Derby 2P – An LMS 4-4-0 in 3½ in. gauge

by: DON YOUNG

Part I – Introduction

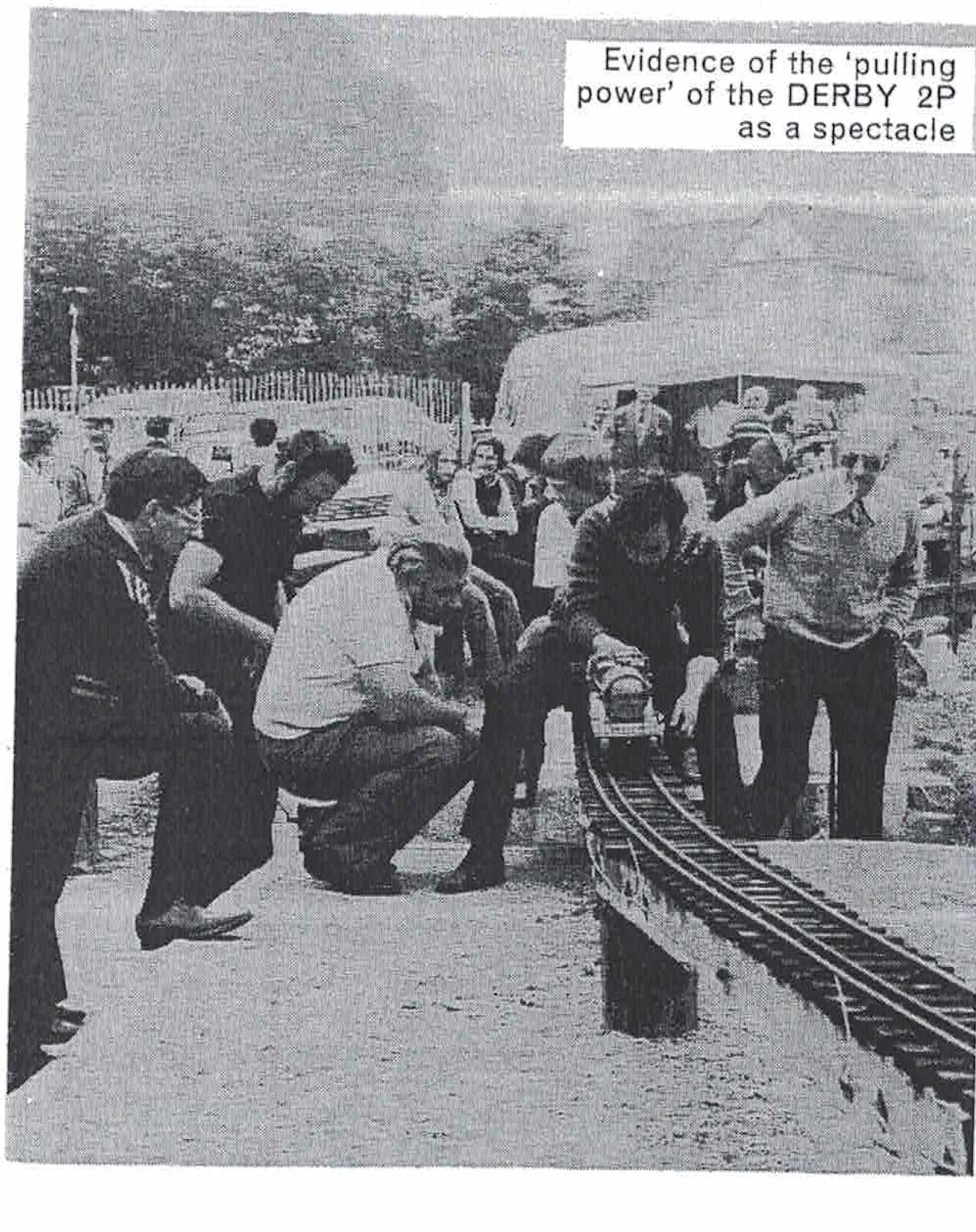
What next I thought? The BLACK FIVE bogie which is the only feature which differs fundamentally from E. S. COX. Being a Great Central fan, and in particular J. G. Robinson, the POM-POM that I slipped into my lists rather quietly appealed, but again it was 5 in. gauge and I do have to ring the changes. When the DERBY 4F 0-6-0 began to do great things on the track, I brought out the 'high flyer' 2P 4-4-0 using all the same castings, save for the coupled wheels which Reeves kindly produced for me, but at the time I drew her I must admit that it was just another engine to add to my growing list, a variation on a theme. I remember that one or two of my friends told me at the time I introduced the design that the full size 2P's were not very good engines at all, but by applying the 4F ingredients, especially Joy valve gear which of course is not prototypical, I had no worries on that score. A few months later I gave a talk to the Fareham MES, when I was entranced by a 75% complete 3½ in. gauge 4-4-0 that seemed vaguely familiar, it was Steve Titley's 2P with Fowler adornments, ones which Steve described for us in LLAS No. 2. From that first sight in 3D my enthusiasm for DERBY 2P grew in leaps and bounds, for she was incredibly beautiful, more so than any photograph can convey, but might she flatter to deceive? Enthusiasm grew to real excitement when she proved to be as good as her looks on the track, so that I can best describe her as 'a high stepping lady' – a thoroughbred. She does not have the sheer strength of a 4F, but I have seen her battle gamely up the 1 in 70 gradient of the Fareham track, experienced it at first hand too, and once over the summit, did she go!

So 3½ in. gauge it is, and there are other reasons why my choice is the DERBY 2P. Model engineers on both sides of the border in Ireland, that lovely country with the friendliest people on this earth, in Holland too where my memories are equally pleasurable, found the 2P to be very similar in general proportions to native engines, so she is assuming different guises. A little aside about the 'Irish 2P' being built by Michael Curran near Wexford; he had the misfortune to discover porosity in the original cylinder block supplied, so telephoned to ask if I would replace it for him. I apologised for the faulty original supply and sent off the replacement forthwith, correctly describing the article on the Customs label as a 'replacement gunmetal casting'. On reaching Dublin, the 'gun' in gunmetal obviously alerted the authorities, and I guess a twin-bore casting aroused suspicion that I was trafficking in arms; for whatever reason the parcel reached Michael minus the cylinder block. It just goes to show how even model engineers are affected by the current unrest, some of my Irish friends are much closer than Michael to the sad events of course; I pray that peace will return and soon.

I said that the 2P was derived directly from the 4F that was described in 'Model Engineer' throughout 1975. When said series was about 50% complete, came the shattering news that no longer could I contribute constructional series to that publication. There is pride that I did not give up at this point, but carried on and completed the series, though I am sure readers will understand this was not easy, and of course there was a full stop at the end of the series, with no chance of any follow-up material; DERBY 2P will provide me with the opportunity to rectify this.

There is a 'Top Ten' of miniature steam designs, just like the record charts, and for some unknown reason it has never been published or even referred to in print before to my knowledge. Back in 1975 the MINNIE and ROYAL CHESTER Traction Engine designs featured prominently, with TICH, JULIET, ROB ROY and SIMPLEX most popular among the Locomotives. I only got to know of the Top Ten because DERBY 4F made a brief appearance at No. 9 in 1975 and seemed destined to go higher; until she was killed off immediately my contributions to ME ceased and now languishes at No. 31 in my own chart, which is a pity as she has started many off on the road of miniature steam locomotive construction and is a surprisingly good performer for her size. More recently, HUNSLET must have been No. 1 in the charts, selling more than 5,000 sets of drawings in the barely 10 years since introduction, MARIE E has been very popular but is now being overtaken by the 7¼/7½ in. gauge MARIE ESTELLE, perhaps the first engine in this gauge to enter the charts? Designs like E. S. COX and DONCASTER will never reach the No. 1 spot, their value is in prestige rather than popularity, plus of course their description can be more widely used. A perfect example of this is that anyone who wants to arrive at a super-detail 2P can take the completely authentic tender from E. S. COX and reduce it in scale by 12/17, so already one series is of benefit to the next.

For the rest of us, there is very little construction that can be tackled in this initial session, but before making a start I should set down some of DERBY 2P's vital statistics to further whet the appetitite. As can be seen from the detail, mainframes are 23⅝ in. overall and as with GLEN, there is no cut-out in them to clear the rear bogie wheels, clearance being provided by means of bogie side control springing. Coupled wheels are a massive 5 in. diameter, real flyers!, and



Evidence of the 'pulling power' of the DERBY 2P as a spectacle because of this it is permissible to open out the cylinders to $1\frac{3}{16}$ in. bore (x $1\frac{1}{2}$ in. stroke). The boiler barrel is the same $3\frac{3}{4}$ in. o.d. as for the 4F, the grate being sloped to come over the trailing horns. A strong point of the design is the Joy valve gear, something that would have been more widely used in full size I am certain but for the weakening of the connecting rod by piercing it for the driving pin; in $3\frac{1}{2}$ in. gauge our connecting rods are not so highly stressed so there is no problem. From this basic specification I can recommend DERBY 2P both to the beginner and experienced builders alike as being something a bit special.

A few general words about the dimensioning before we make a start, though I shall draw attention to specific points as we come to them. At the end of 1973, I was instructed by 'Model Engineer' that the DERBY 4F was to have metric dimensions, so to make life easier both for myself and for builders, I chose a scale of 20mm = 1 ft; it meant for instance that the coupled wheels came out at exactly 100mm tread diameter and the other main dimensions also came out nice and rounded. When the design and the first three sheets of drawings had been completed, the metric instruction was changed in favour of 'imperial decimal', this as a prelude to metrication. I was too far advanced to change the scale back to the traditional $\frac{3}{4}$ in. = 1 ft., so did a straight conversion from metric to imperial; it was a thankless task and one fraught with the danger of introducing errors. For some reason I was not allowed to mention such changes of policy that had occurred behind the scenes, neither of them of my own choosing or liking, but at least I can do so now to resolve the confusion that has existed these past 10 years. For the 2P, the path of least resistance was to adopt the same scale as for the 4F, the tenders, cylinders and motion were then common to both and the boilers varied but slightly to suit the different chassis; I can imagine the comments from Alec Farmer had I changed the scale and arrived at a new set of boiler flanging plates and the like! Very much on the plus side, all the proportions are correct, and the slightly bigger engine that results is that much more powerful, so let us set about proving this statement.

Mainframes

I was tempted to specify 3/32 in. thick steel for the mainframes, as Reeves stock same in the $2\frac{3}{4}$ in. width we require, but although the frame staying is adequate, the structure as a whole benefits from the thicker $\frac{1}{8}$ in. (or 3mm); our need is for two 24 in. lengths which will have to be 3 in. wide initially.

The old hand machinists used to have a two foot rule, not the hinged variety, plus firm joint Jenny calipers, and very little else, with which they could produce the finest work. I have watched Chief Inspector 'Dolly' Gray at shipbuilders J. Samuel White & Co. turn bar to 12 in. diameter with these two implements to an accuracy of within .002 in., simply to demonstrate his skill as a turner in the pre-Inspection era not so many years before. I do not expect DERBY 2P builders to blossom out into such superb craftsmen, though some of you undoubtably will, but the two foot machinists rule will come in very handy as a straightedge if you are lucky enough to acquire one. Hold the straightedge against an edge of a length of the steel flat and hold the combination up to the light, this is the surest test there is for flatness. Choose the edge from the two pieces which is flatest, that means the least light passes through the gaps between material and straightedge, then take a 10 or 12 in. smooth flat file and use long strokes to rectify any unevenness, always along the material, never across, in fact it is akin to planing wood. Especially for beginners, initially the result will certainly be worse than at commencement, but you have $\frac{1}{4}$ in. of material in hand with which to learn the technique. Actually this 'daylight test' is super-accurate, there is no need for any other means of checking, but if you remain unconvinced, wipe the lathe bed clean, apply a light smear of Engineers Blue and gently rub the frame edge on same, this will reveal the 'high spots'. Once you are satisfied, use an engineers square to mark off at one end, file this flat and square, using the daylight test to arrive at an exact 90 deg. angle; we now have the two working datum from which to mark out the rest of the frames. Let these datum be the top frame and front buffer beam edges, so work back from the front beam face, scribing on the main positions like cylinders and coupled wheel centres as a first move, this with the engineers square from the top datum face. Use the machinists rule and measure everything from the front face; this way you will not get accumulative errors. Here I will break off to say a few words about the method chosen for dimensioning, which although arrived at completely on my own, American readers tell me is the Henry Ford system, which cannot be bad.

A one place decimal dimension (.5) denotes it is uncritical and is simply measured with a rule. A two place decimal dimension (.50) can still be measured by ruler, but requires much more care as it has a bearing on the end result. A three place decimal dimension (.500) indicates it is supremely critical; in most cases it means machining to a micrometer, but not always, as in the positioning of the weighshaft and the horn gaps on the detail we are currently working on.

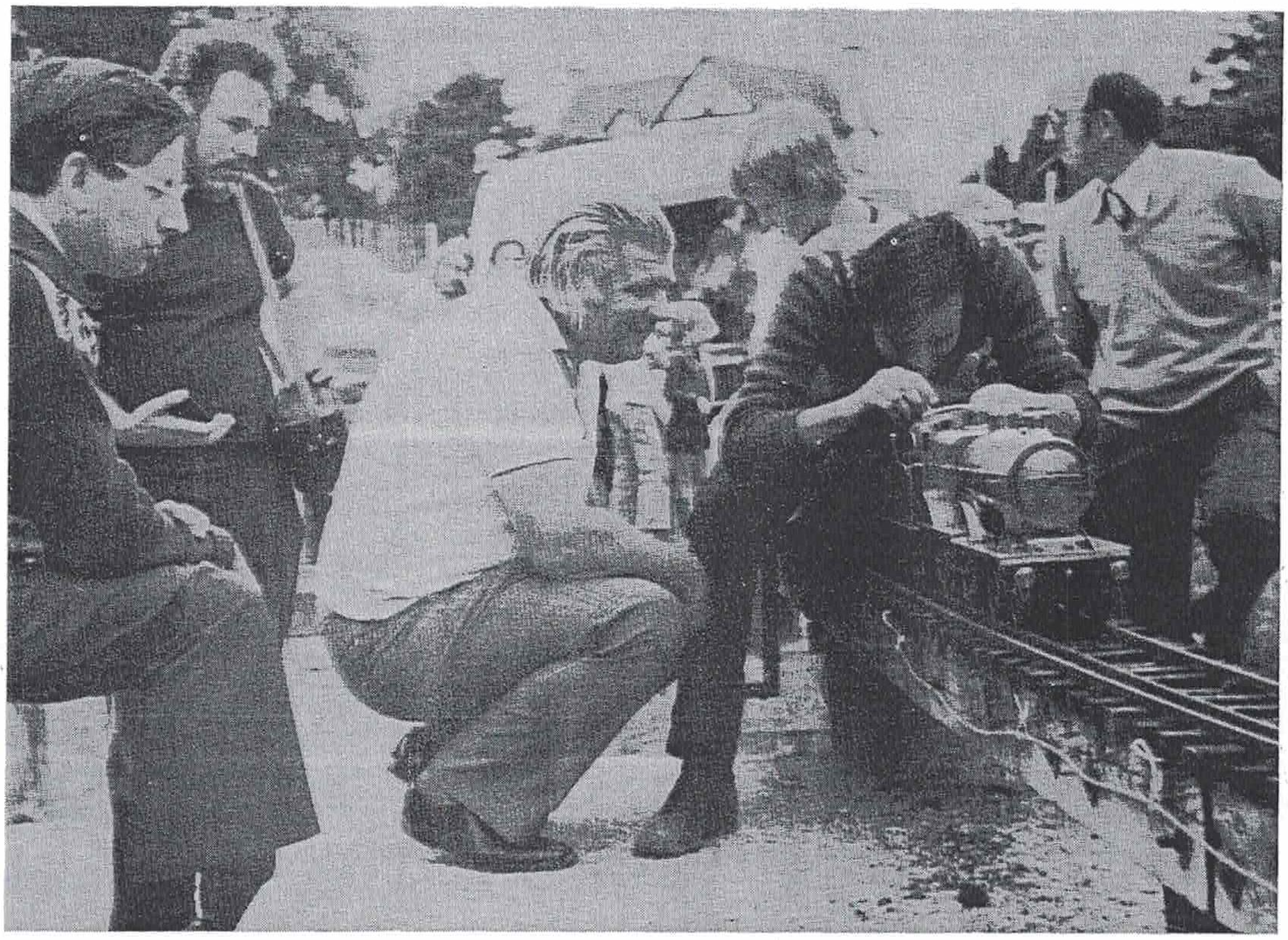
From the above it will also be seen that the position of the centre line of motion is also critical, indeed it is more so with Joy valve gear than most others. So lay the top datum edge of the frame on a surface plate, which can be the real thing, the lathe bed, or a sheet of plate glass, and use blocks to hold it firmly upright. Take a scribing block, the vernier height variety is illustrated in the current DONCASTER article, and set the scriber point at 2 in. above the table, as accurately as possible, and scribe on the centre line of motion along the full length of frame. I should have said before marking off commenced that the frame face be coated with marking off fluid, but now at least I can add the rider than if any line is scribed in the wrong place, simply coat over with more fluid to erase it and start again. Never leave a line that is wrong and scribe another alongside it, for Murphys Law says that at the critical time you will choose the wrong one of the pair. Now, using a combination of engineers square and scribing block, first mark off the frame profile and then the centres of all the specified holes.

