No. 13 to the same ½ in. depth, parting off 5/64 in. slices. Press these onto the pins, silver solder for additional security, then chuck by the shank in the 3 jaw and clean up the head, removing all excess spelter.

Rechuck the 3/8 in. rod again for the collars, turning down to 11/32 in. diameter and after chamfering as shown, part off a 5/32 in. slice and repeat until you have all nine collars. Whilst I had used spring dowel pins in industry, back in 1973 I was unsure of their acceptance by model engineers, now I know better!, so I suggest you ignore my alternative specification of a taper pin.

Now you can erect both combination lever and union link, using a plain length of the 3/16 in. silver steel rod to attach to the valve crosshead.

Expansion link

Although some of the pieces that make up the complete expansion link assembly are a little tricky, I doubt if I will ever describe simpler links themselves. If some kind soul will burn you out a ring from 5/16 in. steel plate then half the job is done, otherwise you will have to use a bit of elbow grease! Grip the ring by its periphery, and you may have to 'dog' it to the faceplate if the 4 jaw chuck won't cope, to first bore out to 6 15/16 in. diameter, then face across the outside. Now grip by the bore in the 3 or 4 jaw, face off to 7/32 in. thickness, then turn down the periphery to 7 13/16 in. diameter. The slot is 9/32 in. wide and 1/8 in. deep, so first rough it out, then carefully turn to the finished dimensions. Saw into individual pieces and if my calculations are correct then you will have enough surplus for a second engine!, then square off in pairs. Clamp each pair back to back to mark off and drill the specified holes, and you may wish to shoulder the fulcrum pin, in which case drill and ream to 3/16 in. diameter. Turn up said fulcrum pins from ¼ in. silver steel rod, the extra length on the outer links is for the lubricator drive, press home and silver solder, removing all excess spelter.

For the link top spacers, grip a length of 7/16 in. square bar in the machine vice and mill steps in each of the corners to reveal the 9/32 in. spigot as shown, chucking in the 4 jaw to part off two 5/32 in. slices; set aside.

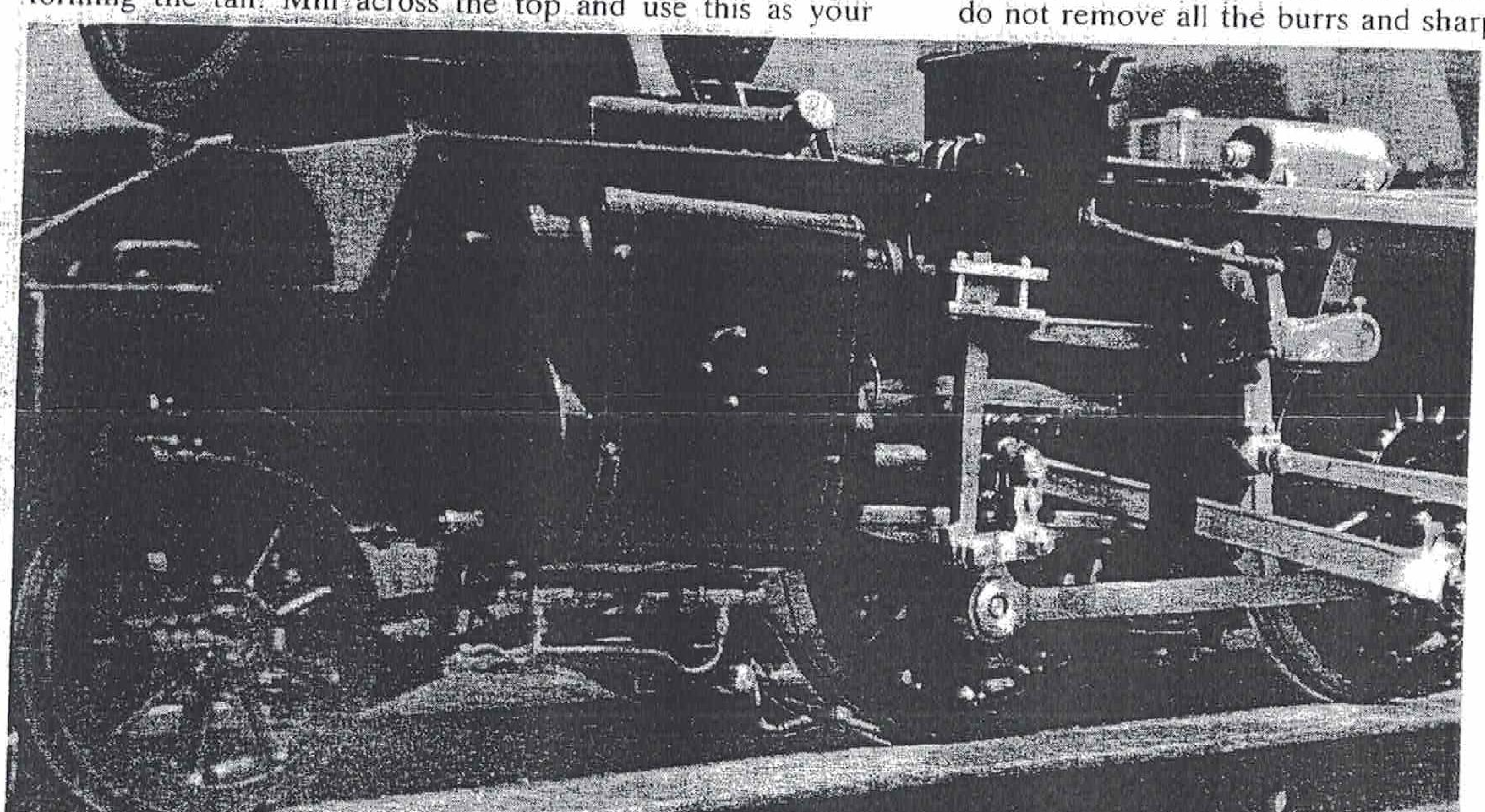
For the expansion link foot we need a length of 1 in. x ½ in. BMS bar, first reducing the thickness to 7/16 in. Next treat the bar exactly the same as for the top spacer to reveal the 9/32 in. spigots, leaving a 3/16 in. thick central portion, only this time you will have to mill more metal away to start forming the tail. Mill across the top and use this as your datum for marking out the ¼ in. hole, drilling through, then complete the top part of the profile before sawing the foot from the parent bar. Complete the profile with saw and files as you will have to be very clever to radius over a mandrel with an end mill, then drill and tap the oil supply, pressing in a bronze bush.

There is only one way to make sure that the complete expansion link is properly aligned and that is to build it up in situ, so erect the links to there respective trunnions, bring up the top spacer and foot, clamping in place and checking that the link swings sweetly before drilling through at No. 44; secure with 8BA bolts.

Radius Rod

After all that has gone before, the radius rod is relatively simple, though to mill it from the solid will produce a bucketful of swarf, and some builders may prefer to fabricate from mild steel. I much prefer the chrome vanadium steel for the lovely finish one can obtain, plus the extra strength is helpful running in when the piston valves are necessarily very tight, so the section we require is ¾ in. x ½ in., length around 5¾ in. As ever, start by marking out and drilling the holes, again you can utilise the cross slide micrometer collar, only this time you can also drill a row of ¼ in. holes to start forming the 9/32 in. slot for the lifting arm die block. At this setting you can also mill said slot, though you will have to file the ends to the die block as your gauge, relieving the very ends as shown. We must now mill the section and at least the outer face is mostly from the raw bar, so concentrate on getting the rear portion of the rod down to 3/16 in. thickness. Next mill away 3/32 in. of material in way of the fork at the front end, blending back to look pleasing; turn the bar over and mill the fork end to 3/8 in. overall. Cross drill 3/16 in. diameter and mill or saw and file the slot to suit the combination lever, then remove most of the surplus material remaining before completing the section by milling. We now have to profile the rod, so mark it out carefully and first mill away to reveal said profile at the 9/32 in. slot. Forward of this, saw away as much surplus metal as you are able, radius the front end over a mandrel with an end mill, which leaves the slightly tapered portion ahead of the expansion link die block pin. If you wish to flute the rod, then treat it as a miniature version of the connecting rod, otherwise simply file to complete.

I should have mentioned much earlier that when milling valve gear components such as I have been describing, if you do not remove all the burrs and sharp edges as you proceed



Probably the best detail shot I shall ever publish of the rods and motion on the Class 2 'Moguls' is of the late Fred Palmers's No. 78019 as it appears in our Catalogue. However, Gordon Ross runs Fred a close second with this shot of his No. 78006; again it could well be mistaken for full size.

then you will soon have need of your first aid kit, so please pay more attention to this than I have! Press in a plain length of 5⁄32 in. silver steel rod as the die block pin and braze it if you are in any doubt, or Murphy's Law says it is bound to cause you maximum embarrassment in the future!

Die Blocks

I have a nasty habit of omitting to detail die blocks and No. 78000 is yet another example of such omission, though in reality they are all 'make to place'.

It is a pity that 5⁄16 in. square phosphor bronze rod is not no longer generally available, for this would be ideal for our purpose, so instead we must start from 7⁄16 in. rod. Chuck in the 3 jaw, face, centre, drill No. 23 to about 1 in. depth and ream 5⁄32 in. diameter. Remove to the machine vice and if you remove the top jaw from the Myford one then you can grip the round bar firmly. Mill one flat so that it measures .375 in. over the bar by micrometer, then deal with the opposite flat to arrive at .3125 in. over flats; deal with the other two faces similarly to arrive at a square. Back to the 3 jaw to part off four 1⁄8 in. slices and now it is a case of filing to suit the expansion links, keeping the hole nice and central.

Chuck the phosphor bronze rod again, this time it is already faced, so centre, drill No. 23 to about 3⁄4 in. depth and ream 5⁄32 in. diameter. Back to the machine vice, only this time mill the first flat so that the dimension reduces to .365 in. over the bar, then deal with the opposite face to arrive at .292 in. over flats, leaving .010 in. of metal to be removed by filing as you fit the block to the radius rod. Before doing so, however, we must complete the machining, dealing first with the other two flats just to clean them up, and a final dimension around 3⁄8 in. will be the ideal, then back to the 3 jaw to part off two 3⁄16 in. slices.

Weighshaft, Collar and Lifting Arm

The weighshaft itself is a plain 8⅜ in. length from 3⁄8 in. bright steel rod with the ends just lightly chamfered and the collar is plain machining from 5⁄8 in. steel bar, which brings us to the reverser arm. Take a length of 1⁄2 in. x 3⁄16 in. BMS flat and scribe on the centre line, gripping in the machine vice. At a full 3⁄16 in. from one end, centre, drill and ream through at 3⁄16 in. diameter, then move on 1⅜ in. by cross slide micrometer collar and drill through at 3⁄8 in. diameter. Produce the 3⁄16 in. radius over a mandrel with an end mill then saw the arm from the parent bar, grip with a 'Mole' wrench and radius the second end, then complete the profile with files. Locate the arm on the weighshaft, just pinching the hole slightly if necessary to hold the arm firmly in place for brazing, then clean up and oil.

Lifting arms I have made several different ways over the years, but for the shape we require this time I reckon that you cannot beat fabricating them, so let us make the jig first. Grip a length of, say, 3⁄4 in. square steel bar in the machine vice to drill and ream a 3⁄8 in. hole. Move on 1⅝ in. by cross slide micrometer collar and this time drill through at No. 23. The first pin is from 5⁄32 in. silver steel rod, it wants to be about 1⅜ in. long, and must be relieved where it projects from the jig to suit the No. 23 hole we shall be drilling in the lifting arm component. The second pin is a plain 1⅜ in. length from either bright or silver steel rod, after which all the jig parts must be liberally coated with marking out blue to prevent the spelter adhering to said jig.

We now require the end bosses, so first chuck a length of 1⁄2 in. BMS rod in the 3 jaw, face, centre, drill and ream 3⁄8 in. diameter to about 1⅛ in. depth, parting off two 7⁄16 in. slices. For the other bosses, chuck a length of 3⁄8 in. bright steel rod, face, centre and drill No. 23 to 1⅛ in. depth, again parting off two 7⁄16 in. slices; assemble to the jig. Now it is a question of fashioning the side arms to suit the end bosses, packing them apart and then clamping to the jig before brazing up. Clean and oil, then saw through at the end of the arm and mill to suit the radius rod.

Erect expansion links and radius rods, coupling the latter to the top of the combination lever. Slide in the weighshaft and set the reverser arm vertical, then you won't have to worry about the 81 deg. angle. Bring up a lifting arm and erect with the die block using a temporary pin, a plain length of 5⁄32 in. rod eased to a sliding fit in the No. 23 holes. Now you simply rock the expansion link and position the radius rod so that it transmits no motion to the combination lever/valve and a d.t.i. on the front end of the valve spindle will be the best check. Once satisfied, drill through lifting arm and weighshaft for an 1⁄8 in. taper pin and deal with the second side similarly.

THE REVERSER

The temptation now is to complete and set the valve gear, but to do so is courting disaster and it is much better to be able to precisely set the gear by use of the reverser rather than clamping the reverser arm on the weighshaft.

A first look at the reverser assembly indicates that it should have been 'Crewe style' with the fulcrum in the centre of the arm roughly where the reach rod attaches and the reach rod attached below said fulcrum, though strangely no builder has ever made reference to this. It was done originally to avoid purchase of a LH tap, which means I was watching the pennies back in 1972! The other point to be made is that the reverser gives slightly too much travel which means the die blocks can bind in the expansion links, but I will cover this during construction, so nothing to worry about here.

Reverser Stand and Spacer

Mark off the base of the stand on a piece of 1⁄8 in. or 3mm steel plate, drill the specified holes, then saw and file to drawing. The stand backplate is specified as a 3⅝ in. length from 7⁄8 in. x 3⁄32 in. steel strip and of course the thickness can be increased to 1⁄8 in. to use standard section flat. For the bearing blocks, we need a length of 3⁄4 in. square brass bar, so first mark on the centre of the hole, then chuck in the 4 jaw with this centre running true. Face, centre and drill 1⁄4 in. diameter to 3⁄8 in. depth, parting off a 1⁄4 in. slice, then face again, centre and this time drill and ream 5⁄32 in. diameter before parting off another 1⁄4 in. slice. Clamp the pieces together, drill the backplate to suit its bearing and then braze up.

The stand spacer is from 7⁄8 in. square steel bar, so saw and square off to length, then offer up to the stand to drill through and mark off for the surplus metal to be removed to clear the trailing coupled wheel; saw or mill this away. Clamp to the LH frame in the position shown, to drill through No. 30 for 5BA bolts, then drill the fulcrum hole into the spacer and tap 7⁄32 x 40T to about 3⁄8 in. total depth.

Reverser Screw and Nut

The reverser screw is plain turning from 1⁄4 in. bright steel rod, so chuck in the 3 jaw, face and turn down to 5⁄32 in. diameter over a 1⁄4 in. length, a nice fit in the stand. Screw the next 2 in. length to your choice of thread and in 1972 Gordon Chiverton was very adept at producing square threads from building the Allchin ROYAL CHESTER as immortalised by the late and great Bill Hughes, thus a 6 tpi screw adorns my K1/1! Part off at 3 3⁄16 in. overall and reverse in the chuck to reduce the end 1⁄8 in. to .086 in. diameter and screw 8BA. Turn the next 1⁄4 in. down to 5⁄32 in. diameter for the reverser handwheel and this latter may be located with a square if you prefer.

For the nut, chuck a length of 7⁄16 in. square bronze bar truly in the 4 jaw and turn down to a full 1⁄4 in. diameter over an 1⁄8 in. length; this we will fashion into the indicator lug later on. Now cross drill No. 23 and press in a 23⁄32 in. length of 5⁄32 in. silver steel rod, silver soldering it for additional security; part the 7/16 in. square bar off at 5/8 in. overall. Rechuck again to drill through at 7/32 in. diameter and tap out to suit the reverser screw and I recommend you do not reduce the length of the nut to 3/8 in., at least not until you have checked the movement of the radius rod.

Reverser Arm, Stirrup and Fulcrum

The fulcrum is plain turning from 5/16 in. A/F hexagon steel bar, so on to the arm which is from 3/8 in. x 3/16 in. BMS flat. Mark off and drill all the specified holes, opening the top one out into a slot, then press in the 5/32 in. silver steel pin and braze. I have shown that the arm has a slight taper along its full length, but this is very much optional after you have radiussed the bottom end over a mandrel with an end mill. Erect arm and fulcrum to check its operation and we can move on to the stirrup.

Bend this up from 5/16 in. x 3/32 in. strip, checking over the reverser nut, then deal with the slot before offering up to the arm and drilling through at No. 41 for a 7BA bolt; again check its operation.

Reverser Handwheel, Collar and Spacer

The handwheel is fancy turning from 13/8 in. diameter bar, and it certainly need not be stainless steel, so chuck in the 3 jaw, face, centre and drill No. 23 to about 3/8 in. depth. With a round nose tool, turn down to 3/8 in. diameter over a 3/16 in. length, then start forming the back of the disc before parting off at a full 13/32 in. overall. Rechuck by the 3/8 in. spigot and complete turning the handwheel, then drill No. 53 through the rim for the handle. For the latter, chuck a length of 5/32 in. stainless steel rod, face and turn down to 1/16 in. diameter over a 3/16 in. length. Part off at 11/16 in. overall, reverse in the chuck and radius the end, then press into the wheel and peen over. Press the whole wheel in turn onto the end of the reverser screw and secure with an 8BA nut.

The collar and spacer are plain turning from 3/8 in. rod, and if you make the collar 1/4 in. thick initially, this will give you extra adjustment if the die blocks still bind in the expansion links; complete assembling the reverser.

Indicator Plate

The indicator plate is from 1.6mm brass strip, so square it off to length to suit the stand, drill the four No. 44 holes and then deal with the slot. Offer up to the stand, check that the nut does not bind in the slot, then spot through, drill the stand No. 50 and tap 8BA for round head screws.

Reach Rod and Stirrup

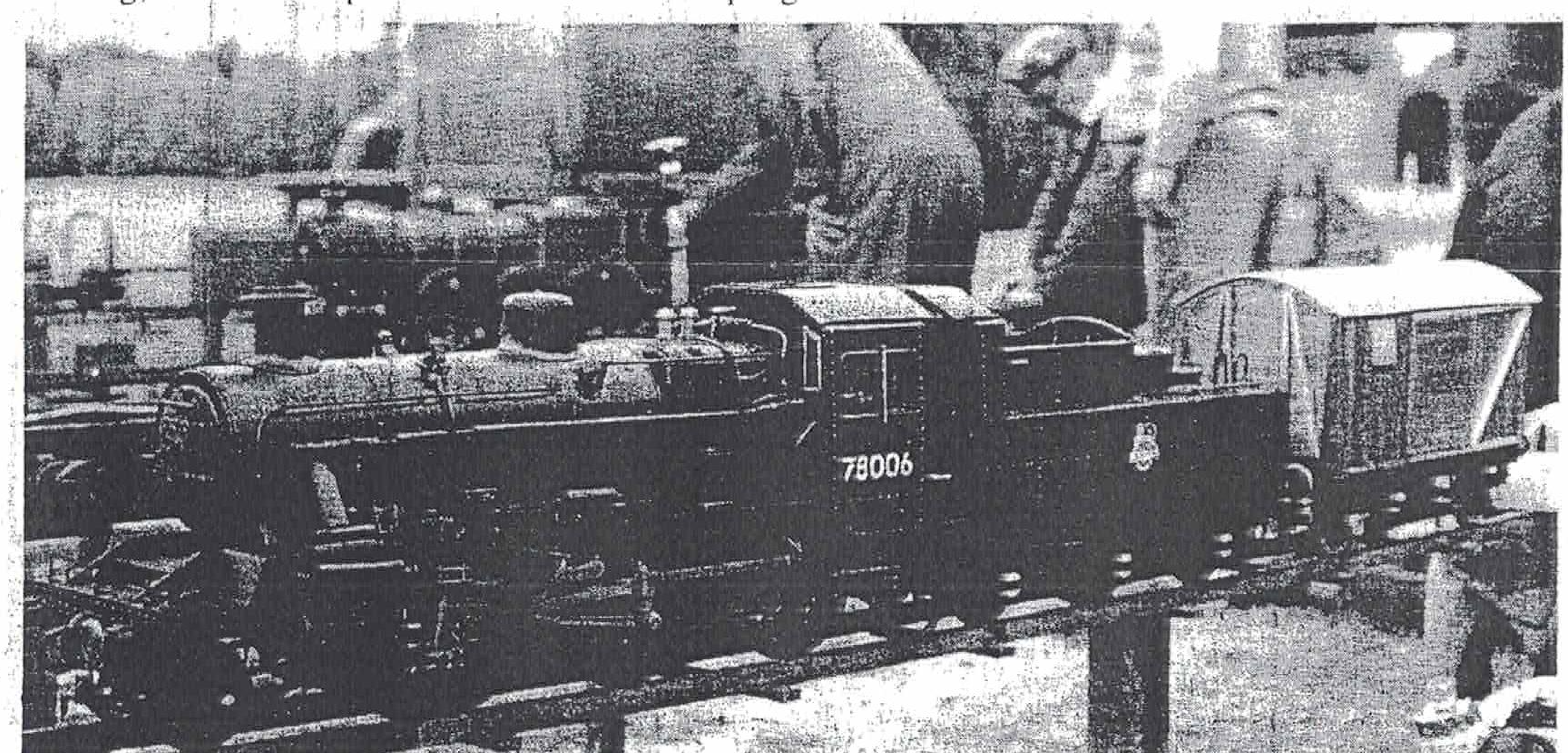
Set the reverser in full fore gear hard against the front bearing, rock the expansion links to come up against the motion plate and lower the radius rod until the expansion link die blocks bottom, then measure off for the length of each rod. This of course will be a straight measurement, so lay on a strip of stiff card, then draw on the reach rod using the other dimensions given on the detail, cutting out and checking to place before transferring to metal. Bend the main portion of the rod up from 3/8 in. x 3/16 in. BMS flat and braze on a 7/8 in. length of 3/8 in. square steel bar for the fork end at the front, dealing with this exactly the same as for the radius rod, then drill and ream 5/32 in. diameter at the reverser end before sawing away the surplus metal and radiussing this end.

Although I have shown the reach rod stirrup bent up from 5/16 in. x 1/8 in. steel strip, it will be easier to machine it from 5/16 in. square bar. Start with a 3 in. length and mark off at one end, drilling as specified, then radius around the 5/32 in. reamed hole. Transfer to the machine vice to mill away 3/16 in. of metal, then turn the bar over to deal with the bolt seating, sawing off to length and finishing square. Erect to the reverser, clamp to the reach rod and drill through the No. 41 holes for 7BA bolts. Now we can set the engine very precisely and the first thing is to find mid gear, exactly as when positioning the lifting arms, only this time we have to mark said position on the indicator plate.

Eccentric Rod, Return Crankpin and Spacer

Full size that large housing at the return crank end of the eccentric rod contains a double row self-aligning ball bearing, but of course we cannot reproduce such a bearing exactly in miniature. Some 26 years ago now I came across 'Heim Unibals' in industry and made very good use of them, thus when I came to my K1/1, I already knew these to be ideal for my purpose, plus I could order them at the same time as my industrial needs. Although produced in a variety of metals, the Type RBJ201 consists of a hardened steel ball operating in a hardened steel housing. Over the years have come tales from builders of horrendous prices for same, yet others have picked them up from stockists very reasonably, and indeed there was hope that Reeves would stock them at one time. In a recent publication I have noted very similar items from another source and I am currently investigating this, so as and when there is news, I will pass it on. Meanwhile, if any builder/reader can throw light on these elusive bearings at their proper price, this would be very helpful.

I have dealt with the bearing at the outset as the next item to be machined is the return crankpin, so chuck a length of 3/8 in. steel rod in the 3 jaw. Face and turn down to 7/32 in. diameter over a 1/4 in. length, screwing 40T, then move on and turn the next 9/32 in. down to 1/4 in. diameter, a good fit



The Class 2's were genuine mixed traffic engines, thus No. 78006 looks very much at home coupled to the fitted van.

in the ball portion of the bearing. Part off to leave a full 1/16 in. head, reverse and face it off, then file or mill on the two flats to suit a spanner; the spacer is plain turning from the same rod.

Before making up the proper eccentric rod, we need a temporary one so that we can check its length accurately. Take two 4 in. lengths of 3/8 in. x 1/8 in. BMS flat and at 3/8 in. from the end of one piece, drill and ream a 1/4 in. hole. At about 1 in. spacing towards the other end of this piece, drill a couple of No. 34 holes. At 1/4 in. from an end of the second piece, drill and ream a 3/16 in. hole. Clamp the two pieces together to give an overall length between hole centres of 4 15/16 in. as specified for the pukka eccentric rod and drill through the No. 34 holes. We now have to make provision for adjustment around the 4 15/16 in. dimension, so open the No. 34 holes out in one piece into slots, assembling the pair with 6BA bolts. Resist the temptation to make up a dummy eccentric rod for each side of the engine as I did on my K1/1, for I have yet to complete the proper ones 20 years on and many miles of running later!

Setting the Valves

At the same time as accurately arriving at the centre distance for the eccentric rods, we can set the piston valves, so first set the engine in mid gear, remove both front cylinder and steamchest covers and rig up d.t.i.'s on both the exposed piston and valve spindle. The only other item of valve setting equipment we require is a length of rubber tube to fix over the end of the drain cocks, and in saying this I realise that I have dropped a real 'clanger'! For taking the front cylinder cover off destroys completely when I am trying to do, so instead locate the second d.t.i. against the crosshead and replace that cover!

Turn the engine towards front dead centre on the side you have set up, blowing into the front cylinder drain cock. As the piston valve starts to uncover the front ports, so you will be able to begin to blow air past them and your 'blow reading' will in fact be accurate to .0001 in. Take a note of the d.t.i. reading on the valve spindle, then turn to front dead centre and you will have a reading of port opening which is 'lead'. Now go to back dead centre, repeating the procedure exactly on the rear cylinder drain cock and obtaining a second reading, which of course will be somewhat different from the first. Add the two readings together and divide in halves and you will arrive at a figure of around .030 in. which is the correct amount of 'lead' required; centralise the valve on its spindle to obtain this.

Now turn the engine to front dead centre again and this time reverse the engine from full forward to full back gear, adjusting the length of the dummy eccentric rod until reversing imparts no movement to the valve. If everything you have made is spot on, then turning the engine to back dead centre should produce exactly the same result without the need to vary the dummy eccentric length. Such though is Utopia and very rarely achieved either in miniature or full size, some slight adjustment being necessary to even out the discrepancy. Try to keep any errors to a minimum in fore gear at the expense of back gear. You should now be able to read off the full fore gear valve travel at .53 in., not perhaps what many builders have previously been used to, but it is equivalent to the 6 in. valve travel full size that E. S. Cox and I reckon is the ideal, and my K1/1 has been proving the same in miniature for quite a number of year now — when I get the opportunity to steam her!