Although I do possess an automatic centre punch, its use is largely confined to soft copper and I find an ordinary one far better when dealing with frames. Hold the punch at a slight angle so that you can see both its point and the marked out 'X' of the hole centre and give the punch a light tap, just to mark the metal. I am fortunate in being able to see the resulting dimple with the naked eye, but many of you have to use a magnifying glass to check same; correct as necessary by angling the punch in the direction the dimple wants to be moved and when satisfied, hold the punch vertical and give it a single smart blow.

Choose four holes roughly equi-spaced along the length of the frame, say front and rear beam fixings and those for the sandboxes, and drill these initially at No. 41. Now bring up the second frame, clamp it firmly in place and drill through this also in the four positions. Use either aluminium or copper 3/32 in. diameter snap head rivets to join the two together, just hammering well down and not worrying what happens to the heads; just support same on the bench vice; I suggest you tackle the rest of the holes next.

All holes must be drilled squarely through the frames, which indicates use of a drilling machine as first preference, alternatively using the lathe with a drill pad fitted to the tailstock. Use of a drilling machine does not automatically mean that holes will be drilled squarely through the frames, small drills are very flexible, and you have to check the drill is

Actually Steve Titley has just taken over from yours truly and is repairing the damage I did to the fire!



vertical by sighting in two planes against an engineers square. This is absolutely vital when you come to the weighshaft hole; drill this No. 34 initially and when satisfied on squareness, clamp the frames to the table, open out in stages to 23/64 in. diameter, then at the slowest speed, ream through at ⅜ in. diameter to complete. The specified rivet holes are countersunk at 60 deg. with the appropriate Rosebit, those for screws at 90 deg., only these latter are shown dotted to indicate they are on the inside of the frames and will therefore have to await their separation, still a little way ahead yet.

Before commencing to cut out the profile with a hacksaw, first file the two datum edges on the second frame to match the master, then saw away to your heart's content, following up with files to the scribed lines. Along the top of each horn gap, drill a row of ⅛ in. diameter closley spaced holes, then saw down inside each vertical line. Grip in the bench vice with the top of the gap flush with the vice jaws and break out the surplus metal by cutting between the holes with a small chisel, just tidying up with a file as our next job is to machine same to size.

All the machining operations I will describe for DERBY 2P will be with reference to the Myford ML7 lathe, mainly because this is the only machine tool to adorn my workshop, so this is the one I check out the machining operations on, though for the 2P the Myford ML10 will also be very suitable. Fit the faceplate, then the vertical slide to the boring table, bring the vertical slide table hard against the faceplate and tighten up the tee bolts to the boring table. Next job is to bolt the machine vice to the vertical slide; grip a length of, say, ¾ in. square bar in the machine vice and lower onto a similar length of 2 in. x ¼ in. BMS flat stood on the lathe bed until the two are in close contact; tighten the machine vice securing bolts. This is a very simple way of setting up the vertical slide and machine vice accurately. Now chuck a ⅝ in. end mill in the 3 jaw, check its side teeth are long enough to cut the full 1⅜ in. depth of horn gap and then clamp the frames in the machine vice, with jaws right behind a horn gap to provide the maximum support. Take a very light cut with the end mill, feeding against the rotation of said end mill; if you do it the other way then once will be sufficient to learn the error of your ways!, then bring that face to the scribed line. Tidy up the bottom of the gap to line, then concentrate on the second side face, only instead of working to the scribed line, use a piece of 1 in. wide commercial steel bar as your gauge and get it a good fit; this is the sort of accuracy you are looking for rather than exactly 1.000 in. Deal with the second horn gap in like manner, then separate the frames and remove all the burrs and sharp edges so that they are safe to handle.

Horns

Specified horns are the standard Reeves 3½ in. gauge hot pressed pattern, this form of manufacture ensuring uniformity and accuracy with a very minimum of machining. The frame fixing face is in fact so flat that it is very feasible to just file the .010 in. or so from the locating spigot to fit in the horn gap, a tight fit therein. Those who prefer machining should first grip the horn in the machine vice with the two bottom feet facing the chuck and mill to 1⅝ in. overall height. Sit these machined feet on the bottom jaw of the machine vice and tighten the top jaw onto the inner top flange, then lightly mill all round the frame fixing face and spigot to arrive at the same tight fit, keeping the axlebox slot central; mill the spigot to be ⅛ in. deep to match the frames. Reverse in the machine vice and mill to ⅜ in. overall thickness, when we are ready to attach the horns to the frames.

Clamp a horn firmly in place on the inside of a frame, then fit a 2BA bolt and nut in the axlebox slot and open out to hold the legs hard against the horn gap at the bottom; drill through as many of the rivet holes as are clear of the clamps. We now need two simple tools as an aid to correct rivetting. First chuck a 4 in. length of ¼ in. steel rod in the 3 jaw, set the top slide over about 5 deg. and turn a taper on the end down to about 5/32 in. diameter. Lightly centre the end, enter a No. 30 drill, then remove to the bench vice and with a hand brace, waggle the drill about to produce a cup to accept a 3/32 in. snap rivet head. Chuck another 4 in. length of the ¼ in. rod, taper the end again, but this time centre and drill No. 39 to about ¼ in. depth; we now have a rivet 'dolly' and 'set' made in that order.

Grip the dolly upright in the bench vice, fit a rivet through horn and frame then sit the rivet head on the dolly; the rivet wants to be $\frac{3}{8}$ in. long. Sit the set over the projecting shank and give it a couple of sharp blows to bring the joint into good contact, then hammer the shank down into the countersink in the frame. Actually $\frac{1}{8}$ in. of projecting shank is a little on the generous side, so you can either crop the end off, or for beginners just hammer as much as you can into the countersink, this without damaging the adjacent horn face, and then file flush afterwards, deal with all seven rivets in like manner.

When all four horns have been fitted, bolt the frames back to back so that the horns are sticking out, and mill the axlebox slot to $\frac{7}{8}$ in. width and $1\frac{1}{4}$ in. depth exactly as we did for the horn gaps, only making sure this time that the slot remains central in the horn as the frame locating spigots are only $\frac{1}{16}$ in. thick; don't worry though if there is a slight discrepancy in the 7 in. coupled wheel centres.

Although there are several more details on Sheet 1, most are there as 'space fillers' rather than in logical building sequence, so we cannot deal with them all, though the frame stay we can at least progress.

Frame Stay

This is a gunmetal casting, one that requires very little machining, so let me quickly describe same. The easiest way to hold the casting for machining is by bolting directly to the vertical slide table, so mark off and drill a pair of $\frac{1}{4}$ in. holes at $1\frac{1}{2}$ in. centres on the vertical centre line to match the slots in the table. For any machining operation, the thing to avoid is ruining the precise faces of your equipment with the tool in use, like for instance drilling through a table or in this case milling away its edges, so pack the casting to be about $\frac{1}{8}$ in. clear of the table to prevent such a disaster occurring. Now with the side teeth of your $\frac{5}{8}$ in. end mill, I find this a most useful size, clean up one flange of the casting, only in telling you how to avoid one disaster I have nearly precipitated a second!

Rule One when dealing with any casting is to run a rule over same to assess the machining allowances provided. 'Measure twice, cut once' was something drummed into us budding woodworkers 45 years ago and this is equally apt when cutting metal today. I have said many times that I love black engines, to me they look the part, though this statement always brings me into conflict with many, indeed most, of my friends. Talking of my junior woodwork days, I was given a cherished piece of japanese oak with which to make an ornamental box. It was fashioned to tutor Dick Maybey's satisfaction, the dovetail joints were all immaculate and only required a very minimum of the evil smelling original cow glue to secure them, but my application of a black wood stain was not to Dick's liking. Thereafter my skills were employed in repairing the fabric and equipment of the school, which effectively killed off any DIY instincts, which perhaps was no bad thing!

Back to the casting, where my rule indicates there is but a bare 1/32 in. of metal to be removed at each flange, so mill away said amount at one side. Having said how the old time machinists got by very well with just a 'measuring stick and calipers', although I don't put myself into such exalted company, for 25 years the only concession I made to this was an 0 – 1 in. micrometer that cost me all of 50p with accuracy to match; the most useful measuring tool in my workshop today are vernier calipers, accurate to closer than .001 in. in outside, inside and depth measurements. Every model engineer should possess this tool, and the ability to use it. Take a light cut on the second flange face and use said vernier calipers over the pair of flanges to assess the remaining metal to be removed, advance the cross slide by said amount and do just that. Although not a licence for poor workmanship, if the final result is not exactly 2.875 in. but within .005 in. of same, then don't worry overmuch. For the most important feature is that the frames be parallel to one another rather than an exact distance apart, so you can use the frame stay as the 'master', bring the vernier calipers up to it at any time, and simply arrive at the same dimension for motion plate, cylinders, bogie bolster and buffer beams as we come to them.

Axles and Crankpins

Reverting to the tale of old time machinists, when they wanted to set up a shaft accurately in the lathe, it was invariably held in the 4 jaw chuck and they simply held a piece of chalk perfectly still with which they could mark any eccentricity. I never acquired this skill, try as I would, but for around 25p gained a superb mechanical equivalent. My original test gauge, the one I still rely on most these days, is called 'The Unique' and was made by J. H. Grant in Erith, Kent; I

This shot by Alan Bealing shows yours truly in deep trouble on the Southampton track, having forgotten that the grate is a sloping one – and I drew it! This is the picture the then printers rejected for LLAS No. 2

wonder if this company and the simple gauge are still flourishing 35 years on? Basically the gauge consists of a spring loaded plunger which follows the workpiece as it revolves in the lathe and displaces a needle over a graduated scale, movement being over a small arc. The scale is supposedly marked in .001 in. increments, but of course such is immaterial, for the work is accurately centred only when the needle stops moving and one doesn't need to pay over £50.00 for a supremely accurate dial test indicator (d.t.i.) to arrive at said result.

Saw two full $4\frac{5}{16}$ in. lengths each from $\frac{3}{8}$ in. and $\frac{1}{2}$ in. diameter bright steel bar, chuck one of the latter in the 3 jaw and check with a d.t.i. that it is running true; if there is any error then change to the 4 jaw and set up accurately. Lightly face the end, just to clean it up, then centre deeply as this is likely to come in useful later, plus it is an authentic feature from full size. The axle only wants to project $\frac{5}{8}$ in. from the chuck jaws, so although you can use the tailstock to support the outer end, such is not mandatory. Because of my recent dissillusionment with Loctite, oh, for the days of No. 35 that was specified on the 2P drawings!, I will describe the tried and long tested press fit method, for which I must assume the wheels are complete and to hand. First reduce over a $\frac{1}{2}$ in. length to around .443 in. diameter, the exact figure not being important, only that a few thous be left to be removed. Now concentrate on the end $\frac{1}{16}$ in. of bar, reducing it further until the wheel will just push over it. Wind the tool away from the job and then advance it to within .00025 in. of the previous setting; turn the wheel seat to this diameter.

I am often asked how to machine axles and the like to length, when most of the bar is hidden by the chuck and headstock mandrel; an accurately scribed line is very rarely visible when it rotates, especially if covered by cutting oil. There are of course several ways of doing most things, but for this particular problem, reverse the axle in the chuck and take a very light skim across its end face, then remove and check the length with the vernier calipers, when you know the amount of metal left to be removed. Chuck again, this time running true and with $\frac{5}{8}$ in. projecting from the chuck jaws, bring the tool up to the job and advance the top slide by the correct amount to face off to length; centre and then complete this end as previous. Only the diameters, $\frac{3}{8}$ in. axle and $\frac{5}{16}$ in. wheel seat vary for the bogie pair, lengths being identical, so these should pose no problem. No machinist was ever 100% successful in all he did, I certainly was not!, and an easy way to retrieve a slack axle end is to knurl it; such is a far better engineering solution than it sounds.

Crankpins can be chucked in the 3 jaw whether they are running slightly out or not, material being 7/32 in. silver steel rod, being first faced off to length. Then with $\frac{1}{4}$ in. projecting from the chuck jaws, reduce over a .2 in. length which is a full $\frac{3}{16}$ in., down to $\frac{3}{16}$ in. diameter. If any beginner has problems machining silver steel, and it is not the easiest, then change to mild steel as this is perfectly adequate. Fit the tailstock die-holder, grip a 2BA die in same with gap opened out to cut a tight thread for the crankpin nut; hold chuck and die-holder in either hand and screw, never try such an operation under power.

Coupling Rods and Brasses

Although these parts are detailed on Sheet 1, to describe their manufacture would have to assume too many other things had been done, so they will have to await the next session.

HELP!

I was hoping to have a much more leisurely run in to the DERBY 2P, but unfortunately this was not to be, one consequence of which being a lack of time to sort out proper illustration for this first part of the series. So if any reader can help me out with photographs of either the full size engines, or ones under construction in miniature, such will be very much appreciated.

Through Don's letter box

I have just received LLAS' No. 23 which includes the last installment of your series of articles on the Horwich 2-6-0. Thank you for sending them to me and although model making has never featured in my repertoire, I have followed your writings and admired the skill with which a 4 ft. $8\frac{1}{2}$ in. gauge machine can be rendered down to a 5 in. gauge model. You say that only a few examples are under actual construction (Ed: The latest count is around 50); this of course is understandable for the 'Crab' has never been one of the 'glamour' prototypes, as is for example the Gresley 4-6-2 which also features in No. 23. Indeed, until now and under your present guidance, I doubt if many models have ever been produced since Basset Lowke's awful gaffe of 1925. At that time they sought an advertising gimmick to the effect that they could say that they were the only firm who had ever produced for sale a model of a locomotive not yet turned out by its building works. By mischance the model was based on the wrong diagram and the project misfired badly.

As I have told you before, you do me too much honour in attaching my name to the present project, but I do feel special affection for this engine in that it did start off my design career and after completing all the preliminary schemes, my diary tells me that just 60 years ago I was engaged in developing the valve gear, quite a novel departure from previous Horwich practice. Perhaps you can picture a willowy 25-year-old enthusiast bending over a full size model in the pattern loft, and setting down on paper the valve ellipses which defined the admission and exhaust events. There was no computer aided design in those days!

The final product turned out in 1926 obviously had some merit, for it found acceptance far and wide, and for more than 40 years continued on the duties for which it was intended, with hardly any alteration or rebuilding and was not surpassed in any way, or even outlived by the later Stanier version of 1933. Now they are talking of renewing much of the Diesel fleet after only 20 years service!

Thus the Horwich 2-6-0 was not an unworthy member of the steam fraternity, and to my ancient ears the short stabbing exhaust joins the chorus of sounds which memory relays from the past. May the gentle sound of the first completed model to your drawings soon assail your own ears as some reward for all the hard work you have put into your now completed effort.

With kindest regards

E. S. Cox

(Ed: That letter arrived on my birthday and all I need say is that it is the best present I have ever received).

Derby 2P – An LMS 4-4-0 in 3½ in. gauge

by: DON YOUNG

Part 2 – Progressing the Chassis

After the struggle to get the show started in Part 1, this time there is plenty to keep us occupied, so let me hurry on.

Main Axleboxes

Material for the axleboxes is a cast gunmetal stick and you can either cut it in halves or leave in one piece initially, depending on the equipment available for machining, or your chosen method. First job is to reduce the section to 1 in. x ½ in., either by chucking in the 4 jaw when half the material length is preferable, or by milling using the machine vice and vertical slide when it is possible to handle the single piece; whichever method is chosen, square off the ends of the bar(s).

Next job is to mill the slots, for which we need the machine vice and vertical slide, so chuck a ¼ in. end mill in the 3 jaw and mill a $\frac{1}{16}$ in. deep slot down the centre of a ½ in. face. Now gradually open out the width of the slot to ⅜ in., a tight fit over the horns, keeping the side flanges of equal thickness and making a note of the vertical slide micrometer collar readings when the final cut is taken. Rotate the bar through 180 deg., mill the same ⅜ in. wide slot but this time only to 3/64 in. depth, then continue to deepen it until it will just enter the horns, again a tight fit. Mark off into individual boxes and stamp them both for identification and handing so that, say, the second slot milled is facing forward on all the axleboxes; saw into individual axleboxes. We next have to face them all off to identical length, so face across a first end of any not so far dealt with, then fit a centre into the headstock mandrel and chuck one box in the 4 jaw hard against said centre. Face off to 1 in. length as close as you are able, then clamp the carriage to the lathe bed, when you will be able to face off the remaining boxes to the same length; this is very important.

Take one box and find the centre of the axle by scribing diagonal lines from corner to corner; I call this the 'X' method. Lightly centre pop and scribe on a ½ in. circle, then grip a pair of axleboxes in the 4 jaw chuck, remembering what I said about pairing the slots, with the scribed circle outermost. Grip a scriber under the toolpost and set the axleboxes so that the scriber point traces the scribed circle; you will easily be able to set this to within .005 in. which is sufficiently accurate for our purposes. Centre and drill through to $\frac{7}{16}$ in. diameter, then I recommend that you carefully bore out to ½ in. diameter using the axle material as your gauge; get this a nice running fit, which means the axle turns freely but without any 'shake' in the bore. Deal with the other pair similarly, then drill a No. 50 oil hole down from the top of each axlebox into the bore, removing all burrs.

We now have to ease each axlebox into its chosen horn by lightly filing the axlebox slots; in conclusion you should be able to slide the axlebox from top to bottom of the horn, again without any shake.

Hornstay, Spring Pin and Plate

The hornstays are 1½ in. lengths of ⅜ in. x ⅛ in. BMS flat, so saw out four pieces and face off to length, then mark off and drill the pair of No. 34 fixing holes, those marked at No. 28 being drilled No. 30 initially so that we can accurately locate the spring pins in the bottom face of the axleboxes.