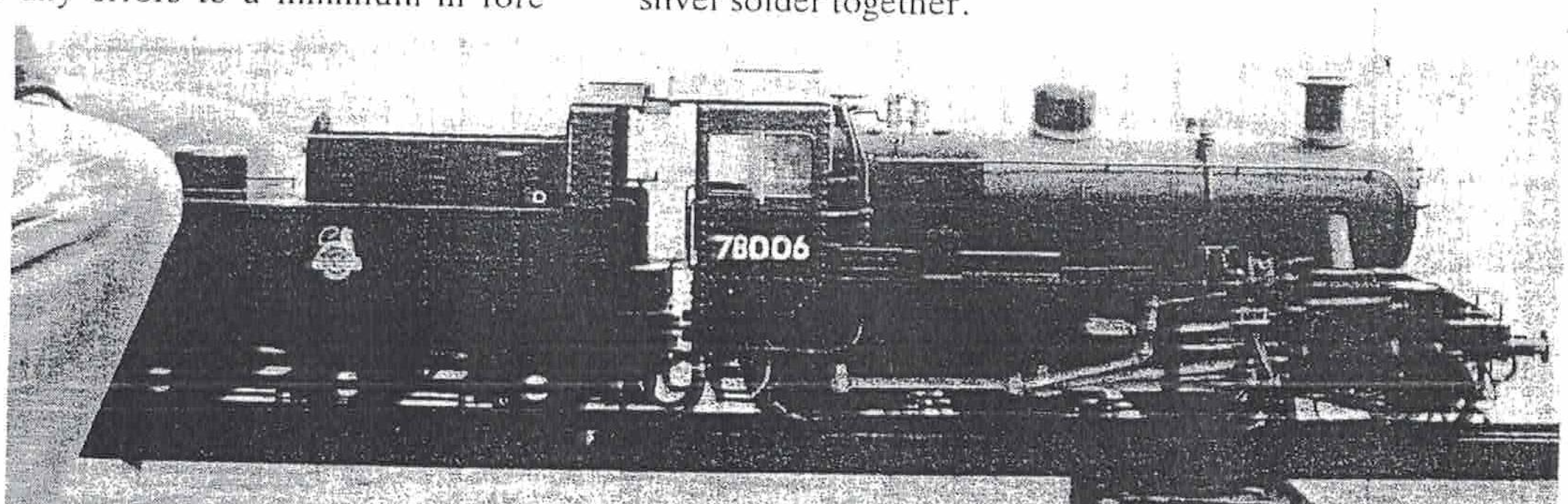
The proper eccentric rods are made from 1 in. x 1/2 in. section material, which almost certainly means using BMS bar. Clamp the dummy rod in place to drill and ream through the end holes, then grip in the machine vice with a stub of 3/8 in. silver steel in the larger hole and with a d.t.i. held in the chuck, set the rod to be perfectly true. Use a countersink to open out the end of the hole so that a 7/16 in. 'D' bit will just enter and run this right through, then if you have a Dore boring head, use this to open out to 3/16 in. depth to accept the outer cage of the 'Unibal'. Now it is simply a question of removing metal to arrive at the complete eccentric rod and as nothing new is required from description of earlier components, I can safely leave this to builders — have fun!

CYLINDER LUBRICATION

The major part of this session over, now for some light relief! Sheet No. 6 was drawn when probably my confidence in the LBSC pattern of oscillating cylinder mechanical lubricator was at its highest, for my RAIL MOTOR No. 1 was performing frequently both 'home and away', smothering me with oil in the process!, and I had yet to discover the superiority of the hydrostatic system as LANKY was still but a pipe dream. I remember particularly an evening run at Illshaw Heath and creeping back to the hotel in Hagley Road with white shirt looking as though it had been frightened by a dalmatian! Anyhow, I was so confident in the LBSC lubricator that I did not even bother to detail its internals!!, so can I ask builders of No. 78000 to look back to LLAS No. 29 for the description of the lubricator on the DERBY 2P, knowing this will bring a howl of criticism. At least RAIL MOTOR No. 1 taught me the value of having a separate lubricator for each, outside cylinder, and my K1/1 was so converted in 1973, though today she is awaiting further conversion to hydrostatic, that is when I have a spare lubricator kit on shelf!

I show the lubricator body/tanks folded up from 20 swg brass strip, completed with a 1/16 in. base, a wee length of 1/4 in. brass angle being tacked on for the fixed pawl of the ratchet system that had by 1972 become one of my 'standards'. With so much running experience at that time, I see I even included a priming handle to further ensure I would be liberally covered in oil!

The 'Silvertown' lubricator is distinguished by a very heavy lid, which I have reproduced from 1/4 in. thick brass, though today I would suggest it be fabricated from two pieces each 3mm thick, one a close fit in the tank and the other to the external dimensions shown. Finish the top piece to drawing, attach to the other piece with a couple of 8BA screws and silver solder together.



Gordon's knee is perfect illustration of the diminuative size of a 5 in. gauge No. 78000.

perfectly on the flange, such was equally true full size, so mark around the shell roughly ⅜ in. from each row of No. 34 holes and saw out the centre, which will immediately make the shell that much more flexible, when it will bolt down to remove any gap.

From what we have achieved thus far, we have established the bottom centre line on the smokebox shell, so by measuring around we can accurately arrive at the top centre line, scribing it on to position the chimney. Scribe a circle at 1⁵⁄₁₆ in. diameter, drill a series of No. 30 holes around the inside of this circle, open out so that the holes begin to break into one another, remove the surplus centre and file to line.

Boiler Joint Ring

Machining the joint ring from a gunmetal casting is totally impractical, so in 1972 my instruction would have been to roll up the ring from ¼ in. x ⅛ in. section brass and then braze the joint. However, even this is a fiddly job, getting the right fit, so in 1990 I can describe something far simpler. Cut two rings from cardboard, one to fit into the bore of the smokebox shell and the other to fit the rear end, holding in place with Sellotape to give a ¼ in. wide channel. Mix the two parts of Isopon P38 and fill the space between the two templates, allowing to cure. Do this before cutting the holes for chimney and saddle, then chuck by the bore in the 3 jaw and simply turn to a fit over the end of the boiler barrel; a nice tight one. Now deal with the two cut-outs as just described, offer the smokebox shell up to the end of the barrel, and if the fit is at all suspect, drill the shell No. 34 and countersink in about eight equal positions, then continue into the end of the barrel at No. 43 and tap 6BA for brass screws, and of course get those centrelines to coincide.

Smokebox Door and Front Ring

Several builders have asked if I could supply a suitable gunmetal casting from which to machine the front ring and on each occasion I have been able to oblige. The channel section is very much optional, so grip by the periphery, face across and bore out to 3⅝ in. diameter. Rechuck by the bore, face off to thickness then turn down to a tight fit In the smokebox shell, completing with those blending radii.

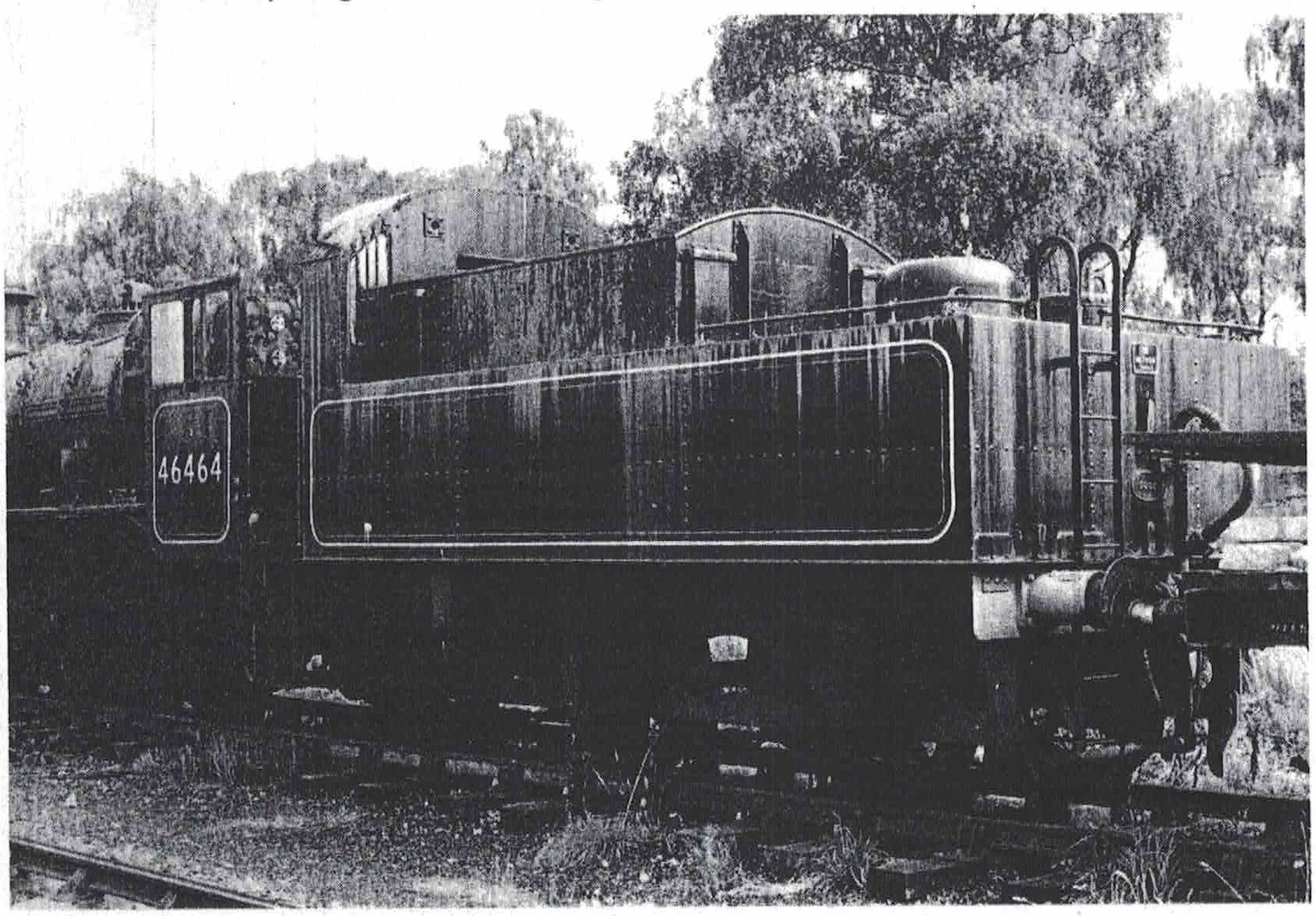
The smokebox door is a 'standard' and with care the centre, raised, boss can be machined from the gunmetal casting to be integral. Whilst the hinges can be fabricated, builders will find it so much easier to start from ⅜ in. x ¼ in. BMS bar. Cross drill No. 50 at a full ⅛ in. from the end, file away as much of the surplus metal as you are able and then radius over a mandel with an end mill. Grip in the machine vice on the vertical slide and use a Woodruff key cutter to deal with the slot to accept the hinge block. Now it is a question of sawing and filing away metal to form the hinge, finally removing from the parent bar. Locate to the door, bending to place, and secure with three ¹⁄₁₆ in. copper rivets, silver soldering if you are unhappy with the end result.

Crossbar, Dart, Hinge Block and Pin

For the crossbar, start by squaring off two 1 in. lengths from ⅜ in. x ⅛ in. BMS flat. The end portions are 1¹³⁄₁₆ in. lengths from ⅜ in. x ³⁄₁₆ in. BMS flat, clamped to the first two pieces to give the specified ⅝ in. slot and then brazed together; complete the profile to drawing. The crossbar supports are bent up from ⁵⁄₁₆ in. x ³⁄₃₂ in. strip and attached to the back of the front ring with a single ³⁄₃₂ in. iron rivet, positioned as shown.