Offer up to the bottom of the horn, spot through, drill No. 43 and tap 6BA for hexagon head bolts, preferably with heads one or even two sizes smaller than standard, then wedge the axlebox hard up to the hornstay, spot through, drill the spring pin holes in turn No. 39 to 7/32 in. depth and tap 5BA. For the spring pins, cut and square off eight 1⅝ in. lengths from ⅛ in. steel rod, fit a 5BA die in the tailstock dieholder and screw the ends of each pin to drawing. Enter a pin in an axlebox, fit two 5BA brass nuts at the outer end and tighten them together, then screw hard into said axlebox. To release the nuts, continue tightening the lower one, when it will break free from its partner and both can then be removed.

The spring plates can start as 1¼ in. lengths from ¼ in. x ⅛ in. BMS flat, clamped firmly and centrally to the hornstays, when the two No. 30 holes can be drilled through before the ends are sawn and shaped to drawing; no need to be too fussy here.

Open out the spring pin holes in the hornstay to No. 28 then begin relieving the sides of the axlebox flanges, as shown on the detail, until with the axle in place, each axlebox can be lifted about 5/32 independent of its partner, allowing the wheel to follow any unevenness in the track, then your 2P will not derail. Reeves have standard axlebox springs, ⅛ in. bore x 19 s.w.g. at a price where it is pointless winding your own, so complete this part of the assembly.

Buffer Beams

In my pre-vernier caliper days I used to make up a fixed frame gauge as is detailed, it even has the appearance of calipers so I was dreaming even then!, but nowadays I would suggest the price of the gauge plate is put towards calipers of your own if you do not already possess same; on with the beams.

The front beam is a 6¼ in. length of $\frac{15}{16}$ in. x 3/32 in. BMS flat or its metric equivalent and will certainly have to be sawn and filed, or milled, to specified width. Mark off and drill the holes, that for the coupling hook being completed with a square Swiss file to a piece of ⅛ in. square bar as your gauge. Saw out two 1 in. lengths from 1 in. x 1 in. x ⅛ in. square root and corner steel angle, grip in either the 3 or 4 jaw chuck to face them off to $\frac{15}{16}$ in. overall, then saw one leg down to ¾ in. Although you can clamp the angles to the beam, I suggest you leave the rivetting until the cylinder block has been machined, so you can use the latter to get the mainframes the correct distance apart, the angles then aligning to the outside of the frames. You can though offer up each of the angles to the frames to spot back and drill through the angles at No. 34 in the four positions. The final job after rivetting together, which is carried out exactly as for fixing the horns to the frames, is to drill and tap the pair of $\frac{5}{16}$ x 40T holes for the buffers.

The rear buffer or drag beam starts from a 6¼ in. squared length of 1¼ in. x 1¼ in. x ⅛ in. steel angle; snape the bottom corners $\frac{7}{16}$ in. x 45 deg. as shown. The ends of the top face have to be relieved by 3/32 in. to accept the valances, a chance for you to get a bit of sawing and filing practice before moving on to mark out and drill the specified holes. For the drawbar slot, start by drilling three 7/32 in. holes along its centre, then break the holes into a slot with a square file before completing to line. Mark off on the top face for the frame slots, fit two hacksaw blades to your frame, when you will be able to saw a slot roughly 3/32 in. wide inside the scribed lines. A key-cutting file is slightly less than 3/32 in. thick at its outer end and this will allow you to open out the slot both to line and to a piece of actual frame material as your gauge, when vernier calipers inside the latter will indicate how close the final result is to 2.875 in. Cut and square off two $1\frac{1}{16}$ in. lengths from 1 in. x 1 in. x $\frac{1}{8}$ in. steel angle, abut against the frame material in the slot, clamp in place, drill through and secure with $\frac{1}{8}$ in. iron snap head rivets.

For the drawbar block, take a length of $\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS bar and square off one end, chucking in the 4 jaw to do so. Offer up centrally under the top face of the beam, hard against the inside vertical face, clamp and drill the No. 11 hole right through; saw and file away the excess bar and radius the drawbar block to drawing; again you need not be exact. Now site said drawbar block below the drawbar slot, poke a No. 11 drill through the drawbar pin holes to ckeck alignment, then clamp in place to drill and tap the block for 6BA x $\frac{3}{8}$ in. long screws. We will leave fixing the beam to the mainframes until we have a few more pieces.

Coupled Wheels

When Reeves agreed to produce the castings for the driving and coupled wheels for me, we decided to omit the balance weights to increase their utility, for 80 in. drivers were very common in full size. The wheels are also the 'solid back' type, which means the pattern is a single-sided one and helps ensure that everything is concentric, though another main reason for the solid back is that it allows finer spoke detail with less chance of scrappage.

First job as always is to assess the machining allowances; next saw and/or file the feed point away at the wheel flange, so that you can chuck truly by the tread in the 4 jaw and allow a knife edge tool to trace out the flange; no need for a d.t.i. here. The beginner should not concern himself about the lack of balance weights, they serve no useful purpose in $3\frac{1}{2}$ in. gauge, but experienced builders can cut a crescent shape from cardboard, position on the outside of the spokes and fill between the latter with Isopon P38 or other similar car body filler. First job is to face off the back of the wheel; according to the sample I am checking there is 3/32 in. of metal to be removed to reveal the individual spokes, though of course it is permissible to remove only $\frac{1}{16}$ in. at the tyre and centre boss, carrying on for another 1/32 in. in the spoke area only, in which case the crankpins will be 1/32 in. less than specified length. Use a round nose tool for this operation, and to turn the flange down to $5\frac{1}{4}$ in. diameter, erring on the slow side for lathe speed as your time is your own, so engage back gear. Change back to direct drive to file a wee radius between wheel back and flange; **always** fit a handle to your file to prevent the tang causing you personal injury. Still in direct drive, centre with a Slocombe drill, carry on through the wheel at around $\frac{3}{16}$ in. diameter, then open out to 27/64 in. diameter and ream through at $\frac{7}{16}$ in. diameter, using paraffin as tool lubricant; it works wonders.

Next job is to find a broken drill of around $\frac{1}{2}$ in. diameter and shank to suit your headstock mandrel, your local scrap metal merchant is likely to be of assistance here. Saw the drill just behind the flutes, it will cut surprisingly easy, then wipe both tapers clean before engaging the drill in the headstock. Face off the saw cut, then turn down to $\frac{7}{16}$ in. diameter, a tight fit in the wheel centres, almost up to the spindle nose. Fit the faceplate, slide on a wheel so that its back is hard up against the faceplate and bolt in place through the spokes; I use countersunk screws here so that the heads do not get in the way when I am turning. Face the wheel tyre off to $\frac{7}{16}$ in. overall thickness, then ease the top slide out by $\frac{1}{16}$ in. to face the crank boss. Turning the tread can be a trying business, so first avail yourself of a tool which can produce the around 3/64 in. root radius; grind this on any ordinary turning tool if you have nothing like this by you. Again run the lathe in back gear and take light cuts, stopping and pulling the lathe round by hand as you reach the root radius between tread and flange to avoid tool chatter. When you arrive at around 5.010 in. diameter by vernier caliper, stop there and bring the other wheels up to the same state. Leave the last wheel in place, take a final cut of a few thous to come close to 5 in. diameter, then repeat for the other three wheels without disturbing the tool setting, then they will all be the same diameter. Set the top slide over 30 deg. to turn on the wee chamfer, then change to direct drive to complete the radius on the flange with a file.

Crankpin Holes

Our wheels are complete save for dealing with the crankpin holes, for which we require the simple jig as detailed. Saw out and square off a $1\frac{1}{2}$ in. length of $\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS bar, then grip in the machine vice on the vertical slide. On the centre line of a $\frac{3}{4}$ in. face and at about $\frac{7}{16}$ in. from one end, centre, drill and ream through to $\frac{7}{16}$ in. diameter. Move on .750 in. by the cross slide micrometer collar, then centre again, drill and ream to $\frac{3}{16}$ in. diameter. If you do not have 7/32 in. silver steel rod by you for the pin, then turn it up from mild steel; in both cases secure with Loctite No. 601. Fit the jig to the crank boss, line the $\frac{3}{16}$ in. hole to be central in the boss, then fit and tighten the $\frac{5}{16}$ in. BSF (or similar) nut to hold the jig firmly in place. Pack the wheel up level on your drill table, then drill through the jig at No. 13 and ream at $\frac{3}{16}$ in. diameter; our wheels are complete except for tidying them up with files as required.

Feed Pump

I do not propose to describe manufacture of the pump itself as being the standard LBSC pattern lock, stock and barrel; experienced builders can easily knock this up and if the beginner is unable to purhcase a complete pump from Reeves then no doubt DYD will be able to oblige. Unfortunately the supply does not extend to the eccentric drive, so let us concentrate on this, starting with the eccentric itself.

Chuck a $1\frac{1}{2}$ in. length of $1\frac{1}{4}$ in. diameter steel bar in the 3 jaw, face and turn down to $1\frac{1}{8}$ in. diameter over about a $\frac{7}{8}$ in. length. We now need a parting off tool with business end ground perfectly square with which to cut the groove; it need not be the full $\frac{1}{4}$ in. width, in fact there is less likelihood of tool chatter if it is only around $\frac{1}{8}$ in. wide. Over the very outer $\frac{1}{4}$ in. of bar, reduce with said tool to $1\frac{1}{8}$ in. diameter by vernier caliper. Now move on to leave a full $\frac{1}{16}$ in. flange and repeat the $\frac{1}{4}$ in. groove to exactly the same diameter, which means recording the cross slide micrometer collar reading. Now part off a $\frac{3}{8}$ in. thick sheave, leaving a plain piece about $\frac{1}{8}$ in. long as gauge for machining the mating eccentric strap, then face the eccentric down to a full 11/32 in. overall with flanges of equal thickness. Facing off in the 3 jaw will indicate the centre of the eccentric, so mark on the $\frac{3}{16}$ in. throw, get this running true in the 4 jaw, then centre, drill and ream out to $\frac{1}{2}$ in. diameter.

The eccentric strap is a gunmetal casting, again first assesss the machining allowances provided, then grip by the bore in the 3 or 4 jaw chuck and face off to .245 in. thickness, removing metal of course from both sides. We now have to cut the strap in halves, so mark on the joint, saw into two and fit each half in turn in the machine vice on the vertical slide to mill the joint faces clean and square. Apply Bakers fluid to the joint faces, heat them gently and tin them with soft solder; allow to cool. Bring the joints together, heat again, press firmly together and allow to cool; these joints will be rather flimsy so do take care. Chuck in the 4 jaw and bore out to $1\frac{1}{8}$ in. diameter, a nice fit over your gauge, then back to the machine vice and vertical slide to drill the fixing bolt holes.

To the bottom bolt is attached the lubricator drive bracket, a detail which appears on Sheet 3, so this hole wants to be drilled right through at No. 34. Because of the presence of the oil boss at the top, we won't be able to fit a nut if we drill a clearance hole right through, so drill No. 34 to $\frac{5}{16}$ in. depth only and then carry on at No. 43 before tapping out at 6BA; separate the strap and clean off all the solder. The front half requires more attention yet, so first back to the machine vice and vertical slide to arrive at that $\frac{3}{4}$ in. dimension to the rod face. Next drill the No. 30 oil reservoir hole to $\frac{1}{4}$ in. point depth, then drill back from the bore of the strap at No. 60 into the bottom of the reservoir to complete the lubrication arrangement.

For the eccentric rod, start with a length of $\frac{3}{8}$ in. x $\frac{1}{8}$ in. BMS flat, drilling a No. 3 hole at 7/32 in. from one end. Radius the end over a mandrel with an end mill, an operation I have described many times over the years and will probably do so again when we reach the valve gear, then saw off and square the end to 1 7/32 in. and file the flanks to $\frac{1}{4}$ in. width as shown. The end flange is a $\frac{5}{8}$ in. finished length of $\frac{1}{4}$ in. x $\frac{1}{8}$ in. BMS flat; set the two pieces up on your brazing hearth, coat the joint with flux mixed to a stiff paste, and silver solder together. Now grip again in the machine vice, face off the flange to thickness, then centre and drill the pair of No. 44 holes. Offer up to the strap, spot through, drill and tap the latter 8BA and secure with hexagon head bolts. The bush is from 7/32 in. bronze rod; chuck in the 3 jaw, face and lightly chamfer the end to enter the No. 3 hole, then centre and drill through at No. 30 before parting off an $\frac{1}{8}$ in. slice. Press into the rod, run the No. 30 drill or an $\frac{1}{8}$ in. reamer through again, when you can assemble to drawing, only we need the crank axle first.

Crank Axle

The main crankpins are $\frac{13}{16}$ in. lengths of $\frac{1}{2}$ mild or silver steel rod which leaves us only the webs to make. Cut and square off four $1\frac{3}{4}$ in. lengths from 1 in. x $\frac{1}{4}$ in. BMS flat, scribe the centre line along one piece, then clamp them all together in the machine vice, on the vertical slide. Centre, drill and ream through one hole to $\frac{1}{2}$ in. diameter, then move on by .750 in. on the cross slide and repeat. You can either radius the ends over a mandrel with an end mill, or simply saw and file to shape; the latter is definitely for beginners. After the recent problems some builders have experienced with Loctite, I am going to change this 'process specifiction' to brazing and to assist in holding the bits in their correct positions, I recommend you lightly knurl the centre $2\frac{1}{8}$ in. length of axle so that the eccentric and crank webs have to be tapped into place. Pack one pair of webs up from the lathe bed and use an engineers square to align the other pair vertically, then coat with flux mixed to a stiff paste and silver solder all the joints. Wash off in warm soapy water, remove all excess flux and polish, then lightly grease to avoid any problems with rust.

Coupling Rods

For the moment I am going to assume that the frames are assembled, as hopefully they will be before this session is over, so that we can give attention to the coupling rods as detailed on Sheet 1. Our material requirement is two $7\frac{5}{8}$ in. lengths of $\frac{3}{4}$ in. x $\frac{1}{4}$ in. BMS bar; first scribe a line along a $\frac{3}{4}$ in. face at $\frac{5}{16}$ in. from one edge and then scribe vertical lines at 7 in. centres to roughly position the centres of the brasses. Pack the pair of axleboxes on one side of the engine hard down onto the hornstays as we did for the spring pins, then bring up a coupling rod blank and sight by eye the 'cross hairs' you have marked on same with the journal holes in the axleboxes; it is surprising how small an error will show up and will easily arrive at the required accuracy; clamp in place.

We next need a simple drill bush, so chuck a length of $\frac{1}{2}$ in. steel rod in the 3 jaw, face, centre, drill 11/32 in. diameter to $\frac{5}{8}$ in. depth and part off a $\frac{1}{2}$ in. slice. Separate the frames, drop the drill bush into the bore of an axlebox, take the whole to the drilling machine and drill through the embryo rod at 11/32 in. diameter; repeat at the other end of the rod. We now have the prime requirement that the coupling rod centres be exactly the same as the axle centres, more than half way to ensuring the coupled wheels will turn without binding. From the drilled holes at the ends of the rod, mark out the rest of the profile, sawing and filing to line. You can mill the end radius over a mandrel with an end mill, though there is an easier alternative, one based on what are known as 'filing buttons'. Chuck the $\frac{1}{2}$ in. rod again, face and turn down to 11/32 in. diameter over a 3/32 in. length and then part off at about $\frac{1}{4}$ in. overall; repeat. Heat to a bright cherry red, drop into a tin of casehardening powder and roll around to pick up said powder; you can reheat if you wish and repeat. This will make the surface glass hard, so wirebrush clean, engage the spigots each side of a rod eye and file down to the hardened surface. Take care with the oil boss though and drill it No. 41 right through into the bore.

The main portion of the rod is shown reduced to $\frac{3}{16}$ in. thickness and there is also a note about fluting, beginners can ignore both of these features and have plain $\frac{1}{4}$ in. thick rods; they will look perfectly O.K. To carry out said operations we first need a 9 in. length of 1 in. x 1 in. x $\frac{1}{8}$ in. bright steel angle in which $\frac{5}{16}$ in. holes are drilled in one face at 7 in. centres so that we can bolt the rod in place. On the other face we need $\frac{1}{4}$ in. holes at around 2 in. centres so we can bolt the angle directly to the vertical slide table. Our cross slide has insufficient travel to reduce the thickness with an end mill over the whole length at a single pass, so we must do it in stages, moving the angle as we proceed. Change to a Woodruff key cutter and flute the rod in the same manner.

The brasses are from $\frac{3}{8}$ in. bronze or gunmetal rod; chuck in the 3 jaw, face and turn down over a $\frac{3}{8}$ in. length to .345 in. diameter, easing the end 1/32 in. with a file to just enter the rod. Centre and drill 7/32 in. diameter to the same $\frac{3}{8}$ in. depth before parting off a 9/32 in. slice; repeat another three times. Press the bushes centrally into the rods, that means 1/64 in. of bush projecting at each side, drill a No. 55 oil hole from the reservoir through the bush and then run the 7/32 in. drill through the bush again.

Quartering and Wheeling the Engine

First job is to fit the crankpins to the coupled wheels, so degrease both parts with Primer 'T', apply a couple of drops of Loctite No. 601 and assemble; leave 24 hours to fully cure. Next job is to fit the driving wheels to the crank axle and for 4-coupled wheel engines, especially inside cylinder ones, there is no necessity to have the crankpins exactly 90 deg. apart; what we require can be achieved by eye. Slip on an axlebox, this omission has caused many a red face!, then enter the wheel on the axle end with its crankpin roughly at 180 deg. to the main one on the axle; take to the bench vice and press home, then repeat at the other side; you can now saw away the unwanted portions of axle and file flush with the webs.

Press one wheel onto the trailing coupled axle, then assemble the frames, erect the crank and trailing axles and fit the coupling rod to one side, all axleboxes still being hard against the hornstays. Bring up the last wheel, use the second coupling rod to get it correctly orientated and press onto the axle. The wheels should now turn sweetly – until you release one axlebox and try pushing it towards the top of its slot – we must ease the brasses in the coupling rods to prevent disaster at the track. Grip the 7/32 in. drill in the bench vice, fit a brass over it and push a $\frac{1}{16}$ in. steel rod down a drill flute. Pull the rod around the drill to pare metal from the brass, just a few thous so that when an axlebox is raised independently of its partner the rods will not bind; we have taken a giant step forward.

THE BOGIE

Bogie Bolster

I will start description with the bogie bolster as this casting has caused me more than a mite of trouble. There is a large chucking spigot on the base, so start by gripping same in the 3 jaw and taking a skim over the second boss above the base. Chuck again by the latter, face right across the bottom and remove that spigot, then centre and drill $\frac{1}{4}$ in. diameter. To complete this part of the procedure, chuck again by the base in the 4 jaw and turn off the upper spigot.

We can now proceed as for the frame stay in bolting the bolster to the vertical slide table, though as we only have a single hole we shall have to 'dog' the upper and lower edges to hold things nice and steady. Use the side teeth of your $\frac{5}{8}$ in. end mill to first arrive as close to $3\frac{1}{8}$ in. overall as you can get, the casting is a wee bit shy here as it was produced for 3/32 in. thick mainframes, then cut the spigots to arrive at the $2\frac{7}{8}$ in. frame dimension, and this is where all the trouble has been. On the sample casting chosen when the drawing detail was prepared, the $\frac{3}{16}$ in. dimension for the spigot was easily arrived at; nowadays the casting seems to have shrunk and the dimension achievable has become $\frac{1}{8}$ in.; many a casting has been returned as 'faulty' because of this. Actually it makes not the slightest difference, for if you look at the bogie assembly it will be seen that by increasing the $\frac{1}{8}$ in. flange thickness on the bogie centre to $\frac{3}{16}$ in. the situation is immediately retrieved, indeed you can turn up a $\frac{1}{16}$ in. washer and leave the centre alone if you wish – end of saga!

Bogie Frames and Axleboxes

The bogie frames are $7\frac{1}{2}$ in. finished lengths from $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat and after the mainframes should come as light relief, though do take the same care with them.

Bogie axleboxes start life as a cast gunmetal stick, first job being to arrive at the $\frac{3}{4}$ in. square section, a tightish fit in the slots in the bogie frames at this stage to assist with alignment later on; cut the stick in halves and square off the ends to arrive at lengths of around $1\frac{9}{16}$ in. Grip a piece in the machine vice, as usual on the vertical slide, and mill a $\frac{3}{8}$ in. wide slot to $\frac{1}{16}$ in. depth starting at $\frac{3}{16}$ in. from one end. Repeat the process at the other end, then rotate the bar through 180 deg. and do exactly the same for the opposite slots; this time we are going to fit the horns to the axleboxes.

Find the centre at one end of the bar by the 'X' method and chuck to run true in the 4 jaw; centre and drill right through. Although I have specified $\frac{3}{8}$ in. for the journal bore, there being no coupling rods or the like to worry about, the main criterion being to keep the engine on the track, the hole can be opened out to 25/64 in. diameter if you wish either by drilling or boring. With a round nose tool, ease the corners as shown to give a 1/64 in. raised face, then part off a full $\frac{11}{16}$ in. slice; reverse and clean up. Turn the raised face on the second piece and face this off to length, stamping the boxes as a pair.

Horns, Stays and Spring Blocks

Bogie horns are the same castings as for the tender and are in multiples of three, so you finish up with one spare horn at the end. Grip a stick in the machine vice and mill the working surface first, then turn over and deal with the frame fixing face. The third milling operation reduces the working face to $\frac{3}{8}$ in. width when the stick can be cut into individual horns and squared off to length. Fit an axlebox into its frame gap, bring up a pair of horns and clamp in turn to the axlebox and frames, then drill through and rivet in place. Later on you can ease the axleboxes to a free fit, but first deal with hornstays, things we already know about and this time there are no spring pins to worry over, springing being at the top.

Cut the spring blocks from $\frac{3}{8}$ in. x $\frac{3}{16}$ in. BMS bar and turn the ends to be a tight fit between the horns. I should have said before rivetting the horns to the frames to drill the No. 41 hole specified, when you can now spot through, drill the spring block at No. 47 and tap to 5/32 in. depth. Both spring block and axlebox are shown 'D' bitted to accept the compression spring, the 'D' bit being a flat bottomed drill obtainable from Reeves, so deal with this next, when you can press the wheels onto their axles, not forgetting the axleboxes of course and have a trial assembly, though the crunch will come after the next pieces have been dealt with. Incidentally, the bogie wheels are simple turning from the iron castings available; this time they are cast with open spokes and their machining was fully described quite recently for the G.W.R. 29xx SAINT CHRISTOPHER.

Bogie Centre, Centre Stay and Cross Tie

The cross ties are plain turning from $\frac{3}{16}$ in. steel rod, but do not rivet them in place just yet.

For many years the centre stay has been specified as a gunmetal casting, it should never have been and now I am able to correct the drawing to read steel fabrication. Cut and square off two pieces each to $2\frac{9}{16}$ in. and $1\frac{3}{4}$ in. finished lengths respectively from $\frac{3}{4}$ in. x $\frac{3}{16}$ in. BMS bar. We now have to build the box structure as shown, so clamp the longer pieces over a length of $\frac{3}{4}$ in. square bar to arrive at the required slot, this without any machining, then bring up the ends and clamp these too in place. If you prefer you can instead drill No. 34 holes in the end pieces, then spot through, drill and tap the ends of the cross members at 6BA and screw together for brazing, this is one decision I can happily leave to builders.

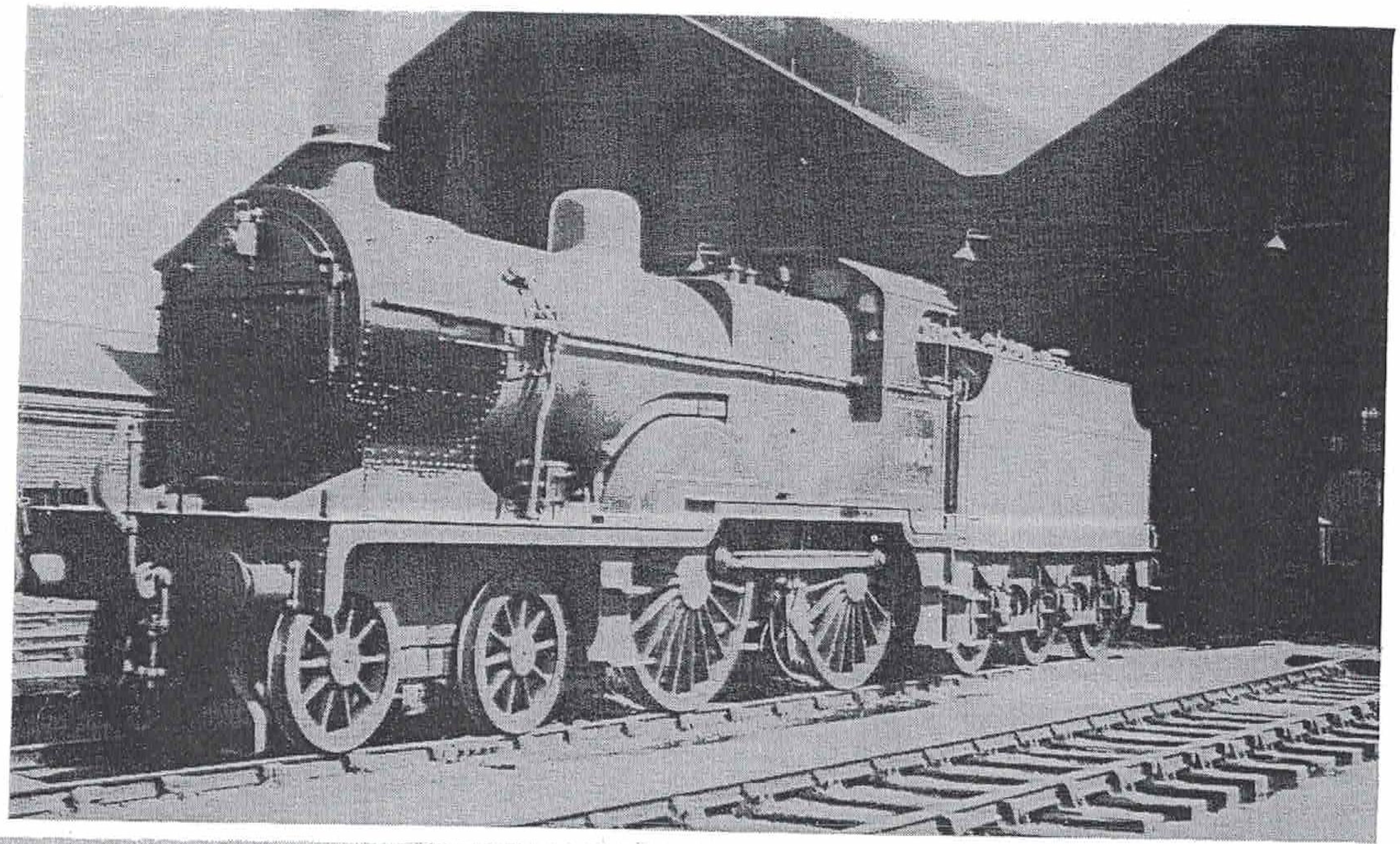
We have already brazed pieces of steel together, but as this is a major job I will go into the process in a bit more detail for the benefit of beginners among our ranks. Basically the problem in heating steel is that it very rapidly oxidises and no brazing spelter will penetrate the joint once this happens. So we have to completely seal out air at the joints and this is done by mixing the flux to a stiff paste and plastering it around each joint. Now heat must be very rapidly applied, to shorten the process and reduce the possibility of oxidation taking place, Easyflo No. 2 being the easiest spelter to use for the joints. All brazing should be done outdoors and in poor light, that way you will produce less of the harmful fumes by not overheating the parent metal and those that do form have the maximum opportunity to disperse without causing you personal harm. Wash off the centre in warm soapy water, use an old toothbrush to scrub away all excess flux and inspect, reheating if there is a problem, then spray with zinc from an aerosol can to prevent rusting.

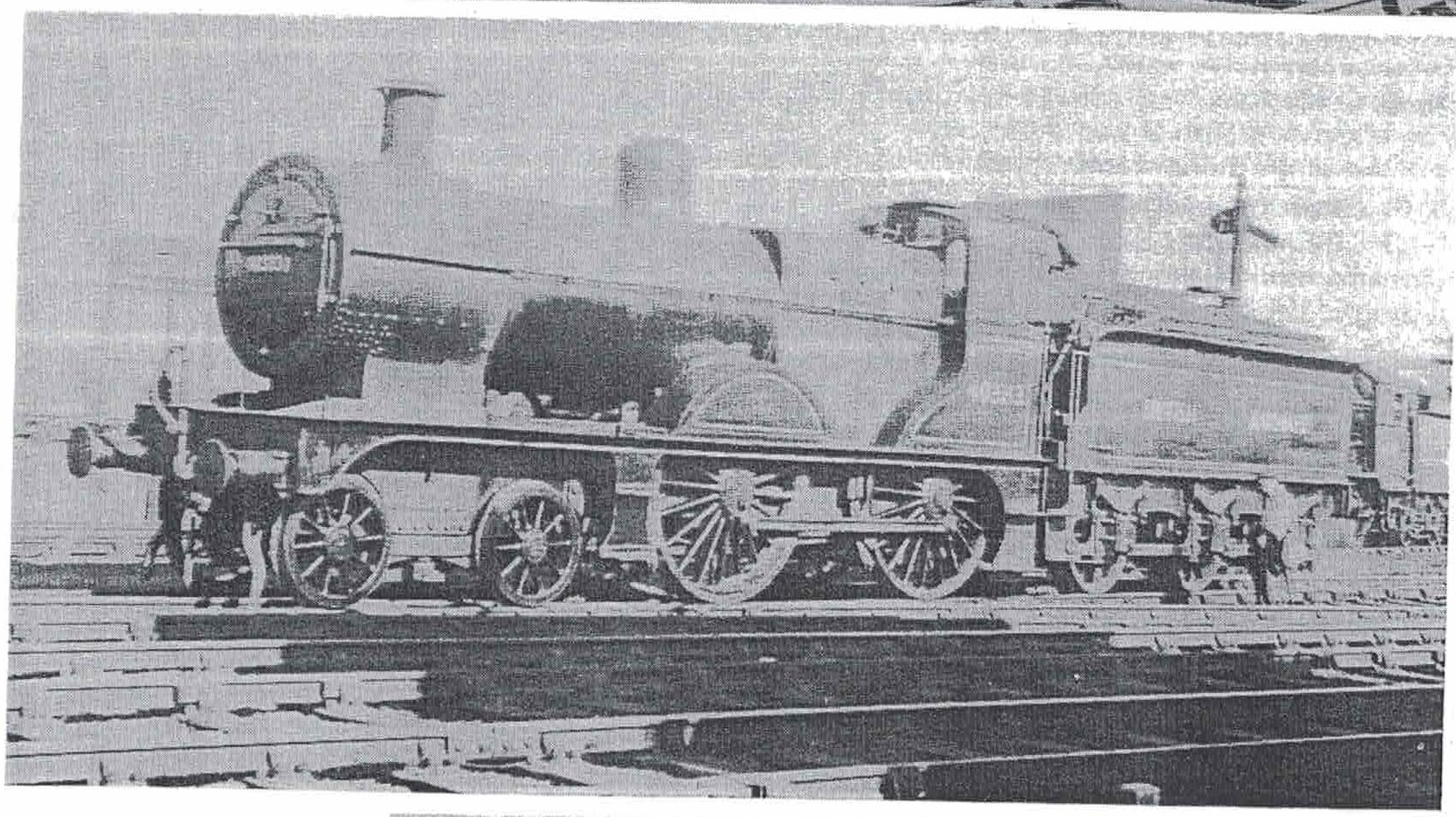
Machining is confined to reducing the overall width to $2\frac{7}{8}$ in. and depth to 21/32 in., all being achieved by medium of the 4 jaw chuck, when you can clamp in place, try the cross ties, and when the wheels turn sweetly, drill and tap the 6BA holes from the frames.

Although there is no specific casting for the bogie centre, indeed it would come out nicely from 1 in. square brass bar, I could supply something suitable if asked. Arrive first at the 1 in. square section, with depth either $\frac{13}{16}$ in. or $\frac{7}{8}$ in. depending on your bogie bolster as machined, then chuck truly in the 4 jaw, produce the raised face; centre and drill through to $\frac{3}{8}$ in. diameter. Reason for the precise dimensioning of bogie centre and stay is to ensure ease of movement within the constraint of the side control springs; more on the latter in a moment. First though we have to mill the two side flanks on the centre, an easy task for the $\frac{5}{8}$ in. end mill with workpiece held in the machine vice after what has gone before.

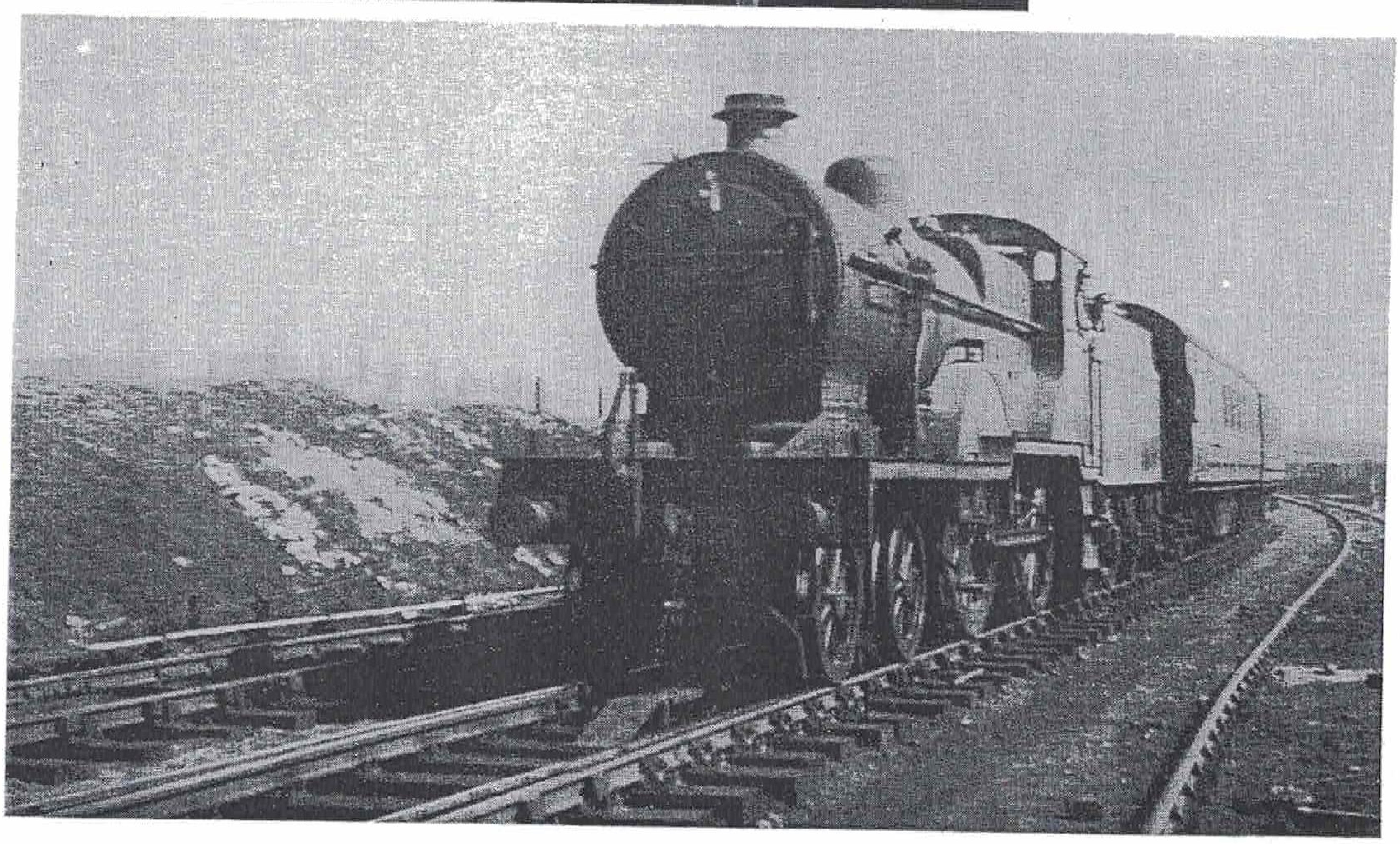
Rather than position the spring pockets independently in bogie centre and stay, I recommend you first mark off and drill the stay, bring up the centre and start the $\frac{3}{16}$ in. hole, completing with a 'D' bit to $\frac{3}{16}$ in. depth. The object of the side control springing is both to guide the engine into a curve, or rather for the bogie to physically pull the front of the engine into same, at the same time keeping the rear bogie wheels clear of the mainframes. So in this respect, be prepared to vary my side control spring specification to arrive at the correct end result, rather than to take same as gospel.