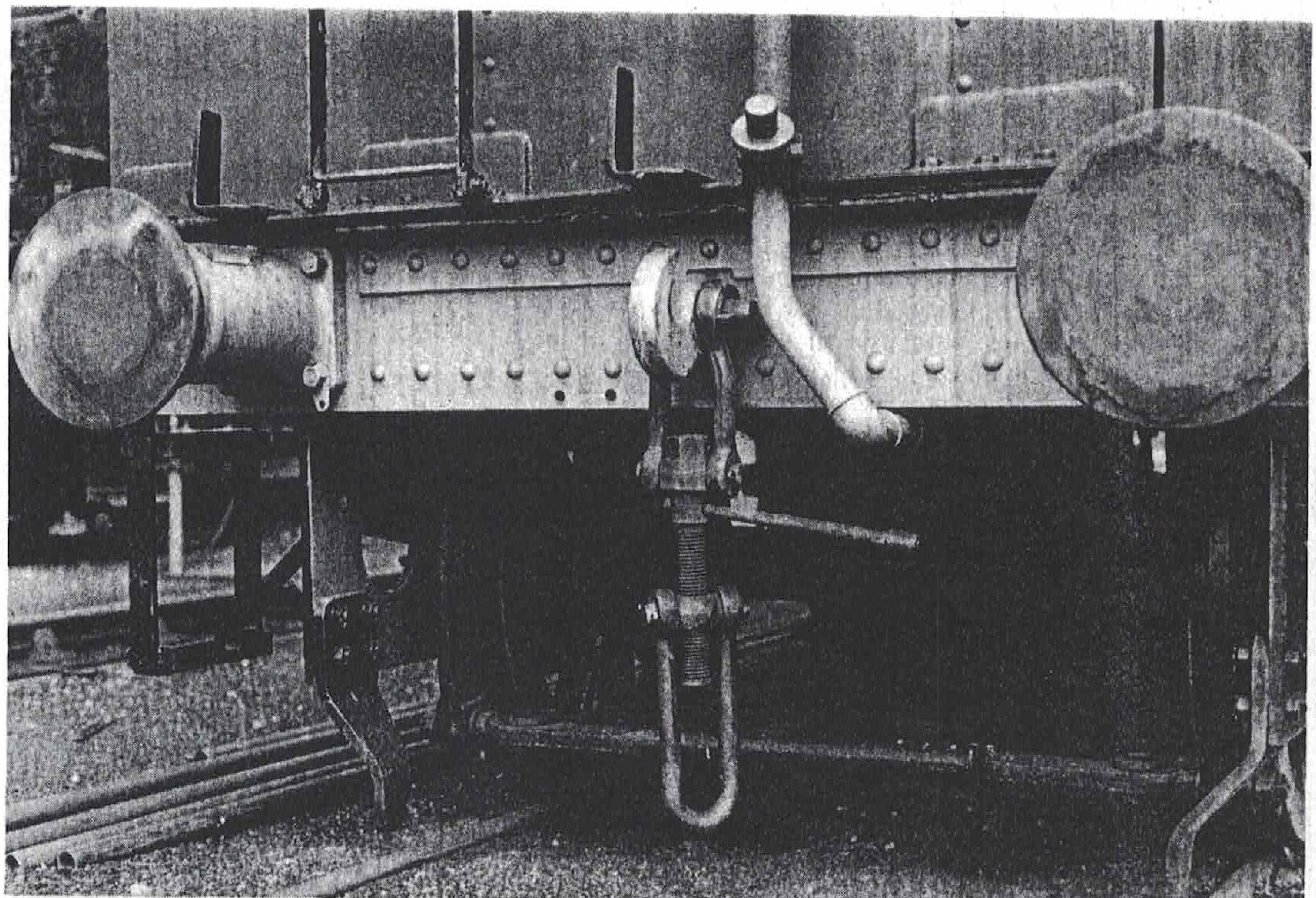
For the dart, chuck a length of ⁷⁄₁₆ in. steel rod in the 3 jaw, face and turn down to .110 in. diameter over an ¹¹⁄₃₂ in. length, screwing 6BA. Reduce the next bare 1¹³⁄₃₂ in. length down to ⁹⁄₆₄ in. diameter in about ½ in. increments, then part off to leave a full ⁵⁄₃₂ in. of the parent bar. Rechuck by the ⁹⁄₆₄ in., portion and turn on the ⁹⁄₃₂ in. end radius as shown, then complete the head with files to suit the crossbar. The ⁷⁄₆₄ in. square will have to await the handle, so erect dart and crossbar, bring up the door, slide a few 4BA washers over the end of the dart and secure with a 6BA nut, centralising the door on the front ring. Now you will be able to mark off and drill the two No. 41 holes for the hinge blocks, the next item on our list.

Chuck a length of ¼ in. square steel bar truly in the 4 jaw, face and turn down to ³⁄₃₂ in. diameter, checking the length of spigot required against the front ring before screwing 7BA. Now reduce the thickness of the block to fit between the hinge forks and enter the No. 41 hole, securing with a



All good things must come to an end, unfortunately!, and now it is time to thank all who have contributed photographically to the success of the No. 78000 series, prominent among them being Clifford Herbert. On this and the following pages, there are further details of the tender as fitted to the Ivatt LMS Class 2 No. 46464 as being useful to No. 78000 builders and I can also cover new information that has come in since some of the earlier pictures were published. In particular I thought the front buffer beam on No. 78019 as published on Pages 14 and 15 of LLAS No. 39 was odd and John Hurley confirms that my original thought that it was the result of accident damage was correct, even though my pubished caption mentions deliberate bending! Readers are invited to calculate the force required to produce such deformation, the miscreant being another one of my designs, the BLACK FIVE No. 45000!!

This photograph will be particularly useful for members of the RCA (Rivet Counters Association), of which I am very definitely not a member! It is also amazing how few photographs manage to capture the refinement of screw couplings, they usually conspire to remain hidden as on the opposite page, thus this photograph will be particularly useful to all small locomotive builders.



7BA nut before drilling through at No. 50. Back to the 4 jaw to part off, when you will have to complete the radius with a file.

For the hinge pin, chuck a length of 1/16 in. steel rod in the 3 jaw and relieve the end to drawing, then part off at 23/32 in. overall. Next chuck a length of 3/16 in. steel rod, face, centre and drill No. 53 to 1/4 in. depth, parting off a 3/32 in. slice which is pressed on to the end of the pin. Apply a drop of silver solder for extra security then rechuck by the spindle and clean up the head to drawing.

Smokebox Door Handles

These handles are extremely ornate, indicating they are from an era before 'accountancy engineering' took over! The central bosses are from 1/4 in. steel rod and require no description on my part. For the handles themselves, chuck a length of 3/16 in. steel rod and use a file to deal with the tapered length, ending in a spigot of about 1/16 in. diameter and length. Part off to leave a full 3/64 in. head, rechucking to polish it to drawing. Drill the centre boss to accept the spigot, press in and silver solder, then clean and oil. Either drill for the outer handle spigot at an angle, or bend the handle after silver soldering in place.

STEAM CIRCUIT

Having ensured our smokebox will be perfectly air-tight, we now have to get steam from the boiler into the cylinders and then exhaust it up the chimney to produce the vital draught for No. 78000 to perform.

I am often asked the question about my earlier designs as to whether in hindsight I would convert them to coaxial superheaters as per POM-POM as example. Whilst there is some merit in doing so for No. 78000 and as she has been running concurrently with POM-POM then builders can refer to my notes on the latter in LLAS No. 40, there is good reason why I had begun to get my superheaters somewhere near right by 1972 as I will explain. Around 1970, Gordon Chiverton embarked on a world 'cruise' with the RN and left his MAID OF KENT in my care. It was a year of intensive running for me, proving my valve gear modification and gaining valuable running experience. The most serious problem I encountered with the MAID OF KENT was keeping the superheater flues clear, for the headers got right in the way of the flue brush. This was the prime reason for my adopting just a pair of superheater flues and positioned as on No. 78000, for that way they could be kept clear, thus removing the major drawback of spearhead superheaters, thus the coaxial type was a design refinement rather than a fundamental change, brilliant though Alec Farmer's solution undoubtably was. Builders of No. 78000 can choose spearhead or coaxial as they wish; I will describe just the former as per drawing.

Superheater

The first item required is the superheater flange, from a length of gunmetal that will turn to 1 1/4 in. diameter over a 1/2 in. length. Face, centre, drill 5/16 in. diameter to 3/8 in. point depth and part off a 1/2 in. slice. Rechuck and clean up, then scribe on the bolting circle at 15/16 in. diameter, drilling four No. 30 holes and tapping the steam pipe flange 5BA to suit. Fixing is by four studs 13/16 in. long and screwed 5BA over a 3/16 in. length at each end, material being 1/8 in. stainless steel rod. The wet header is a 3 9/16 in. squared length from 7/16 in. o.d. x 18 s.w.g. copper tube, each end plugged with a 3/32 in. disc of copper pressed into place which will be silver soldered later on. Offer up to the superheater flange, scallop the latter to accept the header, then drill both header and flange at 5/16 in. diameter to ensure steam reaches said header! One of our standard snifters can be fitted on the bottom centre line of the smokebox ahead of the saddle, and connected by 5/32 in. thin wall copper tube to the wet header so that the tube does not get in the way of the flue brush; now for the elements.

I still recall with some embarrassment burning out my first set of superheater elements on my RAIL MOTOR No. 1 at the M.E. Exhibition at Seymour Hall less than a year after entering service, though their replacements are still in situ today. I was reminded of this not only by the drawing detail, but by a telephone call from my 'No. 1 reader', Vaughan Cherry, earlier this week, as I will explain as we progress. Take a two foot length of 7/32 in. o.d. x 20 or 22 s.w.g. copper tube and bend it in the middle, to start forming the spearhead. Carefully grip in the bench vice and use a Junior hacksaw, I haven't used that for some time!, to saw along on top of the jaws to form one of the joints, rubbing smooth with a file, then deal with its partner. Make up a wee spacer block so that the two pieces can be properly brought together, then wire over the whole assembly so that it will not move during brazing, and that is where the discussion comes in.

Vaughan asked me about railway practice at pipe joints back in the 1950's and experience taught me that same was common also to marine engineering. My reply was that all pipe flanges and nipples were cast in 'brazing metal', an alloy whose constituents I have never been able to completely identify, indeed my experience in machining and brazing same would indicate there were variations. After machining, the end fitting was brought up to the pipe and joined using 'silver solder', by medium of an oxy-acetylene brazing torch. I became quite adept at such joints whilst in railway service, such that during National Service on a ship that did not carry a Coppersmith ERA, I assumed that responsibility. I should add that the flux was borax, which melted into glass hard globules and these had to be quenched when hot to break them away, hence the, wrong, practice of dunking red hot boilers into acid pickle which was prevalent for some time. Now my first set of RAIL MOTOR elements had spearheads joined by B6 alloy and this simply disappeared in time. For the second set I remembered I had a coil of 'silver solder' remaining from my railway/marine days and this has stood the test of time, but what specification it conforms to I cannot say. Looking at Reeves Catalogue today, I would suggest builders use Silverflo 16 for this arduous duty, Easyflo No. 2 being quite acceptable elsewhere. Now we must work back from the oval flanges cast on the cylinder blocks to arrive at the hot headers.

Cut a pair of oval flanges to match the bosses on the cylinder blocks, then chuck in the 4 jaw to bore out to 5⁄16 in. diameter for the steam pipes, before marking off and drilling a pair of No. 34 fixing holes. Offer up to the blocks, spot through, drill No. 43 to 5⁄32 in. depth and tap 6BA. Next take a 2¼ in. length from 5⁄16 in. o.d. x 20 s.w.g. copper tube and bend it roughly as shown to arrive at the position for penetrating the smokebox shell; drill 7⁄16 in. diameter.

For the smokebox connector, chuck a length of ⅝ in. diameter brass bar in the 3 jaw and turn down to 9⁄16 in. diameter over a ⅞ in. length. Further reduce to 7⁄16 in. diameter over a ⅝ in. length, screwing 26T, then centre deeply for the pipe nipple and drill ¼ in. diameter to ⅞ in. depth before parting off at ¾ in. overall. Reverse in the chuck, you may use a screwed adaptor if you prefer, to open out to 5⁄16 in. diameter to a full ⅛ in. depth.

We now need a saddle piece to accept the lubricator delivery check valve, so chuck a length of 5⁄16 in. brass rod, face, centre, drill and tap to suit said check valve, parting off at about ⅜ in. overall and scalloping the end to suit the steam pipe. Braze oval flange, connector and saddle to the steam pipe, then drill from the saddle into the pipe; erect. Inside the smokebox we first require a large washer shaped to fit the shell, followed by a 7⁄16 x 26T backnut which wants to be about 3⁄16 in. thick.

The hot headers can best be machined from the solid, which means 7⁄16 in. brass rod. Chuck in the 3 jaw, face and turn down to 5⁄16 in. diameter over a 1 in. length, then part off at 1¼ in. overall. Reverse in the chuck, turn the end down to about 13⁄32 in. diameter to fit inside a 7⁄16 x 26T union nut, then turn on the taper to suit the connector; centre and drill 7⁄32 in. diameter to 1⅛ in. point depth. Drill both wet and hot headers to accept the superheater elements, trimming and bending the latter to a fit, then assemble the whole on the brazing hearth and silver solder all the joints. As there are quite a few of them it is a wise precaution to apply a hydraulic test, as the last thing you will want is to strip out the smokebox after the first steaming. We now have steam arriving at the cylinders, next we must get it out again and up the chimney.

For the exhaust connectors, chuck a length of ⅝ in. A/F hexagon brass or steel bar in the 3 jaw, face and turn down to ½ in. diameter over a 5⁄16 in. length, screwing 32T or 26T as you prefer. Part off at ¾ in. overall, fit a screwed adaptor and screw the embryo connector into same, to face and turn down to ½ in. diameter again to leave ⅛ in. of hexagon; screw as before. Centre and drill right through at 9⁄32 in. diameter, then make up a couple of union nuts to suit.

Nice sweeping bends have been a feature of my exhaust systems for many years now and they do pay rich dividends, so if these are beyond you then try a hardware store as such things are used on small bore heating systems. You will likely come up with a metric equivalent, in which case vary the size of union nut to suit. As the blastpipe is only 1½ in. long, it can just as easily be machined out of 7⁄16 in. brass rod, in which case you can slightly reduce the bore at the top to accept the 26T screwing, though for goodness sake do not go below .29 in. diameter as at the blast nozzle. Chuck the 7⁄16 in. rod again for the plain nipples at the exhaust connectors; centre and drill to suit the exhaust bends before parting off two 3⁄32 in. slices; braze up. Make up a mandrel from a 6 in. length of 5⁄16 in. steel rod, a nice fit in the blastpipe and check that it is nice and upright protruding out of the top of the smokebox shell, screwing a 7⁄16 in. x 26T backnut to the top of the blastpipe and giving it a tweek so that the chimney will not resemble the leaning tower of Pisa!