40645 standing at Hurlford Loco in Scotland, where both 4F's and 2P's refitted at St. Rollox sported the Fowler chimney





Although not strictly a DERBY 2P, 40383 was the last survivor of the earlier Johnson 4-4-0's, though much rebuilt by BR days. The coupled wheels on this engine were only smaller by $2\frac{1}{2}$ in. in diameter than the 2P's, this being exaggerated by the straight running board



40610 passing Hurlford yard with an up local train and going well. Photos by Alan Rimmer

Bolster Pin and Retaining Plate

Cut the retaining plate 1 in. square from 3mm brass sheet, find its centre by the 'X' method, chuck truly in the 4 jaw, centre and drill out to $\frac{3}{8}$ in. diameter. Mark off, drill and countersink, the four fixing holes, align to the centre with an odd end of $\frac{3}{8}$ in. rod, then spot through, drill and tap the centre at 8BA for screws, applying a drop of mild grade Loctite to same at the final assembly.

The sole reason for a head on the bolster pin is to prevent the bogie falling away from the engine when lifting from the track, so when you turn this pin up, make sure the head is at least 1/32 in. clear of the retaining plate, so that it imposes no restriction on the side control movement; make a $\frac{1}{4}$ x 40T nut from $\frac{3}{8}$ in. A/F hexagon steel bar to complete the assembly to drawing; two large lumps already in this session!

Dome and Whistle

Strange bedfellows indeed to appear at this stage in the proceedings, but they filled a few spaces on the drawing, as they will in this text.

Reeves dome casting is actually in brass, though being an adornment only such is totally immaterial. Grip carefully in the bench vice and first deal with the scallop to neatly fit the boiler cleading; around this all else revolves. Now file the rim of the base to a feather edge, taking care again as there is a nasty lump to be removed at the feed point. You can shape a piece of softwood to a drive fit inside the dome, chuck said wood and polish the rest of the dome at high speed in the lathe with emery cloth, or simply file and polish in the bench vice; complete with the No. 44 hole.

The whistle depicted is LBSC's method of arriving at the genuine Caledonian hooter through medium of the resonance box, though for beginners one of our $\frac{1}{2}$ in. tube ones will ensure wayward bystanders get the message! Experienced builders will be able to construct the whistle to drawing without my description, when the only thing to watch is that the slot at the disc does not fill with spelter on assembly; even professionals have this happen to them!

THE CYLINDERS

These cylinders are entirely conventional, being a mixture of LBSC and Martin Evans both in design and castings employed; I just collected the castings from Reeves shelves back in 1974 and drew up the details around them. Only one feature has caused some builders problems to date, so if I draw attention to same at this juncture then all will be plain sailing afterwards. The lubrication arrangement in feeding up through the block to the portface is pure LBSC. Some builders, however, have found difficulty either in fitting the oil delivery clack to clear the cylinder block, or if this is successfully accomplished, the clack body then fouls the bogie bolster. I am still happy with the arrangement, after all I did copy it from the late maestro, hence its retention. But if you do encounter a problem here, then simply plug the 7/32 x 40T tapping at the bottom of the block, or make up a drain cock to fit same as no other provision has been made for removing condensate other than up the chimney! Then you transfer the oil delivery clack to the front wall of the steamchest, omitting the centre stud to arrive at same; nothing too terrible is it? Bringing the point up here though does indicate the way in which builders should proceed in that the oil check valve be tried in the block **before** the steamchest is tackled. Although the cylinders cannot be completed this session as several of the details appear on Sheet 3, we can at least get off to a good start.

Cylinder Block

The first job as usual is to assess maching allowances, so fit wooden bungs in one end of each of the cored holes in the casting and mark out from same, mainly to establish the portface. All castings that I have handled thus far, quite a few of them, sit nice and flat on the raised ribs for the end covers, just rub with a file if this proves necessary, sit same on the body of your 4 jaw chuck and tighten the jaws. Choose a tool that will produce a good finish for the portface, rather than for its actual shape, though a round nose one is usually best, and at the lowest direct speed remove a little metal at a time, there is only a very minimum to take off here, concentrating with each cut in gaining and maintaining a good surface finish. Check the marking out of the casting, reset if necessary to run true, then centre and drill 11/32 in. diameter to $\frac{9}{16}$ in. depth as shown for the exhaust fitting, tapping $\frac{3}{8}$ x 32T.

Next check the end faces to the portface with an engineers square, on all the castings which I have machined there has always been quite an error; choose the best end and square it off with files, always taking great care to preserve the completed portface. Sit the filed face on the 4 jaw chuck body, tighten the jaws with packing under the portface, and face off the outer end, making sure the cover bolt ribs will be equal at both ends; reverse and complete to $2\frac{1}{8}$ in. length. To complete the 'box' we have to machine the frame fitting faces, chucking with packing from the three faces we have already machined and arriving at the vernier caliper $2\frac{7}{8}$ in. dimension with cores held nice and central, in fact it is a good plan to properly scribe on the bores once the end faces are machined.

Still in the 4 jaw, set one of the bores to run true against a scriber held under the tool post, change to a boring tool that will pass right through the casting, choosing the first step on each of the jaws so that you can see the tool emerge at the inner end. At lowest direct speed and very finest feed, apply a cut of around .020 in. for the first pass so that you quickly get to clean metal. Allow four passes at this setting to assess the surface finish obtained, sharpening the tool if this is indicated, then proceed at cuts of around .010 in. and four passes each towards your chosen finished bore size. Again actual size is less important than surface finish, so on the final cut keep traversing until only the finest of dust is removed. If the tool is not sharpened or set correctly, you will hear the slight hiss of it cutting for a while followed by silence; attend to either fault immediately, then deal similarly with the second bore.

I will use a 4 jaw chuck whenever feasible, whereas other builders such as Chris Moss with his DERBY 4F favours the between centres boring bar, indeed it was only on DONCASTER that I was able to convince some readers that I had ever heard of a boring bar! With said implement you pack the block up on the boring table until a scriber held in the 3 jaw chuck indicates the bores are at centre height, then you use strongbacks as did Merlin to hold the block firmly to the table, checking from same that all is nice and square, then you bore one hole and move on by 1.375 in. to deal with the second to be exactly parallel; such an operation does make a lot of sense.

Carefully mark on the positions of the ports and if you cannot grip the block in the machine vice on the vertical slide, change to an angle plate and put bolts through the main bores with large washers or a strongback to hold firmly in place. A $\frac{1}{16}$ in. end mill is a fearsome animal to handle, but with care it can be mastered, the rules being to run it at the highest speed possible and to give the tool a chance to keep up as you feed it along the job. So along the centre of a steam port, feed it in about 1/32 in. and traverse from end to end. It will tend to wander as you feed it in, so either drill a No. 49 hole to $\frac{5}{16}$ in. depth initially and feed it in at that point, or if tackling solid metal then feed it in at different points along the port, arriving at a slot that will in the main be wider than $\frac{1}{16}$ in., but $\frac{5}{16}$ in. deep. Now carefully widen the slot, one side at a time and again in depth increments of 1/32 in., taking particular care that the end mill does not wander at the ends of the slot, which means you do not try to force it, until you arrive at a uniform 3/32 in. width; deal with all four steam slots in this fashion. For the exhaust ports, start with a $\frac{3}{16}$ in. or $\frac{1}{4}$ in. end mill down the centre and to $\frac{5}{16}$ in. depth, then open out and complete if your nerve will allow, perhaps your pocket if you have been unfortunate!, with the $\frac{1}{16}$ in. end mill to line. If you have scraps of 3/32 in. and $\frac{3}{8}$ in. thick material by you, then you will be able to insert same in the ports and take various check measurements with micrometer of vernier calipers.

When satisfied, turn the block through 180 deg., centre and drill the No. 41 oil right through, use a $\frac{3}{8}$ in. end mill to produce a wee land for the fitting, then follow up at $\frac{3}{16}$ in. diameter and tap 7/32 x 40T. For the exhaust passage, centre pop deeply at the centre of the bottom corner on the inside face, drill an $\frac{1}{8}$ in. pilot hole through and then open out in stages to 7/32 in. without damaging the port edges you so carefully milled. Usually the steam passages have to await location of the cover bolts, but this time one of them is on the top centre line, so file a wee flat so that when a No. 24 drill is entered it will not disturb the completed bore, set the block over by eye in the vice so that you can drill vertically down to the steam port, but only put a No. 43 drill through initially. If there is a problem in that the hole emerges too close to top or bottom of the steam port, then you can correct it with an $\frac{1}{8}$ in. end mill held in your drill brace, because an end mill will cut its own hole rather than follow that made by the No. 43 drill. Open out finally to No. 24 and then use this drill as a 'sight' for the second passage alongside, the $\frac{3}{16}$ in. dimension merely being there to ensure beginners don't let one hole break into its partner, with tragic results for the drill.

Frames Assembly

Now that we have a substantial block of metal the frames can be assembled, although beginners may delay this until Sheet 3 appears in the next issue as it will contain a complete Chassis Arrangement as a check as to where everything goes. At least the description can appear here, so clamp the frame stay, beams, bogie bolster and cylinder block in their appointed positions, sit the chassis on the lathe bed or surface plate and check for flatness and squareness in as many positions as possible, trying the coupled axles as the ultimate check. Now you can drill and tap away to your heart's content; with one word of caution. I have been criticised by those unfortunate enough to penetrate a main bore for placing the bottom row of cylinder fixing screws on the centre line of said bores, where of course there is least metal. Just for once I do not accept such criticism, for there comes a time in every builders career when depth of tapping becomes vital, so why not learn the discipline here where the feature is obvious and easily measured. So if you turn up a wee collar, like a coupling rod brass, and secure it to the No. 43 drill with an 8BA screw, you can positively drill the holes to a depth not to break through into the main bores and then tap out to suit. Really it is a question of being alert to the dangers **before** you tackle a particular operation, not afterwards!

Steamchest and Cover

Very little metal has to be removed from the steamchest to bring it to drawing thickness, a question of maximum utilisation, neither from the inside of same, a file sufficing here. Chuck in the 4 jaw to face to thickness, then deal with the sides to $2\frac{7}{8}$ in. overall to match the block and keeping the walls of equal thickness, then face off the two valve spindle bosses and mark on their centres. Using the chucking spigot provided on the opposite side, set one up to the marked on centre, centre and bring the tailstock into play to turn down to $\frac{3}{8}$ in. diameter and then face that part of the wall. Drill through at No. 23, follow up at 7/32 in. diameter to $\frac{1}{2}$ in. depth and tap $\frac{1}{4}$ x 40T, then run a 5/32 in. reamer through the remains of the No. 23 hole; repeat for the second boss. You can now saw off the chucking spigots on the opposite side and turn or mill this face to complete the profile. Mark off and drill the seventeen No. 29 holes, remembering to omit the central one at the front if your oil check valve is to occupy said spot, tapping 7/32 x 40T for same.

Offer up to the cylinder block, spot through, drill No. 40 to $\frac{1}{4}$ in. depth and tap 5BA. The studs are $\frac{15}{16}$ in. lengths of $\frac{1}{8}$ in. mild or stainless steel rod and screwed 5BA for $\frac{3}{16}$ in. at each end, save for the four corner ones which want a longer thread at the top so that the steamchest can be tightened down with the cover removed, this for the valve setting later on; if you do happen to forget about this then washers will do in lieu. Fit all the studs, if you have to tap any of them upright then do fit a brass nut so that you do not damage the exposed threads, and check the steamchest slides easily over said studs. There is no provision for a gasket at the steamchest joints, well made they will assemble 'dry' and be perfectly steamtight; use a liquid jointing compound such as 'Hermetite' if there is any leakage.

The cover can be cut from 3mm brass sheet to drawing, although a gunmetal casting is included in the casting set, complete with chucking spigot. Grip by same, face across both sides as far as you are able, then part off the chucking spigot and complete facing the second side, gripping in the 4 jaw chuck. Sit on the steamchest, clamp in place and drill the fixing holes, then trim the edges to match. As you will want to remove the cover at some stage with the cylinders in place between the frames, which latter may be painted by then, make the cover an easy fit between the frames rather than an exact one. Find its centre by the 'X' method, centre and drill through at $\frac{3}{8}$ in. diameter for the exhaust fitting, then drill and tap the $\frac{3}{8}$ x 32T steam entry hole to complete.

Cylinder End Covers

Only the cylinder covers to complete this session, so chuck the front ones by their periphery and clean up the chucking spigots, then revese in the chuck. Turn down to $1\frac{5}{8}$ in. diameter and face across, then concentrate on the 1/32 in. spigot to fit the bore. Although for the front covers the spigot need not be an exact fit, for the rear ones to follow it has to be, so practice your skill in this direction. Face off the back of the cover, part off the chucking spigot and offer up to the block. First mark off the overlap on the centre line, saw and file or mill this to a match, then relieve the outside to an easy fit between the frames for the same reason as the steamchest cover. Mark off and drill the cover fixing holes for 6BA countersunk screws, offering up in turn to the block to drill and tap the fifteen holes. Just one operation to complete, the most important one of connecting from the end of the steam passages to the bores by easing the spigot in way of said passage ends; on to the rear covers.

For the rear covers, chuck by the periphery and deal with the chucking spigots, then reverse and just skim the periphery to clean up, ditto with the cover face, then part off the chucking spigot. Chuck by the periphery, face off the slide bar/gland boss, then centre and drill through at No. 13. Follow up at 11/32 in. diameter to $\frac{1}{4}$ in. depth, 'D' bit to $\frac{5}{16}$ in. depth and tap $\frac{3}{8}$ x 32T before running a $\frac{3}{16}$ in. reamer through the remains of the No. 13 hole.

Next chuck an odd end of $\frac{5}{8}$ in. diameter bar, face and turn down to $\frac{3}{8}$ in. diameter over a bar $\frac{1}{4}$ in. length before screwing $\frac{3}{8}$ x 32T and fitting an embryo rear cover to same. This adaptor ensures the piston rod gland is concentric with the spigot you now turn on exactly as for the front cover, completion being identical save that the slide bar bosses must be set vertical; we will complete same and the rest of the cylinders in the next session.

Derby 2P – An LMS 4-4-0 in 3½ in. gauge

by: DON YOUNG

Part 3 – Progressing the Chassis

The great beauty with a 'simple' engine, as is my version of the Derby 2P, is that it is possible to draw the complete chassis without confusing even the rawest recruit, so that one can see at a glance what has to be done, and what piece part goes where. Oh, yes, I have omitted the feed pump and its drive, this to avoid any confusion, as it would merely add to the number of lines on the drawing without providing any useful information. I won't waste space in describing what you see, this is one instance where a drawing speaks for itself, just remind builders of its existence to help resolve any mysteries that may arise.

Just one point to be mentioned for those who have purchased drawings ahead of Sheet No. 3 appearing in LLAS, in that the slideshaft has been moved from the centre line of the slides to the top of them. I put the slideshaft on the centre line originally because this was the approximate position full size on all engines fitted with Joy valve gear, plus this helped mask the presence of said Joy gear in lieu of the authentic Stephenson gear with rockers, but it meant in practice that the .16 in. dimension of metal to be removed between the slides had to be exceeded to achieve working clearance for the vibrating links, and although the end result was perfectly satisfactory, moving the slideshaft upwards to what I would call the 'LBSC position' means the drawing dimension can be adhered to, thus saving me a query or two. Before we can tackle said components though. we must complete the cylinders.