Petticoat Pipe and Chimney

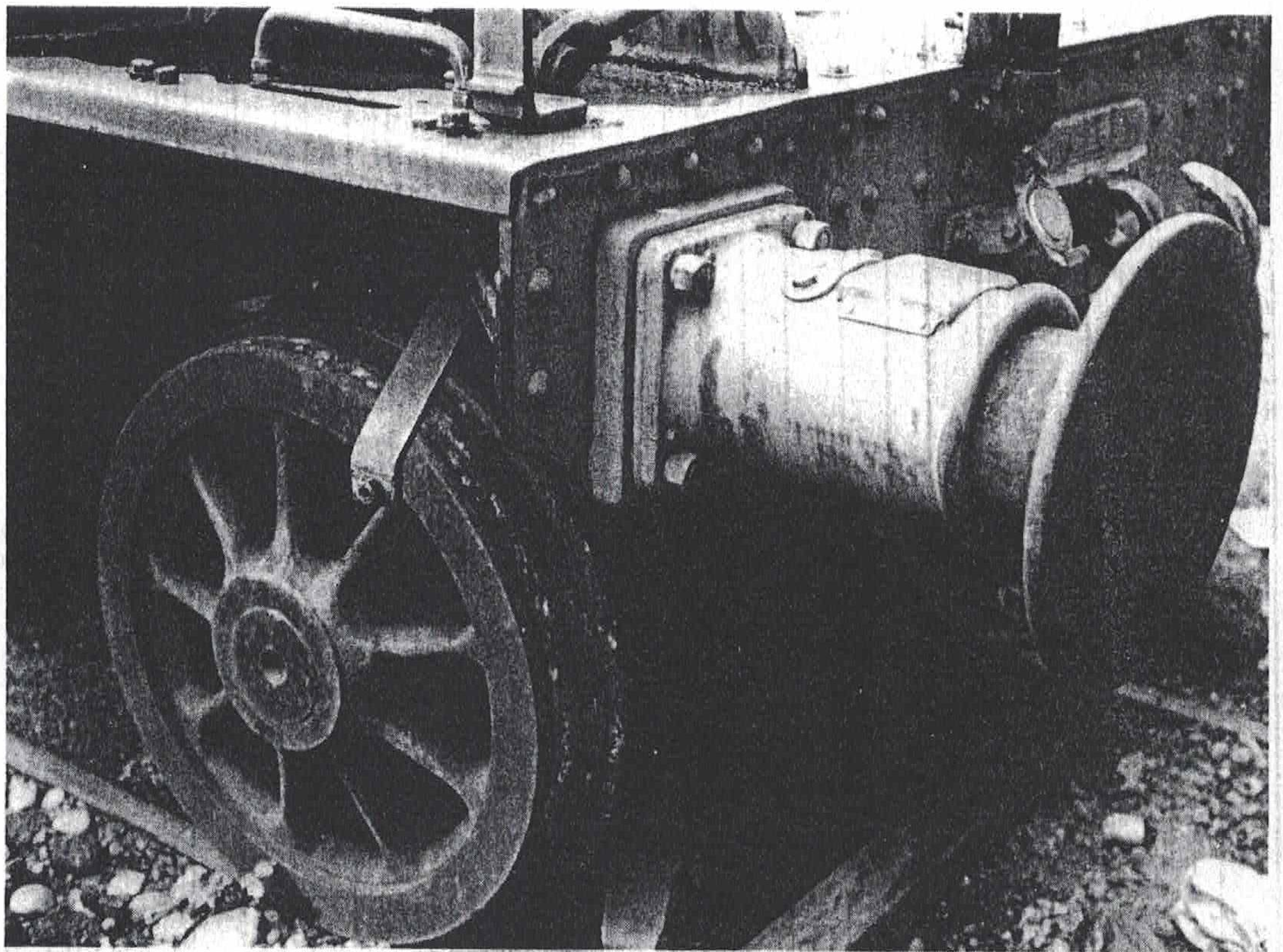
Chuck the petticoat pipe casting by its flare in the 4 jaw and set to run true before turning down to 1¼ in. diameter over a full 1⅜ in. length, facing across at the top. Change to the 3 jaw and chuck by the machined portion in same, then face off to length. Next bore out to ⅞ in. diameter before setting the tool over 2 deg. and opening out until the throat comes ¾ in. up from the flare as shown, tidying up the radius with a round file as you run the lathe at top speed, then complete the outer profile. The flange is a 1¾ in. square from 1.6mm brass; find the centre by the 'X' method and chuck truly in the 4 jaw to bore out to an easy fit over the petticoat pipe spigot. Bend the flange to match the smokebox shell, get the flange fitting tightly, packing it up from the brazing hearth for additional security before silver soldering together. Erect to the smokebox, use inside calipers to get the bore central about the mandrel, then drill through at No. 44 in the four corners, countersinking the shell for 8BA screws, nuts inside the smokebox.

E. S. Cox's chimney is a lovely shape, one that originated from his days at Horwich and worth spending time to get right. Use the chucking spigot provided and if the chimney does not run true then chuck initially by the main body of the casting in the 4 jaw and clean up the spigot. The flange wants to be nice and delicate, as drawn, so you may wish to deal with this first by transferring to the bench vice and filing same to suit the smokebox shell; I would advise against fly cutting the base. Back to the 3 jaw to turn the outside to drawing, then bore out to 1¼ in. diameter and ¾ in. depth to accept the petticoat pipe; a good fit. Do this with the boring tool still set over those two deg. when you can carry on and bore out the top of the chimney to match the petticoat pipe. Back to the bench vice to clean up the rest of the chimney profile before parting off the chucking spigot.

Blast Nozzle and Blower Assembly

When the smokebox is finally erected, a layer of soft setting asbestos or better magnesium silicate has to be trowelled in at the bottom, both to seal all the joints and for ease of

Buffers seem to have featured prominently in this series, though this one is allied to a straight front buffer beam! Removal of the front step, for whatever purpose, also reveals the pony truck wheel, which is an added bonus.



cleaning. We do, however, require the blast nozzle to complete the mechanical parts, starting with a length of 1 in. diameter brass bar.

Chuck in the 3 jaw, face and then rough out the outside before centering and drilling 9/32 in. diameter to 5/8 in. depth. Follow up with a 13/32 in. drill and 'D' bit to 1/4 in. depth, tapping 7/16 x 26T, then part off at a full 1/2 in. overall. Chuck an odd end of 1/2 in. rod, face and turn down to 7/16 in. diameter over a 7/32 in. length, screwing 26T then fit the embryo blast nozzle to same. Complete turning to size, the upper flange being turned to suit the 1 in. o.d. x 18 s.w.g. copper tube for the blower belt, then set a boring tool over approximately seven degress to complete the exit to .29 in. diameter. Part off the blower belt, turn up the union connection for same, assemble the three parts and silver solder together. All we need now are those four No. 70 holes and I still find these easiest to achieve with my 6/10d (34p) Woolworths hand drill; it is much more sensitive than the powered variety. Screw the blast nozzle to its pipe, arrive at the 1 17/32 in. dimension, then make up the blower tube to suit.

Boiler Erection, Grate and Ashpan

The next instruction, that the boiler be set level in the frames, is far from easy to achieve, as everything about the boiler is tapered. All you can do is pack up the back of the boiler from the trailing coupled axle and trust to your eye. The expansion brackets are bent up from 2.5mm copper exactly as for POM-POM and secured by medium of those home made 6BA bronze cheese head screws, the only difference being that they are only 2 in. long. Their position is dictated by the frames profile, and of course the firebox stays.

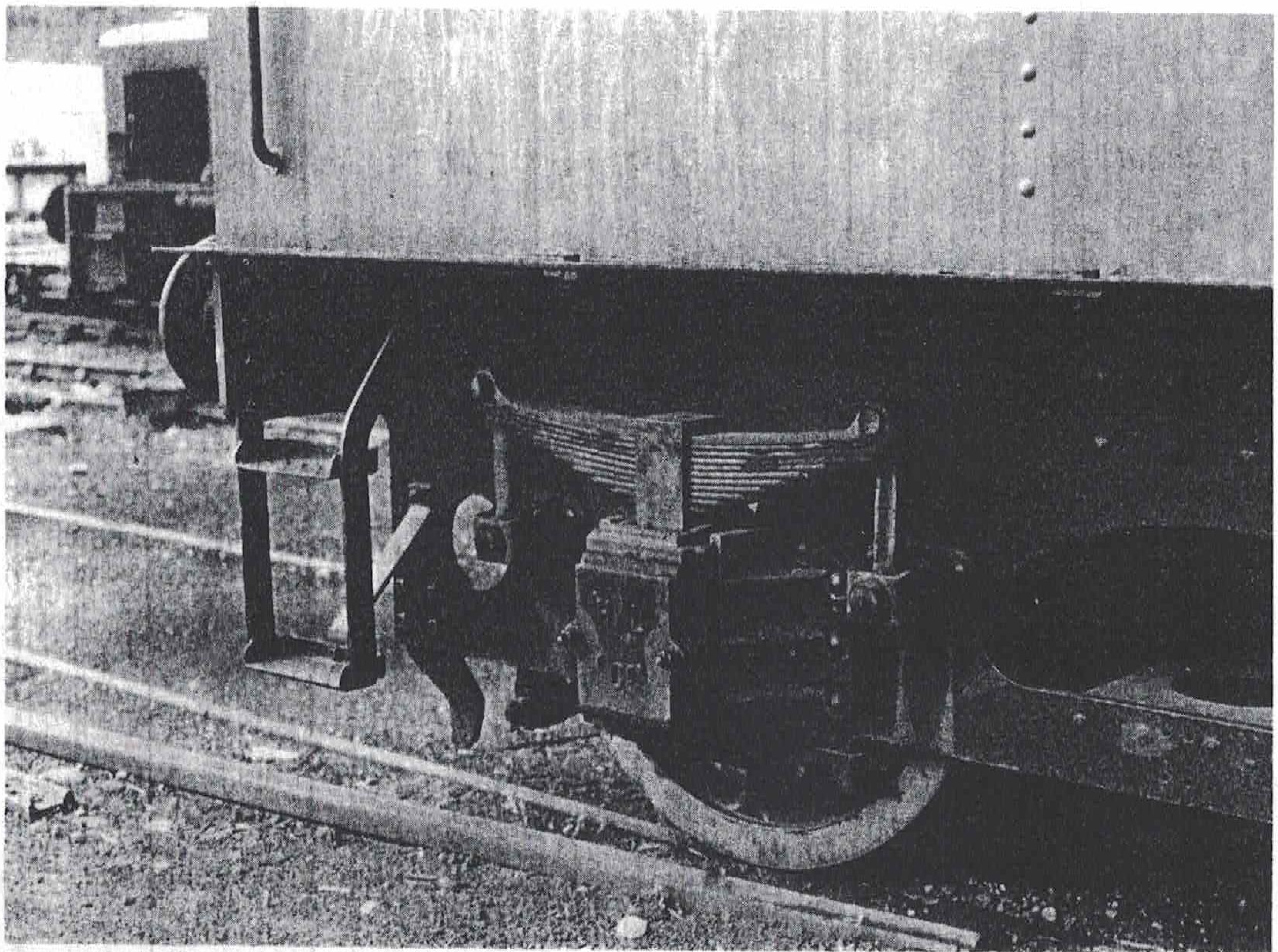
Although the ashpan is extrememly generous, it does require a mite of care to be taken in way of the trailing horns, so make one up from cardboard initially and then transfer to 1.6mm sheet, folding up and brazing all the joints. I have had the odd complaint of poor steaming, which has always been traced to the lack of a closing plate at the front of the ashpan, air entry only being at the rear as shown. Full size there is a mechanism that allows the ashpan door to be lowered and tilted, but what works and well in 4 ft. 8½ in. gauge would not do so in 5 in., thus I have substituted a simple dumping pin. It is important though to deny air ingress around the ashpan door, otherwise any unburnt fuel will ignite and distort the door, thus you may use 3mm steel sheet as an alternative to 1.6mm. Rivet on the 1/4 in. x 1/4 in. x 1/16 in. brass angle, offer up and drill through from each side of the ashpan at No. 30, using the same ashpan dumping pin as specified for POM-POM.

The grate is made up in three sections, the centre one passing easily through the firehole door to allow the fire to drop, all three sections being supported on the grate bearers, a feature I have described many times in LLAS. Cut the grate bars from 3/8 in. x 1/8 in. stainless steel flat, mark off and drill one of them, then use as a drill jig for the remainder. The spacers are from 1/4 in. steel rod, drilled centrally at 1/8 in. diameter and parted off in 3/16 in. slices; assemble the sections with 1/8 in. steel rod, peening the ends well over.

The grate bearers can either be bent up from 1 in. x 1/8 in. steel flat, or the end flanges cut separately and brazed on, the rest is straightforward. The top of the grate must be level with the top of the foundation ring, so check this out before drilling through from the ashpan and securing the grate supports with 6BA bolts.

Firebox Doors

Having learnt to fire 'through the flap' on LNER locomotives, why the LMS sliding doors were perpetuated on the BR Standards I will never know, for they are quite unwieldy and require the assistance of the driver for correct use, opening for every shovelful and being closed immediately it has been placed; it would require a gymnast to emulate this in 5 in. gauge! Anyhow, perhaps ours is not to reason why, but simply to reproduce the feature. From now on we shall be making increasing reference back to Sheet No. 1, starting with the view on the backhead showing assembly of the doors.



The main talking point arising from this photograph will be the "H L Co" cast into the axlebox cover, indicating I guess North Eastern builders Hawthorn Leslie as the source. It used to be a fascinating exercise 40 years ago to stand on the lineside as a freight train passed to identify the variety of axlebox covers on wagons, ranging from BR (E) to LNER, GNR and an assortment of private wagon builders.

The firehole surround requires a piece of 1.6mm steel sheet size 3¼ in. x 2¼ in.; mark off to drawing then chuck in the 4 jaw to bore out to 1⅜ in. diameter. The top guide is from 3/16 in. square steel bar, so grip a 3¼ in. length in the machine vice on the vertical slide and mill the 1/16 in. x 3/64 in. slot to accept the doors. Attachment to the baseplate wants to be with about three 3/64 in. copper rivets in the first instance, reinforced with silver solder later on. For the tray, grip a 2¼ in. length of ½ in. x 3/16 in. BMS flat in the machine vice and mill away as shown to leave 1/16 in. walls on three sides and a 1/16 in. base, though mill this latter away in way of the top guide; again this will be silver soldered in place.
For the bottom slide, start with a 3¼ in. length of ¾ in. x 3/16 in. BMS flat and first mill the 1/16 in. x 3/64 in. slot to accept the door. Offer up to the baseplate and drill No. 31 at the fulcrums, then profile to match the baseplate. For the fulcrum, chuck a length of 7/32 in. steel rod in the 3 jaw, face and turn down to ⅛ in. diameter, a press fit in the bottom guide, over a ¼ in. length. Part off at ½ in. overall, reverse in the chuck and turn an ⅛ in. diameter spigot over a 3/16 in. length; press into the bottom guide then silver solder the whole assembly.
The base of the doors is a piece of 1.6mm stainless steel, size 1½ in. x 13/16 in., with fulcrum pin hole drilled No. 43 and the three air holes at No. 41. Bend up the air shield from the same size material, trim off the excess, then cut side plates to fit, holding in place for silver soldering with the 3/32 in. pivot pin which is 11/16 in. overall length.
The link is from 7/32 in. square steel bar, so mark off and drill the No. 41 holes at 1½ in. centres. You may just be able to radius the ends over a mandrel with an end mill, otherwise use a file, then complete with the end slots to suit the operating levers. The shorter is from 7/32 in. x 3/32 in. steel strip, marked off and drilled to drawing, the only point to be watched is that the slot is long enough to allow the RH door to move from full open to full closed positions without jamming. It will probably be easiest to mark the long lever out on a sheet of 2.5mm steel, then of course it can be bent up from 7/32 in. x 3/32 in. strip. What is more important is to bend the operating handle outwards, then upwards again of course, so that you do not catch your knuckles on either the oil tray or blower valve.
To hold the levers on the door surround, chuck a length of 3/16 in. steel rod, face, centre and drill no. 43 to ⅜ in. depth, parting off two 5/64 in. slices, which are then pressed on to the end of the fulcrum pins, trapping the levers in place. The remaining pins are 3/32 in. snap head brass rivets, cross drilled for 3/64 in. split pins.

Lagging and Cleading

Lag the barrel to about 5/32 in. thickness to come flush with the smokebox shell and using the materials as I discussed for POM-POM, then add a 1/16 in. layer over the firebox. After your struggle with the tapered boiler barrel, you will know how to deal with the cleading over same in identical fashion, securing with 3/16 in. wide boiler bands.

Dome Cover

There is no way you can machine the dome cover and in any case it is cast to size, so deal with the flange with files to sit snugly on the cleading, making sure that the top face is level, then polish the outside before drilling the No. 44 fixing hole and securing with an 8BA bolt; we are getting along famously now!

Safety Valve and Casing

Safety valve technology has come a long way in the 18 years since I drew the detail for No. 78000 and I would recommend every builder acquires for himself a pair of our lovely 'pop' ones made specifically for this engine. The casing is from 6mm brass sheet; mark off and drill the pair of 45/64 in. holes, the rest being saw and file work to end with the lovely shape as shown.

Check Valve (Clack)

This was my first attempt at a top feed check valve and it has worked out very well, though it does take a mite of patience to make the pair. The body at least is straightforward, so chuck a length of ⅜ in. bronze rod in the 3 jaw, face, centre and drill No. 31 to 19/32 in. point depth. Follow up with a 7/32 in. drill and 'D' bit to 13/32 in. depth, tapping the outer 5/32 in. at 1/4 x 40T, then run an 1/8 in. reamer through the remains of the No. 31 hole. Part off at 11/16 in. overall, lightly radiussing each end as shown.

For the inlet connection, chuck a length of 5/8 in. diameter bronze bar in the 3 jaw, face and turn down to 1/4 in. diameter over a 3/8 in. length, then centre and drill No. 22 to 5/8 in. depth. Reduce over the next 3/8 in. length to 9/16 in. diameter, then part off to leave a full 3/64 in. flange, parting a second flange off at 1/16 in. thickness for the delivery pipe. Chuck the inlet connection by its shank to clean up the flange and mark on the pitch circle for the 10BA bolts at 13/32 in. diameter, drilling No. 50; offer up the pipe flange and drill through. Offer the inlet connection up in turn to the clack body to mark off and scallop to suit the body, then drill No. 30 into the body below the ball seating.

For the boiler connection, chuck a length of 7/16 in. bronze rod, face and turn down to 1/4 in. diameter over a 1/4 in. length, screwing 40T; part off to leave a 3/32 in. thick flange. Fit a 1/4 x 4T screwed adaptor to the 3 jaw and fit the boiler connection to same to centre and drill through at No. 30, then follow up at No. 12 to about 1/16 in. depth. Take a fairly long length of 3/16 in. o.d. x 20 s.w.g. copper tube and make a sharp bend as close to one end as you are able. Cut to place, scalloping to suit the clack body and drilling same at No. 30, then make up the 1.6mm brass web, when you are ready to assemble all the parts on the brazing hearth. Use Easyflo No. 2 and pickle well, then clean up and polish. Seat a 5/32 in. rustless steel ball on the 1/8 in. seat and we must turn up the cap to complete.

Measure with a vernier depth gauge from the top of the clack body down to the ball and deduct 3/64 in. for the lift. Chuck a length of 5/16 in. brass rod in the 3 jaw and turn down to 1/4 in. diameter over the length you have just arrived at, then further reduce to leave just an 1/8 in. at 1/4 in. diameter, fashioning the end into a pip as shown; screw 40T. Part off to give the 11/64 in. dimension, grip the 1/4 x 40T screwed adaptor in the machine vice on the vertical slide and tighten the embryo cap hard into same. Now use an end mill to deal with the four flats to arrive at 5/32 in. square; screw the clacks into the boiler.

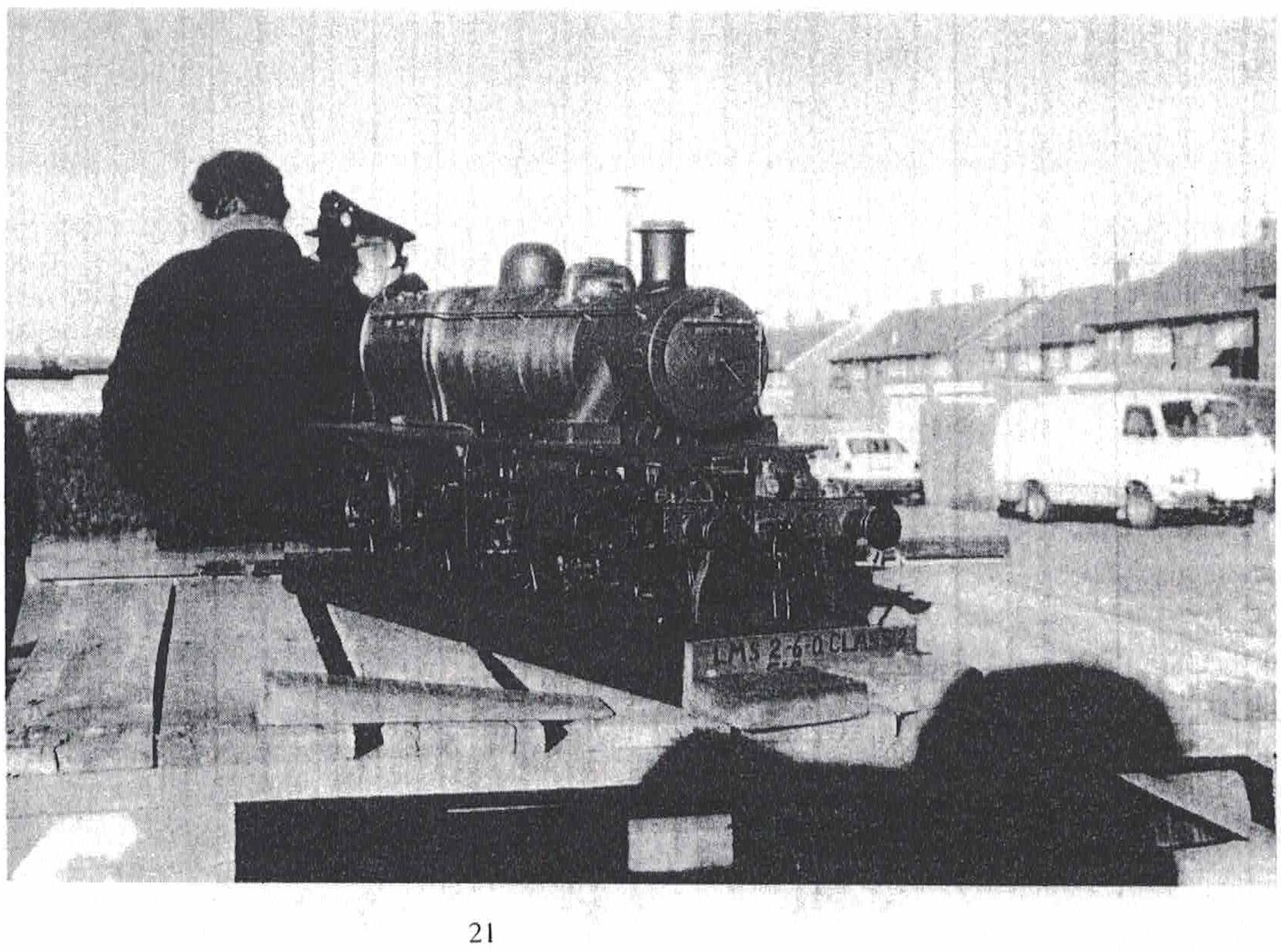
Manifold

The manifold adds a nice finishing touch and according to Doug Hewson's advertisements a lost wax casting is available for same, though I have not yet had the opportunity to check it out. If, however, the samples that Doug has sent me over the years are anything to go on, then a cast manifold would be a good investment.

The basis of the fabricated detail is a 1 1/4 in. finished length from 7/16 in. square bronze bar, each corner having a radius as shown. Chuck truly in the 4 jaw, centre and drill right through at 9/32 in. diameter. For the boiler connection, chuck a length of 5/8 in. diameter bronze bar, face and turn down over a 5/16 in. length to 3/8 in. diameter, screwing 32T, then part off at a full 13/16 in. overall. Chuck a 3/8 x 32T screwed adaptor and fit the embryo boiler connection to same, to first centre and drill right through at No. 11. Turn on a 1/4 in. diameter spigot over a full 1/16 in. length, drilling the cross portion to suit, then deal with the remainder of the connection to drawing. The end connections, plus the three outer ones that fit into the cross piece are all simple turning, which leaves just the whistle valve on the centre line.

For the spring retaining boss, chuck a length of 5/16 in. bronze rod and turn down to .282 in. diameter over a 7/16 in. length. Centre and drill No. 11 to 3/8 in. depth, tapping the outer 3/16 in. at 7/32 x 40T, then part off at 11/32 in. overall; press into a 9/32 in. hole drilled right through on the centre line.

Chuck the 5/16 in. rod again and this time turn down to 9/32 in. diameter over a 1 in. length, then centre and drill no. 41 to 1 in. depth. Follow up with a 3/16 in. drill and 'D' bit to 1/4 in. depth, then part off at a full 7/8 in. overall. Reverse in the chuck to drill and 'D' bit 3/16 in. diameter to 15/32 in. depth, tapping the outer 3/16 in. 7/32 x 40T. For the whistle union, chuck a length of 7/32 in. brass rod in the 3 jaw, face, centre deeply for the pipe nipple and drill No. 40 to 3/8 in. depth. Screw the outside 40T over a 7/32 in. length, then start parting off at 1/4 in. overall, but only reduce to around 5/32 in. diameter before moving on another 1/16 in. and parting right off. Mike the spigot and drill the whistle valve body to be a press fit, then assemble all the parts made and silver solder; pickle and clean.



Geoff Kelso from the Gravesend Society started to build No. 78000, then gradually changed her to an Ivatt 'Mogul' and is now considering a further conversion to an Ivatt 2-6-2T. Geoff confides that such changes have led to an overfull scrap box, not all of which can be blamed on the designer!, plus an extended building time. What is clear from this photograph is the uniformly high standard of workmanship, something to enthuse over.

The end fitting starts life as 3/8 in. square brass bar, so chuck truly in the 4 jaw, face and turn down to 7/32 in. diameter over a 5/32 in. length, screwing 40T. Centre and drill No. 50 to 1/2 in. depth before parting off at 13/32 in. overall. Screw hard into the manifold to determine the correct orientation and the whistle lever need not be perfectly upright, then cross drill for the 1/16 in. fulcrum pin before dealing with the 3/32 in. slot. Now mill away the excess metal to arrive at the shape shown. The lever is from 2.5mm brass and the plunger 1/16 in. stainless steel rod; now seat the 1/8 in. rustless steel ball as the whistle valve. There must be a clearance, of the order of .010 in. between plunger and ball to ensure it seats properly and now we have to ensure that the ball will not disappear into the boiler should its retaining spring break, for Murphy's Law would apply here! Chuck a length of 1/4 in. A/F hexagon brass bar, face and turn down to a full 1/16 in. diameter over a 7/16 in. length, checking that the chosen 24 s.w.g. spring will slide easily over same. Turn the next 3/16 in. length down to 7/32 in. diameter and screw 40T, then part off to leave a 3/32 in thick head, one that you should now lightly chamfer. Fit a 1/16 in. snap head brass rivet as the lever fulcrum pin and screw the completed manifold into the boiler.

Platework

Because the side running boards are bent up from 2 5/8 in. wide strip with a 1/4 in. wide lip in place of a separate valance, they will be perfectly robust if made from 1mm thick steel or brass. Alone among all the BR Standards, the running boards on the Class 2's are attached to the frames rather than the boiler, so simply use lengths of 1/4 in. x 1/4 in. x 1/16 in. brass angle positioned to place for attachment to said frames.