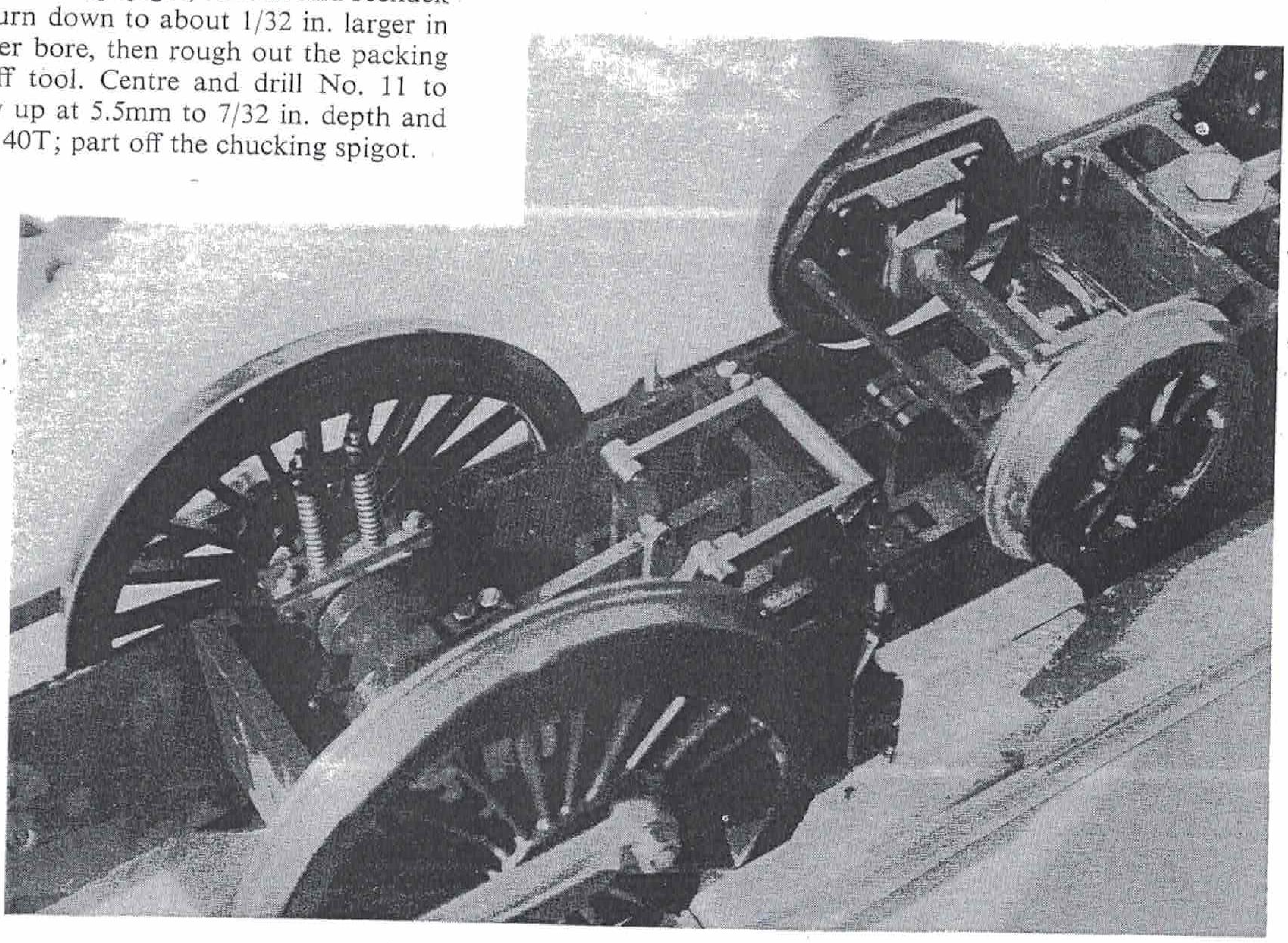
COMPLETING THE CYLINDERS

Piston, Rod and Gland

Grip a piston blank by its periphery, setting to run true in the 4 jaw, then clean up the chucking spigot, reverse and rechuck in the 3 jaw. Face and turn down to about 1/32 in. larger in diameter than the cylinder bore, then rough out the packing groove with a parting off tool. Centre and drill No. 11 to about ⅝ in. depth, follow up at 5.5mm to 7/32 in. depth and tap the remainder 7/32 x 40T; part off the chucking spigot.

Next chuck a 3⅜ in. length of 7/32 in. stainless steel rod in the 3 jaw, check with a d.t.i. that it is running true, this is vital, and if not so then change to the 4 jaw chuck and set accurately. Face off then fit a 7/32 x 40T die in the tailstock dieholder, opened out slightly so the thread is a tight fit in the piston, then screw the end of the rod over a 7/32 in. length. Screw on the piston and face across the end to finished thickness, this will in turn help to screw said piston hard onto the rod, then reduce in diameter to a nice sliding fit in the cylinder bore, one that is a little on the 'teeth chattering' side when assembled dry, but becomes a smooth fit when oil is applied. Complete by cutting the packing groove to drawing and my dimensioning calls for some comment, indeed I was able to demonstrate its purpose to a SAINT CHRISTOPHER builder only a couple of days back at time of typing up these notes.

Look at any Catalogue, say the Reeves one that is constantly by my side when on the drawing board or writing up a description, and you will find that packing is listed as ¼ in. square, yet my groove is only 7/32 in. deep; why? Well, soft packing is produced for normal use in a gland, being compressed to fill the space between housing and shaft, and if we do not make sure that our packing is also compressed, then it is a complete waste of time fitting same. So cut a length of ¼ in. square packing, either graphite or PTFE impregnated, first hammering it down on a block of steel, I use the bench vice for this, until it fits the width of the groove. Once in the groove, hammer down again with a block of wood to come just proud of the surface of the piston and cutting the end of the packing to a butt joint; it is not worth the effort making a scarfed joint. Enter the piston in the

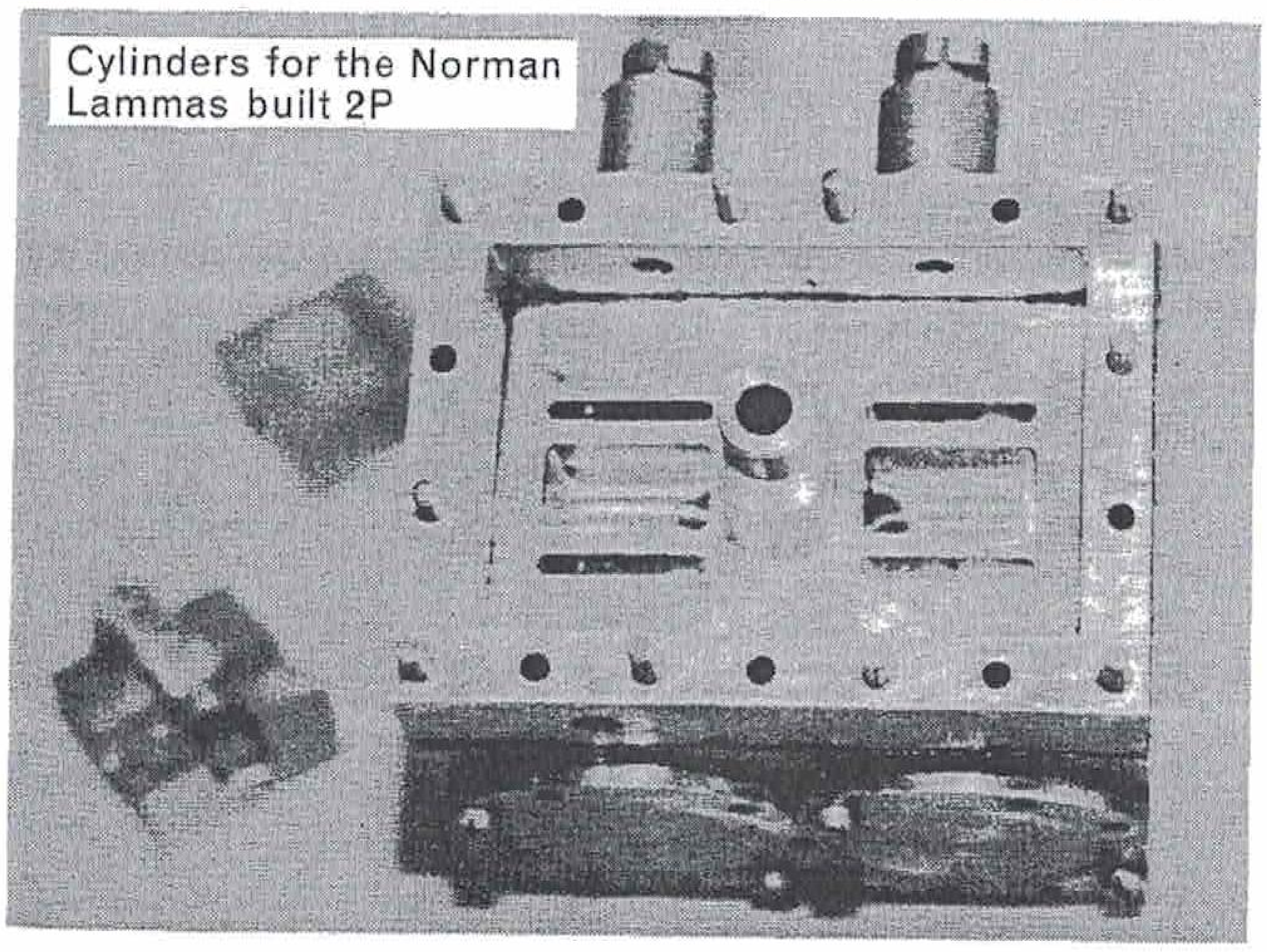


Steve Titley inverted the chassis of his Midland 2P to provide us with much useful detail bore, then use a blunt screwdriver to locally depress the packing, so it too begins to enter the bore. It is always difficult to squeeze the last bit of packing in, so when nearly home, tap the exposed piston with a block of wood, when a very small portion of the packing will be cut away, and you have the correct fit. At this stage the piston will be a very tight fit in its bore, so it is best to delay the packing operation until much later on in the proceedings. For the gland, chuck a length of $\frac{1}{2}$ in. gunmetal or bronze rod, face and turn down to $\frac{3}{8}$ in. diameter over a $\frac{3}{8}$ in. length before screwing 32T. Centre and drill 7/32 in. diameter to $\frac{9}{16}$ in. depth, then part off to leave a full 3/32 in. thick collar. To complete, file the four slots to be $\frac{1}{16}$ in. wide and extend down to the top of the threads. From this description, you will also be able to vary the dimensions and arrive at the valve spindle glands.

Valve, Bar and Spindle

Measuring a sample valve casting, it is barely $\frac{7}{16}$ in. deep in one position, so the first point to be made is that this dimension is not critical, though 13/32 in. should be taken as the minimum permissible. Start by rubbing a file over the working face to get it nice and level, then chuck in the 4 jaw and just clean up the top face, removing a minimum of metal. Mark the profile of the valve onto the working face, using the cast-in cavity as reference, then machine to line, and as easy a way as any is to chuck in the 4 jaw to achieve this. On to the machine vice and vertical slide to mill out said cavity, including the '4F' stamp, doing this first and then concentrating with the $\frac{1}{16}$ in. end mill on one edge of the cavity at a time, the $\frac{11}{16}$ in. width not being critical, but the .188 in. bar to the valve working edge certainly is so, so use a micrometer to check. Incidentally, when my 4F pencil drawing was traced back in 1974, a poor 6 became a 0, so what should have read .561 in. became .501 in., something that was perpetuated initially on the 2P. It was in fact a 2P builder who advised me of my error, I guess that by the number of 4F's already running at the time it was a rather obvious mistake, so I simply corrected the drawings and forgot about it. Unknown to me, however, the designer of a Clayton Steam Waggon that has become very popular through a series in 'Model Engineer', used those 4F cylinders and repeated my dimensional error!

Turn the valve in the machine vice, so that the top face is towards the chuck, then use a $\frac{3}{16}$ in. end mill to deal with the $\frac{1}{4}$ in. wide slot, this for a length of square brass or stainless steel bar to be an easy fit therein, so the valve is free to rise from the portface when water is present in the cylinders, this without bending the valve spindle. Change to an $\frac{1}{8}$ in. end mill and deal with the 5/32 in. slot in the other direction; the bottom of this slot will also be square. I originally envisaged drilling a No. 22 hole to start forming this second slot, for the valve spindle, but the way the casting was produced, the drill would have broken out into fresh air in the middle.



Cylinders for the Norman Lammas built 2P

I have left machining the working face until last, for my experience has been that the heavy milling at the top for the bar and spindle does distort the valve, so a working face machined at the outset was no longer flat; chuck in the 4 jaw and again remove a minimum amount of metal, to clean up either to drawing dimension or as close to same as possible. If you have a sheet of 'wet and dry' abrasive paper by you, lay this on the lathe bed and lightly rub the working face on same to remove the machining marks, otherwise leave well alone as the valve will bed itself to the portface.

Cut two $\frac{3}{4}$ in. lengths from $\frac{1}{4}$ in. square bar and square off, then mark on the centre for the 5/32 x 40T tapped hole, grip either in the machine vice or 4 jaw chuck, to drill No. 29 and tap through. The spindle is dealt with as for the piston rod, save that it is screwed at both ends, when you can assemble the valves in the steamchest and check the valves sit properly on the portface.

Exhaust Fitting and Flange

We now have to arrange for exhaust steam to pass through the steamchest on its way to the blastpipe, so start with a length of $\frac{5}{8}$ in. diameter gunmetal or brass bar, chucking in the 3 jaw. Face and turn down over a $\frac{1}{4}$ in. length to $\frac{3}{8}$ in. diameter and screw 32T, then centre and drill No. 2 to $1\frac{1}{8}$ in. depth before parting off a full 1 in. slice. Rechuck, face and turn down again to $\frac{3}{8}$ in. diameter, getting the length of original bar to match the depth of the steamchest; screw this end also at 32T. If you fit same into the steamchest, the valves have insufficient room, so tighten carefully with a 'Mole' wrench, mark on the flats to give clearance. Mill or file these to arrive at the $\frac{3}{8}$ in. dimension, then refit using a spanner over the flats.

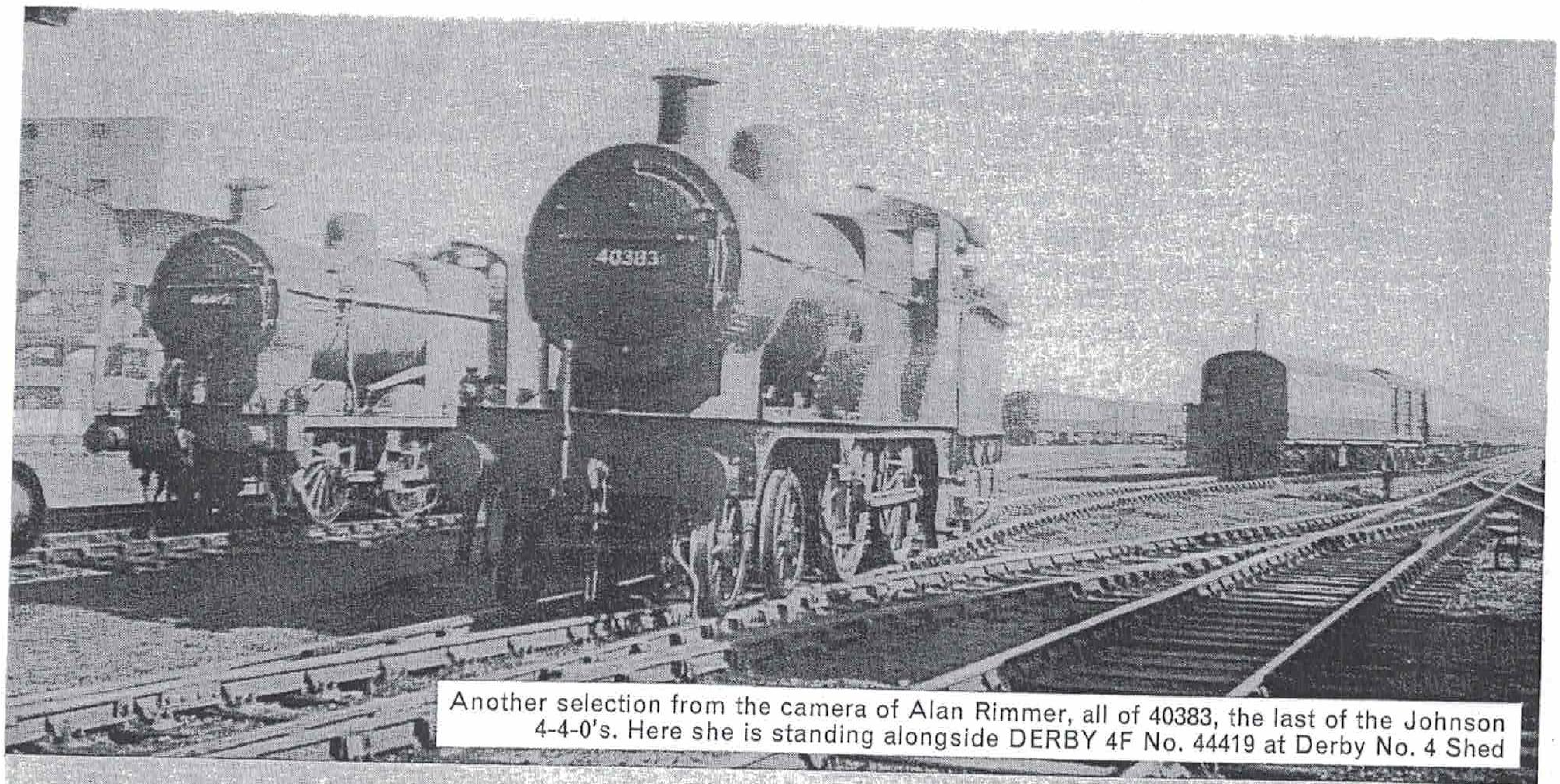
The flange is turned from $\frac{3}{4}$ in. diameter brass or gunmetal bar, I seem to have gone 'gunmetal crazy' in those days! Face, centre, drill 11/32 in. diameter to $\frac{5}{16}$ in. depth and tap $\frac{3}{8}$ x 32T before parting off a full $\frac{1}{8}$ in. slice; reverse and clean up. On final assembly, 6BA bolts can be fitted in the tapped holes to provide a purchase for tightening up, but for the moment just screw the flange over the projecting fitting by hand to, almost, complete the cylinders.