The tender cab was good training for the engine one and as the profiles are identical, if you used cardboard templates then the spectacle plate will be plain sailing. The back surround also makes for a very robust cab structure, the outer profile matching the spectacle plate, when the cab sides and roof are also made to match. Builders can now continue adding 'extras' to their heart's content, lifting dimensions directly from Sheet No. 1, all of which will improve appearance without making one iota of difference to the performance of No. 78000 at the track. I will end my description though with one part that will make a vital difference to your enjoyment now that you are nearly ready for the first track outing, this being the regulator operating mechanism.

Regulator Rod, Handle and Fulcrum

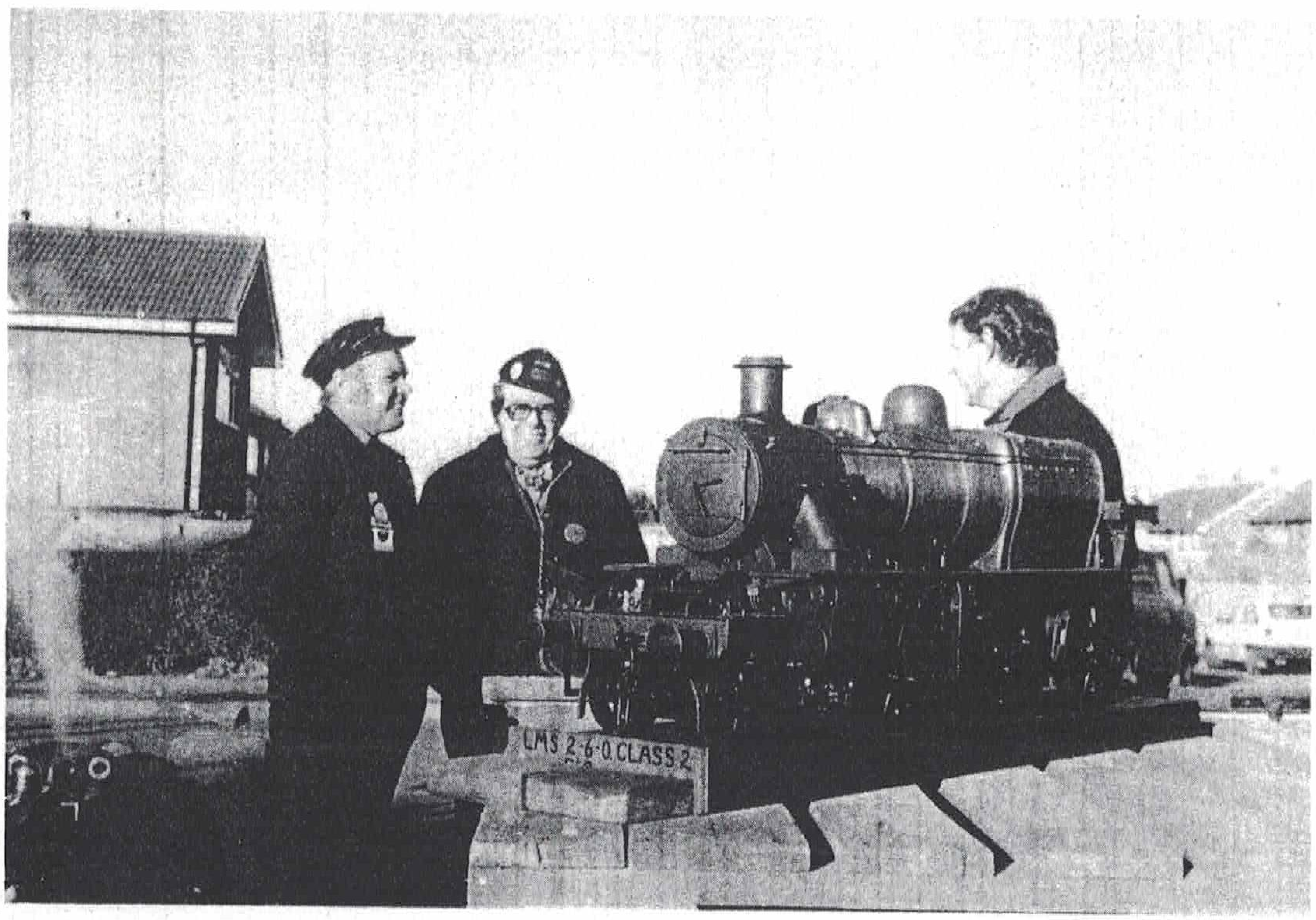
After all the fuss over the valve gear, the rear 'clanger' I dropped was in operating the regulator and I have left the drawing until after my description before putting it right. For as drawn, it takes only about 1/4 in. movement of the regulator handle from fully closed to wide open, which is not very sensitive!

The main portion of the regulator rod is a length of 3/16 in. o.d. tube and the 18 s.w.g. copper variety as used for the internal blower tube in the boiler as good as any, as I doubt if many builders can avail themselves of steel tube in this size. We had made any number of fork ends over the past months, so no need to repeat description; braze the fork ends to the tube.

Now I have shown the fulcrum bracket only extending down 1/2 in. from the cab roof whereas a more correct dimension would be 1 in. Bend up from 1.6mm steel and rivet firmly to the cab roof, then bend the regulator handle up from 5/16 in. x 3/32 in. steel strip to suit yourself, setting the regulator rod nice and horizontal before drilling through for 3/32 in. pins which can be brass snap head rivets as we used for the fire doors.

Conclusion

No. 78000 has been gaining me friends for all of 18 years now and seems set to continue for a long time yet. She is a lovely little engine with bags of character and only one vice that I have been able to discover. For one must remember that she has a rather steeply sloping grate, so do not try to fill it level, but just drop coal through the door and let it shake forward whilst you run; that way you will quickly have steam coming out of your ear holes; have fun!

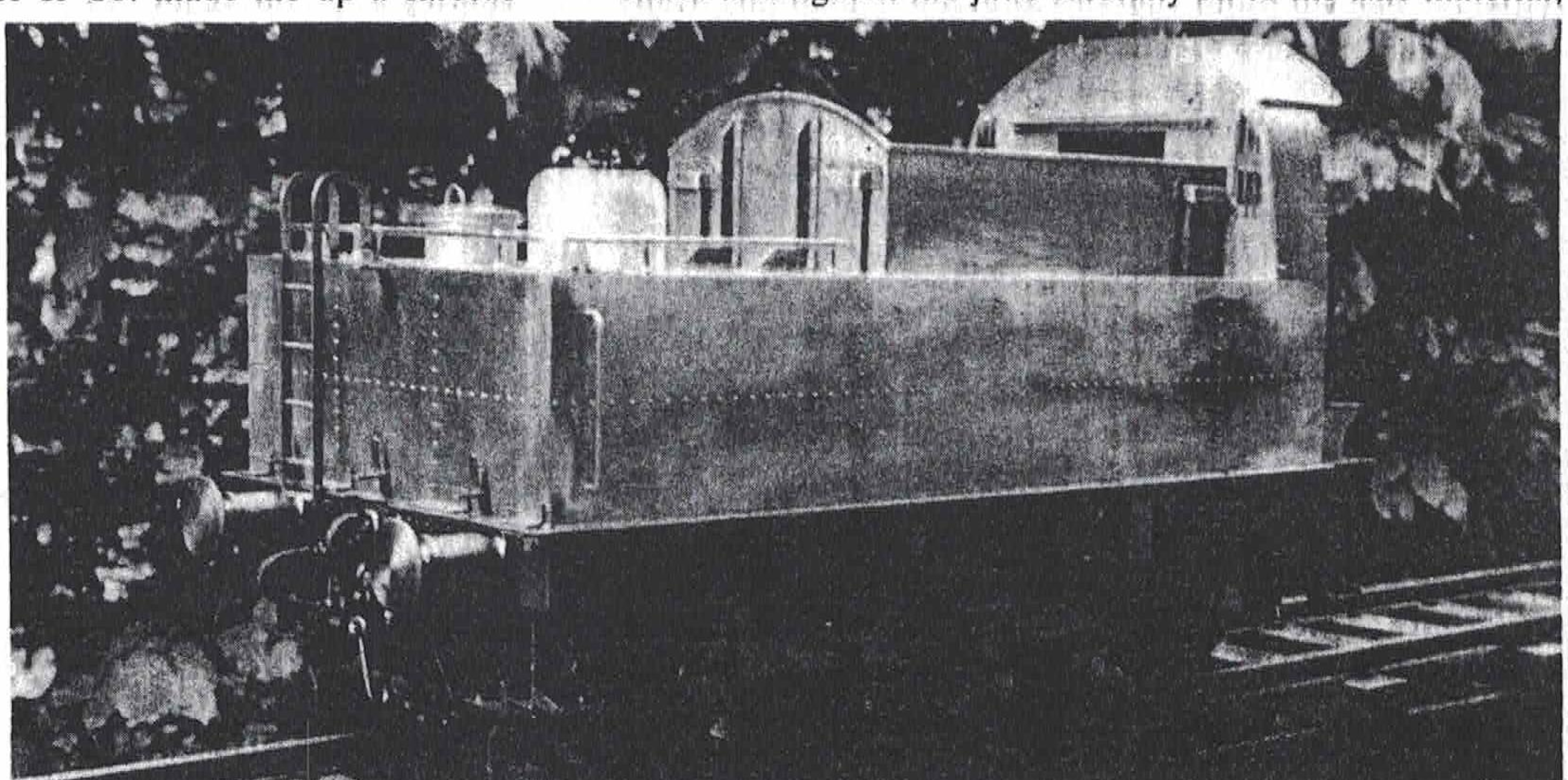


Beauty and the beasts suggests Geoff Kelso? Ben Healy, Bill Holmes and Frank Staviforth are the Gravesend Committee. Bill Holmes, an ex-patriate Geordie, is in the process of building one of my Gresley A3 Class 'Pacifics' which will be appropriately named ROBERT THE DEVIL! That reminds me that another Bill, Holland of CALL BOY fame, rang me last night to say he has finally got round to resetting the LH outside piston valve on his engine, with very encouraging first result; now CALL BOY should really fly!

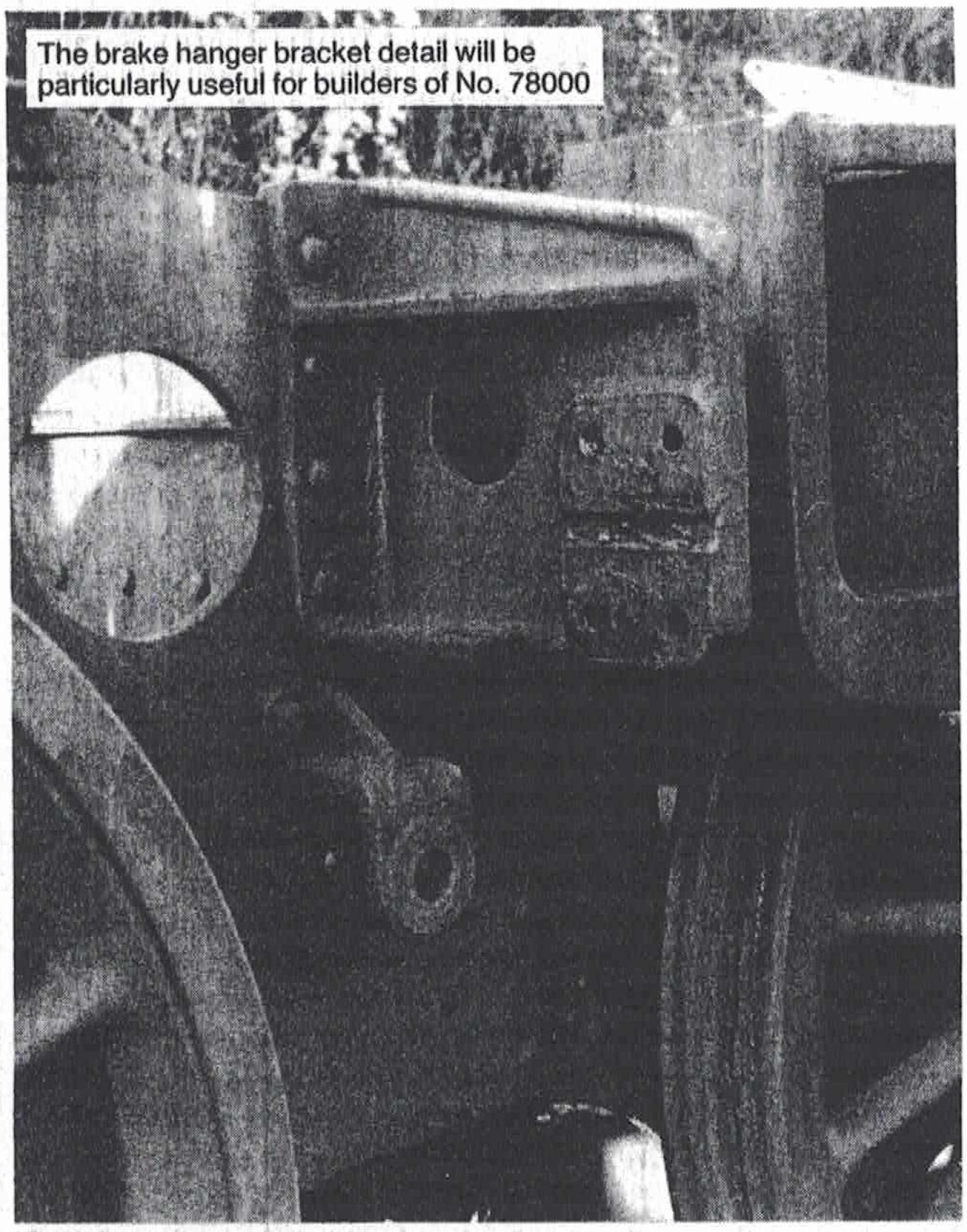
same size. Now deal with the 1⁄64 in. raised face on the outer box of the pair, rechucking the inner box to deal with same to be identical.
The spring plates are 1 in. lengths from ½ in. x ⅛ in. BMS flat; offer up to the hornstays and drill through the pair of No. 10 holes, then grip with a 'Mole' wrench and carefully radius the ends over a mandrel with an end mill.
For the spring pins, chuck a length of 3⁄16 in. steel rod in the 3 jaw, face and screw 40T over a 3⁄16 in. length with the die opened out to give tight threads, then part off at 2 in. overall. Reverse in the chuck, tidy up this end, then screw 2BA over a 7⁄16 in. length to complete.
You will likely have to ease each axlebox into its mating horn with files, just to be a tight sliding fit at this stage, then fit the hornstay, clamp the axlebox hard down on to same, to drill and tap the keeps 3⁄16 x 40T to 3⁄16 in. depth; fit the spring pins. Later on when the axles are complete and the frames have been properly aligned, we must relieve the flanges as shown, so that each axlebox can be raised by 5⁄32 in. relative to its partner, so that the wheels can follow track irregularities without the fear of derailing.

Wheels and Axles

Back in 1972 my "out and about" career was still in its infancy and I had a lot to learn, I still do for that matter!, but it is evidenced on both wheel details in that no root radius is specified, so builders of No. 78000 should refer to POM-POM. These are the first patterns produced for me by Norman Lowe, bearing the Pattern Nos. 1 & 2, and set a standard for what has followed, thus I predict you will enjoy machining them, so first assess the machining allowances.
Coupled wheels first, so grip by the tread in the 4 jaw and set to run true before machining right across the back of the wheel, then turning the flange down to 5 9⁄16 in. diameter. Radius the corner of the flange with a file, then centre, drill and ream through at 11⁄16 in. diameter; repeat for the other five wheels.
You next require an old drill of around ¾ in. diameter and shank to suit the headstock; saw off behind the flutes and fit to said headstock, then turn down to a good fit in the wheel boss. Next fit the faceplate, fit a wheel over the mandrel and use 2BA or ¼ in. bolts, with large washers, to hold the back of the wheel hard against the faceplate. Deal with the crank boss by turning down to 41⁄64 in. overall thickness, then reduce a further 1⁄64 in. to leave the raised face to 13⁄16 in. diameter; this represents the axle end in full size. Move on to reduce the tyre thickness to 9⁄16 in. and we must concentrate on the tread, for which we need a special tool.
I was fortunate in that Alec Flux in the Tool Room at shipbuilders J Samuel White & Co. made me up a carbide tipped tool for wheel turning 30 years ago. Basically it is an ordinary turning tool with a 3⁄32 in. radius ground on in the corner, so it will produce tread and flange at one pass without the need for tool changes; try and arm yourself with such a tool. At the slowest speed and finest feed, take an initial cut to get right under the skin of the casting, knocking out the auto-feed and continuing by hand to arrive at the 3⁄32 in. flange thickness. Now you can continue reducing the tread to around 5 9⁄32 in. diameter, knowing the tool will come up to that hard shoulder at the flange, more than likely without any tool chatter, though pull round by hand should the latter occur; bring all six wheels up to this stage. Leave the last one in place and take a final cut to come as close as you can to 5¼ in. diameter, though the actual figure within a few thous is not important. What is vital is that all wheels have identical tread diameter, so leave the tool setting well alone and repeat for the other five wheels. Now set the tool over 30 deg. to machine on the 1⁄16 in. chamfer at the outer corner, then file on the flange radius to complete the wheel profile.
Crankpin holes next, for which we require a simple drill jig. Start with a 2¼ in. length from, say, 1¼ in. x ⅜ in. BMS bar and mark on the centre line. Grip in the machine vice on the vertical slide and at ⅝ in. from one end, centre and drill through to ½ in. diameter, then move on 1 1⁄16 in. by micrometer collar on the cross slide to drill a second hole at ⅜ in. diameter. Next chuck a length of ¾ in. diameter steel bar in the 3 jaw, face and turn down to 11⁄16 in.. diameter, a good fit in the wheel boss, over a 1 in. length. Further reduce to ½ in. diameter, a press fit in the drill jig, over a ⅜ in. length, then part off at a bare 1 in. overall and press the pin into the jig. Scribe the centre line on each crank boss, offer up the jig and clamp firmly in place, then on to the drilling machine to drill through and ream at ⅜ in. diameter.
There is still one operation to complete the leading pair and that is to remove 1⁄16 in. of metal at the crankpin and I doubt if many builders possess a spotfacing tool; commercially these are like large pin drills with detachable cutters. The solution though is easy, for all we have to do is bolt the wheel directly to the vertical slide and use a large end mill to remove metal.
After all that the pony truck wheels are easy and follow an identical machining pattern, so deal with the wheel back and flange, then turn the mandrel down to 7⁄16 in. diameter to accept the wheel boss, then complete machining the front of the wheel and the tread; on to the axles.
Just one pony truck axle, so let us deal with this one first, starting with a 6 in. length of ¾ in. diameter steel bar. Chuck in the 3 jaw, face the end and centre deeply, then reverse in the chuck, face off to 5 15⁄16 in. overall and centre this end. Rechuck between centres and if you change to the 4 jaw chuck and tighten the jaws carefully on to the axle material,



I seem to get photographs of tenders for No. 78000 in gay profusion. This example is by Dr. Bill Naunton, who asks that every builder look at the detail depicted


The brake hanger bracket detail will be particularly useful for builders of No. 78000

then you can dispense with the alternative driving plate and lathe carrier set-up. Start by reducing for as much of the total length as possible to 23⁄32 in. diameter, then concentrate on the outer end and turn down to 7⁄16 in. diameter over a 5⁄8 in. length. Before completing to size though comes the decision as to whether yours will be a press or Permabond fit, and sadly some DYD builders are still experiencing failure of Loctite No. 636 joints, even after years in service. Move on and turn the next 25⁄32 in. length down to .498 in. diameter using your micrometer, then reverse the axle and repeat. Only the central portion left to deal with, so set the tool over approximately 2 deg. and start turning one of the tapered lengths; the actual figures of 19⁄32 in. diameter at the collar and centre plain length of ½ in. are not vital, especially as there is only a single axle, but get as close to same as you are able, then reverse and complete the remaining tapered length, tidying up the centre to complete; assemble both wheels.

Coupled axles next and 7⁄8 in. diameter bright drawn mild steel will be perfectly acceptable here, so saw into 6 in. lengths, chuck in turn to face off to 5 15⁄16 in. length and centre each end, using the same set-up as for the pony truck axle. Deal with the wheel seat first at the outer end to the required fit, then deal with the journal and this time you have an axlebox as your gauge. Reverse and repeat at the other end, then complete by reducing the central section to ¾ in. diameter with a round nose tool.

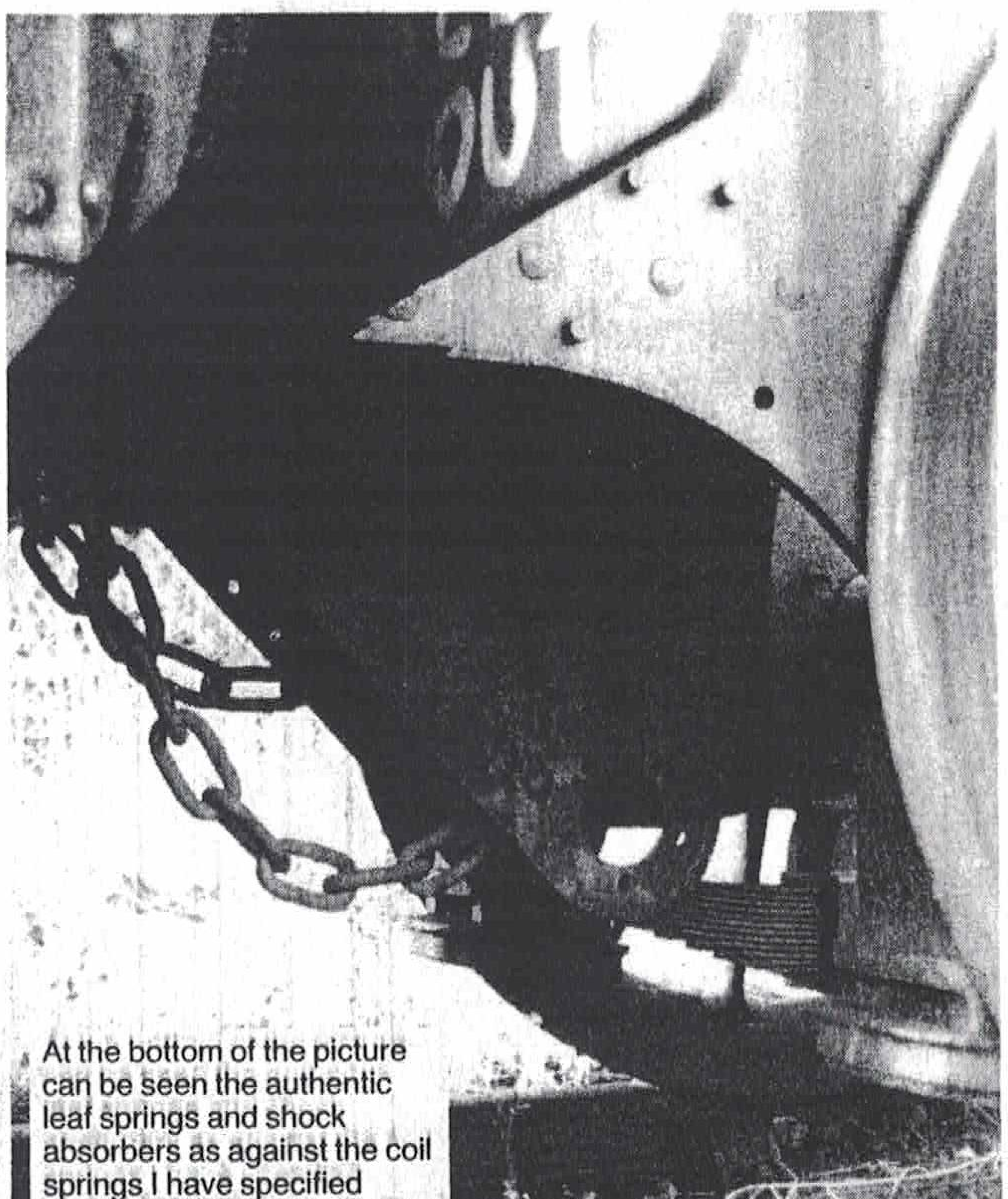
Assembling the Frames

We shall need a large number of clamps to hold the drag box and stays firmly in place to check alignment before drilling for any fixing screws and these are easy to make by bending up odd ends of 3⁄8 in. x 1⁄8 in. black steel strip, then drilling and tapping for a 2BA bolt. Commercial clamps are OK and I have a fine pair of Record ones, but the home-made ones you can form into a horseshoe to suit a particular application, then hang them up in the workshop ready for another time. Erect all the frame parts and if you lay the frames on their backs on the lathe bed, then check across in as many places as you can with an engineers square, we are getting close, though the acid test is to fit all the coupled axles, when they should turn sweetly. Now you can begin drilling and tapping for all those 6BA bolts, a few in each stay then check again with the axles before moving on, then if any misalignment does develop, you can quickly locate the fault and correct it.

Crankpins and Crankpin Caps

Driving crankpins first, though we cannot fit them until the return cranks have been made in the next session. I have specified silver steel, but if you experience difficulty in turning to a good surface finish, then mild steel will suffice. Chuck a length of the chosen material in the 3 jaw, face and turn down the first ¼ in. length to 3⁄8 in. diameter, this for the return crank square. Move on and turn the next 15⁄32 in. down to 7⁄16 in. diameter, then part off at 1 21⁄32 in. overall. Reverse in the chuck and turn down over a 5⁄8 in. length to 3⁄8 in. diameter, a press fit in the crank boss; now we must deal with the square. The Myford machine vice has an indent to accept the top vice jaw, but if said top jaw is removed then that indent is perfect for gripping round bar, so grip the embryo crankpin by its wheel seat portion, the return crank end facing the chuck. Grip a 3⁄8 in. end mill in said chuck and using the vertical slide, cut the first face of the square until the dimension reduces to 5⁄16 in. by micrometer, then deal with the opposite face to arrive at the required ¼ in.; use the cross slide in identical fashion to complete the other two flats.

Trailing crankpins next and if your 3⁄8 in. silver steel rod is not a press fit in the crank boss, then start with the same ½ in. rod as for the driving pair and turn the first 5⁄8 in. down to be a press fit, parting off at 1 9⁄32 in. overall. Reverse in the chuck and reduce the outer ¼ in. to 3⁄16 in. diameter, screwing 40T, then deal with the journal to 3⁄8 in. diameter to complete; press into the wheels. For the trailing crankpin cap, chuck a length of 5⁄8 in. diameter steel bar in the 3 jaw, face and turn down to 3⁄8 in. diameter over a 5⁄32 in. length, then turn the next ¼ in. or so down to 9⁄16 in. diameter. Centre and drill No. 22 to ½ in. depth and tap 3⁄16 in. x 40T, but before parting off, take the bar to the machine vice to deal with the two flats in the same way as for the square on the driving crankpin. Back to the 3 jaw to part off at a full ¼ in. overall, then


At the bottom of the picture can be seen the authentic leaf springs and shock absorbers as against the coil springs I have specified