Crossheads and Slide Bars

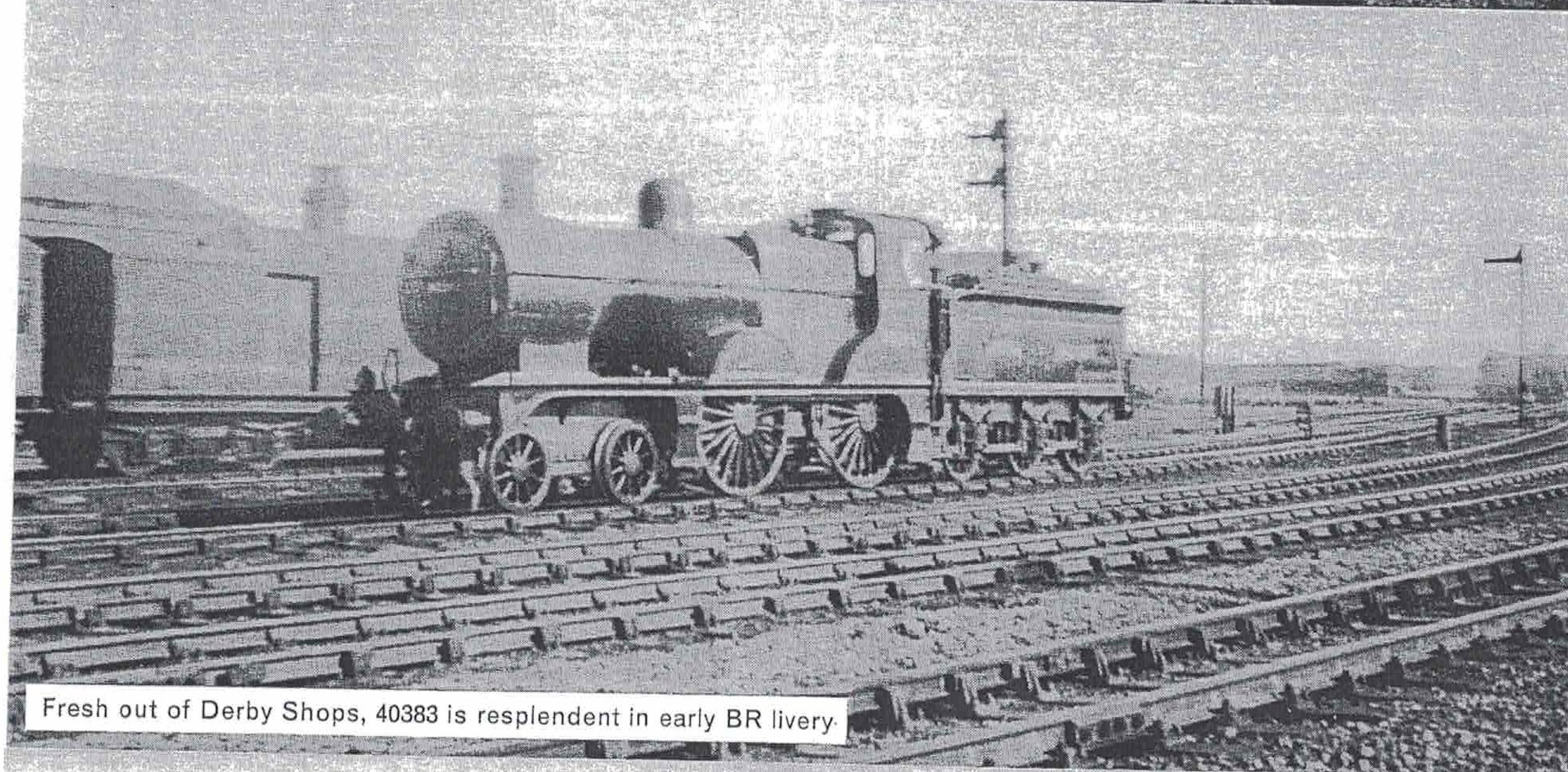
Crosshead material can be $1\frac{1}{4}$ in. x $\frac{5}{8}$ in. BMS bar, or from a gunmetal stick machined to $1\frac{1}{16}$ in. x $\frac{5}{8}$ in. section; if steel is used then the first step is to arrive at this latter section. Face the ends, mark on the centre for the piston rod, set in the 4 jaw and drill 5.5mm diameter to $\frac{1}{2}$ in. depth. The cross drilled hole for the crosshead or gudgeon pin comes next, so mark this off, go back to the 4 jaw chuck and set to run true, then drill right through at No. 27, following up at No. 12 to about $\frac{5}{16}$ in. depth.

Transfer to the machine vice and vertical slide, and with a $\frac{1}{4}$ in. end mill, produce a $\frac{5}{16}$ in. wide slot to $\frac{5}{16}$ in. depth right along the top to accept the slide bar material. Insert same and clamp a plate over the top of the slot to check that the slide bar does not become trapped. Cut into invididual crossheads, face the ends square, then back to the machine vice to mill the full $\frac{5}{16}$ in. wide recess to accept the connecting rod small end. From experience with the coupling rods, we can machine the crosshead pins and small end bushes without the need for description on my part, but I must say something about the top plate for the crossheads.

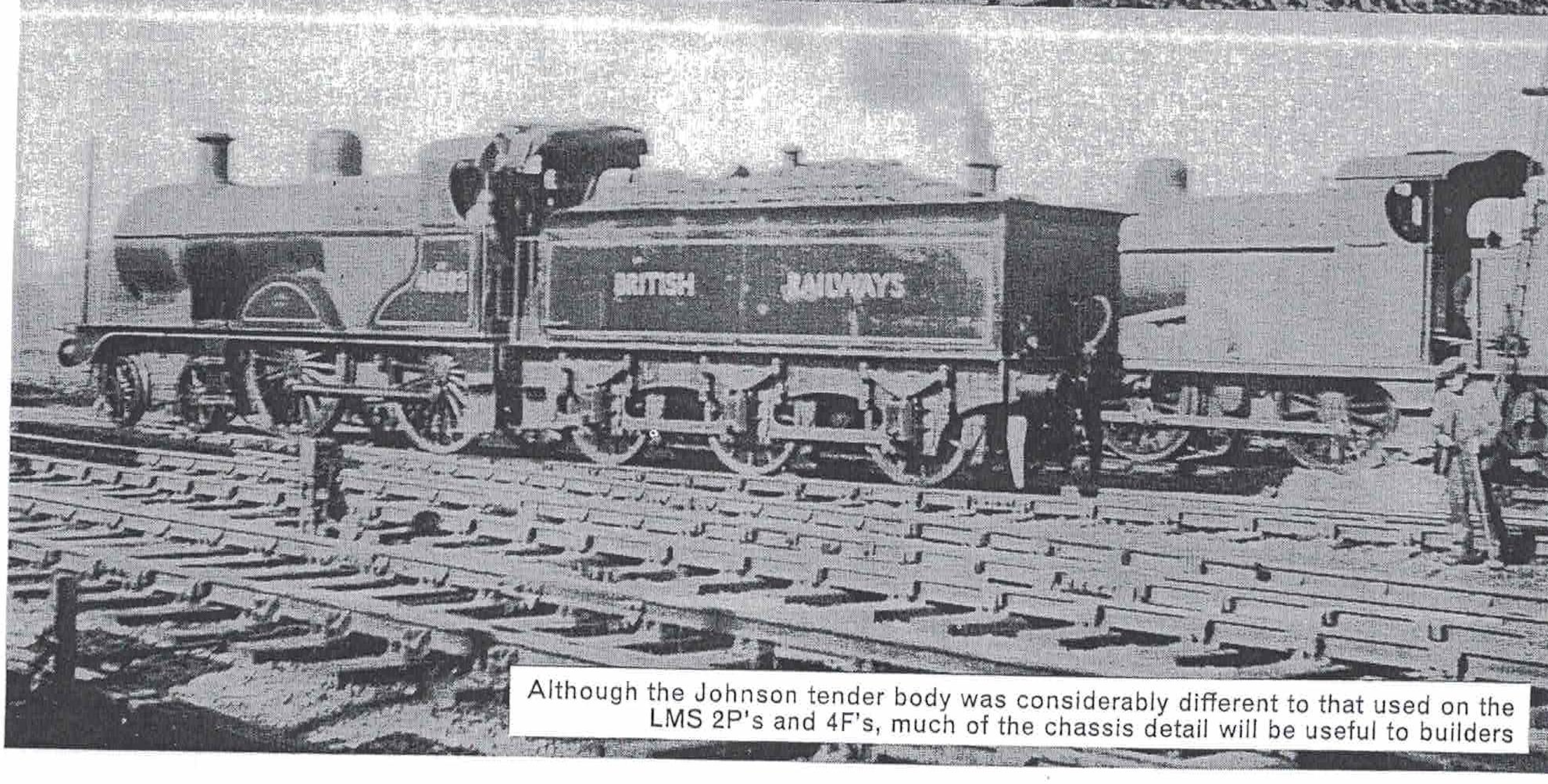
The cast gunmetal stick which either Reeves or DYD can supply for the crosshead itself, contains sufficient material for the top plates, so turn or mill these to size; otherwise use $\frac{5}{8}$ in. x $\frac{1}{8}$ in. BMS flat which is a standard section in Reeves 21st edition Catalogue. Mark off, drill and countersink the plate for 8BA screws, offer up to the crossheads to drill and tap same to suit; assemble using steel screws.



Another selection from the camera of Alan Rimmer, all of 40383, the last of the Johnson 4-4-0's. Here she is standing alongside DERBY 4F No. 44419 at Derby No. 4 Shed



Fresh out of Derby Shops, 40383 is resplendent in early BR livery.



Although the Johnson tender body was considerably different to that used on the LMS 2P's and 4F's, much of the chassis detail will be useful to builders

We have already selected the slide bar material, so cut and square off two lengths of the $\frac{5}{16}$ in. square bar to $3\frac{1}{2}$ in. overall, dealing with them as a pair to be of identical length. Still as a pair, grip in the machine vice and mill the step at the rear end to be $\frac{5}{16}$ in. long and 7/32 in. deep, then mark off and drill the holes at each end.

Fit a crosshead to a piston rod, bring up the slide bar and assess the amount of metal to be removed at the seating on the rear cylinder cover; we have to mill the latter to obtain a fit. To do this, set up the vertical slide and bolt an angle plate to same. Sit the cylinder block upright on the angle plate, remove the front covers and bring the front face of the block hard against the vertical slide table. Now take a 4 in. length of, say, 1 in. x $\frac{3}{8}$ in. BMS bar and drill a couple of $\frac{5}{16}$ in. holes at $\frac{3}{8}$ in. from each end. Sit this bar on top of the block, or steamchest cover if this is fitted, and bolt down through the angle plate to secure. With the side teeth of your $\frac{5}{8}$ in. end mill, remove metal at the slide bar seating until when the slide bar is clamped in place, the crosshead slides sweetly along it. Now you can drill and tap the rear cover 5BA to $\frac{3}{16}$ in. depth for a hexagon head steel bolt; repeat for the second slide bar.

Motion Plate

After assessing the machining allowances, chuck first in the 4 jaw and face across the back; mark out the profile and mill the edges in the machine vice on the vertical slide. When dealing with the top edge, mill the 1/32 in. deep recesses to accept the slide bar ends, bringing up the complete cylinder assembly to check the crossheads still slide freely when the slide bar ends are inserted in the motion plate. Next mark out the cut-outs for the connecting rods to pass through, and the hole to accept the feed pump. All three are cast in at a reduced size; there is no problem with the two rectangular cut-outs which are simply opened out with an end mill, but the circular hole for the pump can be tricky. Using a drill, the hole can easily wander, so if you want to do the job in the machine vice, chuck a large Slocombe centre drill in the 3 jaw and let this arrive at the correct alignment before changing to a drill; otherwise chuck in the 4 jaw and bore out to size. Incidentally, later on you are going to arrive at a clash between the suction side of the pump and the anchor link pin/spacer. It is relatively easy to file the latter to give clearance, push the pump forward a little too if you wish by simply adding a washer, but some builders have cut out the spacer altogether and made another pair of anchor link trunnions to fit under the motion plate, when the anchor link pins become $\frac{3}{8}$ in. long. Drill through the motion plate from the slide bar ends, bolt together and erect the whole cylinder/motion plate assembly to the frames, when you can drill and tap the motion plate from the frames to maintain proper alignment.

RODS AND MOTION

Joy valve gear is very aptly named, it being a joy to make, set, and performs with great distinction, the valves opening and closing very rapidly with a long dwell period in between. Before we get down to its construction though, there are a few parts to be made ahead, the connecting rods in particular.

Connecting Rods

$\frac{5}{8}$ in. x $\frac{1}{4}$ in. is a standard commercial section of BMS, available from Reeves, which will save us a lot of work. Cut two $5\frac{1}{4}$ in. lengths and square off one end on each, then mark off and drill the $\frac{1}{4}$ in. and 9/32 in. holes; you can do this as a pair if you wish. The central portion has to be reduced to $\frac{3}{16}$ in. thickness, so set up the vertical slide and angle plate again, clamping the embryo rod in place. With the side teeth of your $\frac{5}{8}$ in. end mill which is certainly earning its keep!, reduce the centre portion, it will be sure to 'banana' when released, but hand pressure will restore its flatness, checking against a straightedge.

I will now describe how to radius the eye of the rod over a mandrel by use of an end mill, as we shall be employing this technique quite frequently for the valve gear parts. I have several pieces of $\frac{3}{8}$ in. square steel bar into which lengths of various sizes of silver steel rod have been pressed, so that I can simply grip said square bar in the machine vice to form a mandrel; do this at the specified $\frac{1}{4}$ and 9/32 in. sizes. Next saw and file away most of the excess material at the eye at the small end of the rod, slip over the 9/32 in. mandrel and chuck a $\frac{3}{8}$ in. end mill in the 3 jaw. Bring the end mill up to the rod, but before switching on the lathe motor, rotate the end mill by hand against the job, and assess the way you have to pull the connecting rod around AGAINST the rotation of the end mill; you will only do it the wrong way once! Carefully remove metal to complete the eye, then move on to the $\frac{1}{4}$ in. one for the Joy gear drive. Although you can mill the rest of the profile, using the angle plate and vertical slide set-up and the end teeth of your end mill, a bit of filing never did anyone any harm!, and this is a good way to improve your skills in this direction without the risk of scrappage.

The straps are from $1\frac{1}{4}$ in. x $\frac{1}{4}$ in. BMS flat, so cut two pieces about 2 in. long and square off the ends, the easiest way is to turn them in the 4 jaw chuck. Next job is to drill the pair of No. 34 holes right through, so mark them off and set up in the machine vice on the vertical slide; centre one hole. Now drill right through, $1\frac{1}{4}$ in. is a long way!, and check the drill emerges in the centre of the face at the opposite side. If it doesn't, then you have sufficient material to turn the piece end for end to try again; once mastered you will be able to drill such holes like shelling peas.

Now mark on the profile and roughly saw out the $\frac{5}{8}$ in. slot which is $1\frac{3}{16}$ in. deep. Back to the machine vice and with the $\frac{3}{8}$ in. end mill, complete the slot to a tight fit over the connecting rod end. Complete the profile by a mixture of milling and filing, to include drilling the 3/32 in. diameter oil hole to the journal. Lay the strap aside for the moment to give attention to the brasses, these from a chunk of gunmetal.

First arrive at a section of $\frac{3}{4}$ in. x $\frac{5}{16}$ in. by either turning or milling, the thickness to be an easy fit between the crank webs, then saw into four individual pieces and square them off together to be an identical $\frac{5}{8}$ in. long. Warm each up in turn, apply a few drops of Bakers fluid and rub the face with a stick of soft solder, just to tin it. When all four pieces have been dealt with, bring a pair together, heat and squeeze out any excess solder, then allow to cool. We now have a pair of embryo brasses which if machined carefully, will not separate. Find the centre by the 'X' method, centre pop lightly, scribe on the $\frac{1}{2}$ in. circle, then chuck truly in the 4 jaw. Centre, then drill and bore out to $\frac{1}{2}$ in. diameter, a nice fit over an odd end of the crankpin material. Remove to the machine vice and with a $\frac{3}{16}$ in. end mill, cut a $\frac{1}{4}$ in. wide groove which is a tight fit in the strap, to $\frac{1}{16}$ in. depth, this in one of the edges containing the soldered joint. Turn through 90 deg. and repeat to $\frac{1}{4}$ in. width, but for depth use the strap as gauge to achieve another tight fit. If you take note of the vertical slide micrometer collar readings when the final cut is taken, then you will be able to go on and achieve equal flange thickness all round the brass; deal with the other two edges. You can either drill a $\frac{1}{16}$ in. oil hole in the joint as shown, or separate the pair, clean off all the solder, and file a 'V' groove in each half as an oil channel.

Fit the brasses into the strap and bring the latter up to the connecting rod end to drill the No. 34 holes through from each side. No matter how much pressure is applied to hold the brasses firmly in place, I always find when the 6BA bolts are inserted to complete the assembly that the brasses have a wee bit of axial movement. The cure though is easy; I merely cut a piece $\frac{5}{8}$ in. x $\frac{1}{4}$ in. from .002 in. shim brass, insert it between the brass and rod end, when the retaining bolts are tapped home to give a perfect assembly.

Taking the 'Bumps'

No, yours truly has not turned into a mind reader or anything of that nature; what I am about to describe is a very necessary exercise to avoid a piston ever striking the cylinder covers in service. First though both the small end and Joy gear bushes have to be pressed centrally into the connecting rods, the latter you can now make without my description, and put a drill or reamer through the bore again to tidy it up to size. Assemble a rod over the main crankpin and couple to the crosshead with the gudgeon pin.

Turn the engine to back dead centre, that is with the crosshead as far back along its slide bar as it will go, then remove the front cylinder cover and tap the piston with a piece of wood until it strikes the back cover, this is the rear 'bump', so scribe a line on the piston rod where it enters the crosshead. Turn to front dead centre, refit the front cover, then insert a screwdriver between the connecting rod eye and piston rod end, forcing the latter forward until the piston strikes the front cover; scribe a second line where the piston rod enters the crosshead. Now divide the distance between the two scribed lines on the piston rod, scribe a third and get this aligned to the point of entry into the crosshead. Cross drill No. 42 as shown on the Chasis Arrangement, follow up with a taper drill or reamer and fit a taper pin, only don't drive it right home as yet. You may also find that the piston rod end is fairly adjacent to the connecting rod eye, in fact they may come into contact before the piston strikes the rear cover; in either case shorten the piston rod to be clear.

The Slideshaft

The only slightly difficult part to be made with Joy valve gear is the slideshaft, so let us get this out of the way first. Whilst it is entirely feasible to turn the slides themselves on the faceplate of the Myford ML7, it does require a complete cast ring from which only a small portion is then used, so for the convenience of builders DYD can supply finished machined slides, which removes the major headache. Merlin Biddlecombe who machined the DONCASTER middle cylinder for me as described in LLAS No. 24, which incidentally gained much favourable comment, produces the slides for me and he includes the No. 12 hole in all of them so that a length of $\frac{3}{16}$ in. silver steel rod can be employed as an alignment check; thoughtful chap is our Merlin.

The slideshaft itself, often referred to as the yoke, I now recommend be from $\frac{1}{2}$ in. x $\frac{3}{8}$ in. steel bar, and do avoid the free cutting variety that has a lead content, as this will cause certain fracture of the silver soldered joints to the slides, as I know to my cost! Cut and square off to $2\frac{3}{4}$ in. finished length, a section of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. steel bar. Mark it off carefully, then grip in the machine vice on the vertical slide and deal with each recess to accept a slide to be a tight fit. Erect on the brazing hearth with that length of $\frac{3}{16}$ in. rod to check alignment, then turn up the fulcrum pins from 7/32 in. silver steel rod; insert and braze up. Pickle clean and inspect. I have said nothing about modifying the yoke section to that shown on the drawing, for although experienced builders can do so, I recommend beginners leave the material section well alone, except for a radius on the two back corners if such is pleasing to your eye. Left at the original section, you can now grip this in the machine vice to mill away the shaded portion to give clearance to the vibrating links.

For the reverser arm, take a length of $\frac{3}{8}$ in. x $\frac{1}{8}$ in. steel flat and first bend to drawing, leaving plenty of excess material at the bottom end. Mark off, drill and ream the reach rod pin hole, radius the eye over a mandrel with an end mill, when the excess length will come in very handy, then file the flanks before marking off and drilling the pair of No. 44 holes. Cut off to length, file locally to clear the end of the yoke, then offer up, spot through, drill and tap the slide for 8BA bolts.

For the slideshaft bearings, chuck a length of $\frac{3}{4}$ in. diameter bar in the 3 jaw, it can be brass as very little wear will result, face and then turn down over a $\frac{1}{4}$ in. length to $\frac{3}{8}$ in. diameter. Centre, drill and ream 7/32 in. diameter to $\frac{1}{2}$ in. depth before parting off at a full $\frac{3}{8}$ in. overall, then reverse and face off until when the pair are assembled over the fulcrum pins, the whole slips neatly between the frames, though of course you will have to separate the frames to achieve this. Now you can drill the No. 41 holes and cut the flange to drawing.

Correcting Link

For this item we need a length of $\frac{7}{16}$ in. square steel bar, the same stuff that was specified for the bar frames on MARIE E, my previous beginners Locomotive described in LLAS. Cut and square off two $1\frac{3}{4}$ in. lengths, scribe a centre line along one piece, then grip as a pair in the machine vice. Starting 7/32 in. from one end, centre and drill right through the pair at No. 23, move on by .500 in. by the cross slide micrometer collar to centre again, drill No. 31 and ream through at $\frac{1}{8}$ in. diameter. Move on another .750 in. to complete the holes, centering and drilling No. 31. In the last session I told you how to cut slots in the drag beam angle by using two hacksaw blades in the frame and now I recommend you use the same technique to start the pair specified. Whether you complete with an end mill or files is a decision I will leave to you the builder, but as the $\frac{1}{8}$ in. one is easier to file, why not tackle the other in like fashion? Now it is a case of radiusing the ends over mandrels, using an end mill and gripping the link firmly with a 'Mole' wrench, when the flanks can be filed or milled to complete.

Vibrating Lever, Die Block and Anchor Link

Although I have specified both vibrating levers and anchor links from gauge plate, because they are a massive $\frac{1}{8}$ in. in thickness, BMS is a suitable substitute, section being $\frac{1}{4}$ in. x $\frac{1}{8}$ in. Cut to length, drill the total quantity in one operation to be identical in exactly the same way as for the correcting links, then radius the ends over a mandrel with an end mill.

I have always specified die blocks from gunmetal or bronze, but have now been told that mild steel is much superior, which makes life a lot easier as they can be cut from $\frac{3}{8}$ in. x $\frac{1}{8}$ in. BMS flat. Saw the section down to 9/32 in. x $\frac{1}{8}$ in., mill the edge to be clean, then saw into $\frac{5}{16}$ in. lengths and face them off to be identical. Now it is a matter of filing them to fit the slides, roughing them out and placing them over the slides initially, then getting them to enter the slot to a tight sliding fit; they will soon wear to a sweet sliding fit. Centre one die block, then chuck the whole batch in the 4 jaw to drill through at No. 31 and ream through at $\frac{1}{8}$ in. diameter. At this stage you can make up all the valve gear pins, the drive pair to drawing and the rest to the table of dimensions, all simply involving turning plain pieces of silver steel rod to length, which will cause no problems. Erect the vibrating levers over the correcting link and press in the pin, similarly the anchor link at the bottom, then thread on the die blocks and insert in turn in the slides, completing this part of the assembly by pressing in the drive pin. If you want to check things out before assembling so permanently, chuck a length of $\frac{1}{8}$ in. mild steel rod in the 3 jaw and use emery cloth to reduce same to an easy fit in the No. 31 holes before cutting up into temporary pins.

We next have to anchor said anchor links to the motion plate, for which we need the trunnions. Saw and square off $\frac{7}{16}$ in. lengths of $\frac{3}{4}$ in. x $\frac{3}{4}$ in. x $\frac{1}{8}$ in. bright steel angle, remembering the centre pair if this is your 'pump solution', reducing one leg to 21/32 in. length. In the other face, and clamp together as a pair to achieve alignment, drill a No. 31 hole and then complete the profile. Locate on the bottom face of the motion plate, and here I should have said the latter be machined to $\frac{7}{16}$ in. over flanges, spot through, drill and tap 8BA for round or hexagon head screws.

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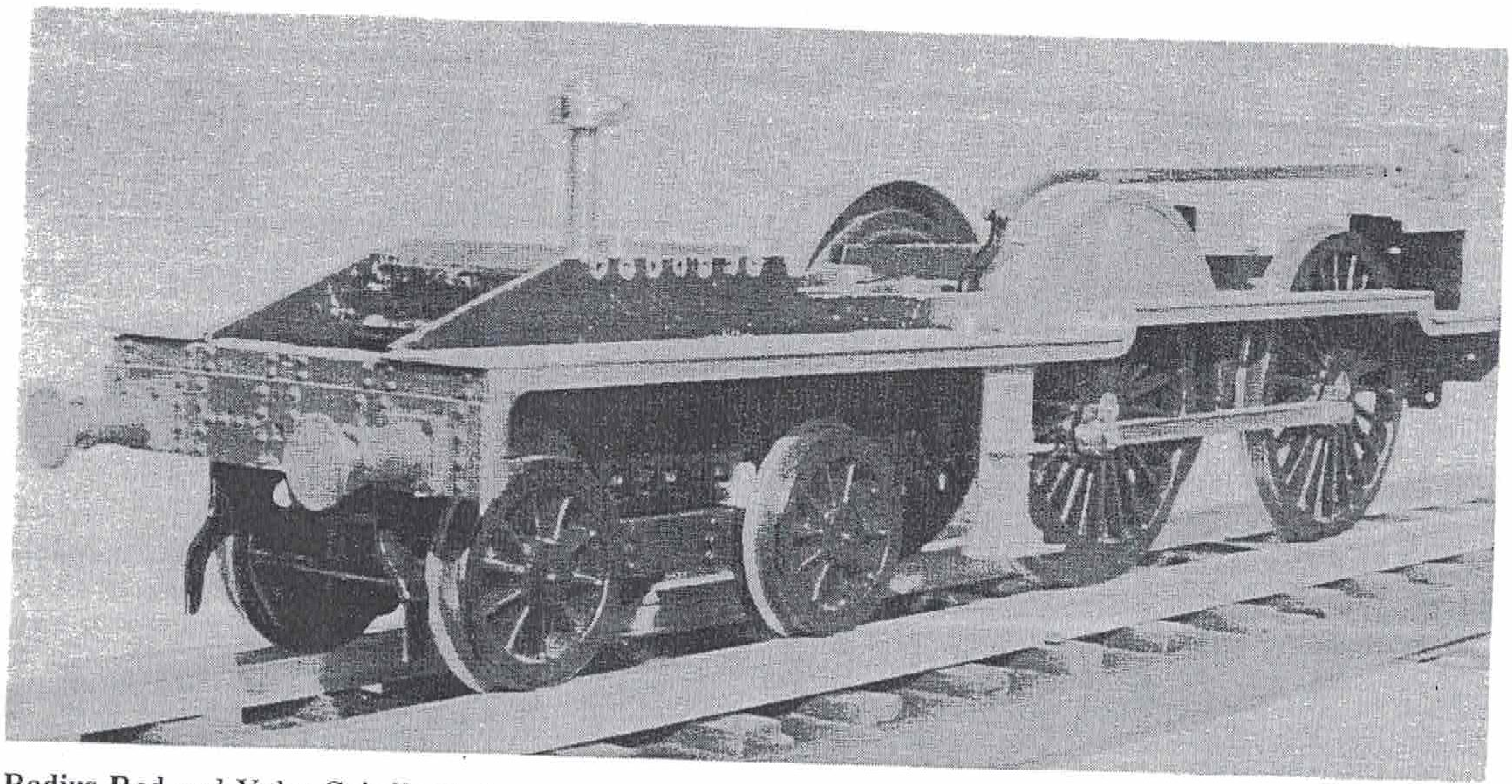


The Steve Titley 2P chassis ready to receive its boiler

Radius Rod and Valve Spindle Fork

Almost there, just to connect from the top of the vibrating levers to the valve spindle, so let me hurry on to the radius rod, for which a simple jig is required. Take a 4 in. length of, say, $\frac{1}{2}$ in. x $\frac{3}{16}$ in. BMS flat and drill two No. 31 holes at $3\frac{1}{2}$ in. centres, pressing in $\frac{1}{2}$ in. long lengths of $\frac{1}{8}$ in. silver steel rod; coat the whole job liberally with marking off fluid to stop any stray spelter adhering. Turn up the end boss from $\frac{1}{4}$ in. bronze rod, it only needs drilling and reaming plus facing off to length, then drop it over a pin on the jig. The main portion of the rod is a $3\frac{3}{4}$ in. length of $\frac{1}{4}$ in. x $\frac{1}{8}$ in. BMS bar, so drill and ream the $\frac{1}{8}$ in. hole at 5/32 in. from one end, then scallop the other until it fits the jig. There is no need to reduce the rod to $\frac{3}{16}$ in. width, you can simply radius the end if you wish, when the rod is silver soldered together.

For the valve fork, start with a length of $\frac{5}{16}$ in. square steel bar, cross drilling and reaming to $\frac{1}{8}$ in. diameter at 5/32 in. from one end before radiusing over a mandrel with an end mill; you can leave the section at $\frac{5}{16}$ in. square if you wish, instead of reducing to $\frac{1}{4}$ in. as shown. Now saw and file the slot to accept the radius rod before sawing off, chucking truly in the 4 jaw to face, centre, drill and tap 5/32 x 40T to suit the valve spindle; assemble.

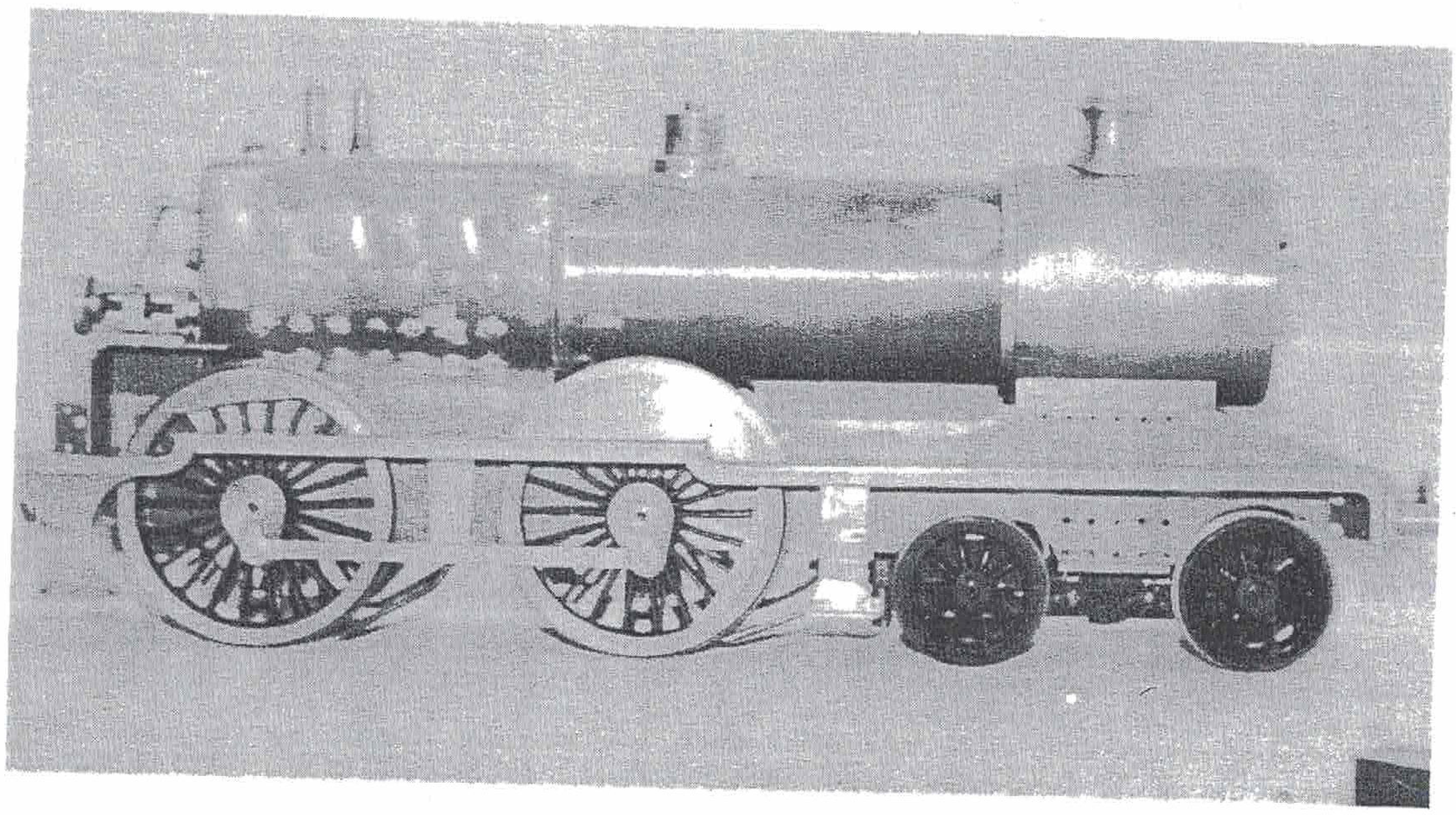
Valve Setting

Although the valves should not be set until the reverser and reach rod have been made and erected, I can at least cover the rudiments of valve setting here as this will only take a few lines. Set the reverser in mid gear, that is when the valves travel their shortest distance, release the valve spindle at the cross-head and adjust until the valve opens each steam port by the same amount, though practically and due to the 'coarse' 40T thread this is not quite possible. You will easily get within .005 in. of equality however, and make any error in favour of the back port. That is it, the valves have been set, or rather will have when I add the important note that the driving axle MUST be packed up to its working height, which is $\frac{1}{8}$ in. above the hornstay; pack it tightly in this position for valve setting and I won't get a single query!

Reach Rod

Last item in this session and one I cannot complete, though it can be well advanced.

Braze a $\frac{3}{4}$ in. length of $\frac{3}{8}$ in. square BMS bar to a 12 in. length of $\frac{5}{16}$ in. x $\frac{1}{8}$ in. strip, cross drill the block at No. 31 then cut the $\frac{1}{8}$ in. slot to accept the reverser arm on the slideshaft before radiusing the fork end over a mandrel with an end mill; by now you will have completely mastered this technique. Taper from $\frac{5}{16}$ in. down to $\frac{1}{4}$ in. width over a 4/5 in. length at the fork end, then bend roughly to as shown, this mainly to clear the splasher, and that is as far as we can go in this session.



Norman Lammas halted the stripping process to 'expose' his No. 2691 for us in October 1985