E. S. COX – The Horwich 'Crab' in 5 in. gauge

by: DON YOUNG

PART I – Introduction

Virtually since the very inception of LLAS at the beginning of 1979 I have been funking the decision between my BLACK FIVE and E. S. COX designs as to which of the pair should be favoured with a series. I knew when preparing the E. S. COX drawings that I would in part be competing with myself, but had the feeling that builders would decide for me which was the most popular, and that this choice would fall on BLACK FIVE. Life, however, is full of unexpected surprises and one of them is that the two designs were running just about neck and neck. Finally, taking the bull by the horns and being a dedicated 'Mogul' supporter, I decided as the 4-6-0 SAINT CHRISTOPHER had been my choice for 3½ in. gauge, then I would ring the changes and make E. S. COX my choice for the next 5 in. gauge series. I made that decision around the end of September 1981 and before I could change my mind yet again, quickly put pen to paper to prepare the introductory notes; really the only people who knew of this decision were those building ahead of my notes, in the hope that they might be able to supply illustration, and illumination(!), for a dull script; the omens thus far on that score are good. The strange thing is that since that decision, E. S. COX has been moving decisively ahead of her BLACK FIVE rival, though I don't think I have done anything to contribute to this, indeed am still fearful the pendulum will swing the other way! It does mean that BLACK FIVE will not now appear as an individual series, though this is by no means as sad as it may seem, indeed the very reason it will not appear is the very marked similarity between the two designs, for Stanier did not make as many radical and fundamental changes to L.M.S. design as we are often led to believe, there are many amazing similarities which extend to such a major item as the longitudinal section of the boiler. I did not of course realise this at the outset, but when I had tracings of the two designs at identical scale and was able to gaze through one at the other it was a revelation. Once this is realised, then it is perfectly logical, for one cannot change the habits of whole drawing offices overnight. In fact from around 16 years spent in drawing offices and knowing how senior and brilliant men reacted when presented with a design concept of which they did not approve, one can almost sense what happened with the BLACK FIVE boiler. The MKI design was very much of Swindon origin, though it lost something in translation. I can sense what amounts to a feeling of relief when the MKII boiler was authorised and can imagine the draughtsman concerned reaching into his drawer for the 'Crab' boiler drawing, indeed it is well within the realms of possibility that the MKII drawing was already in being in somebody's reference drawer. I have done precisely this in industry, but radar reflectors are not steam driven, so form no part of this tale!

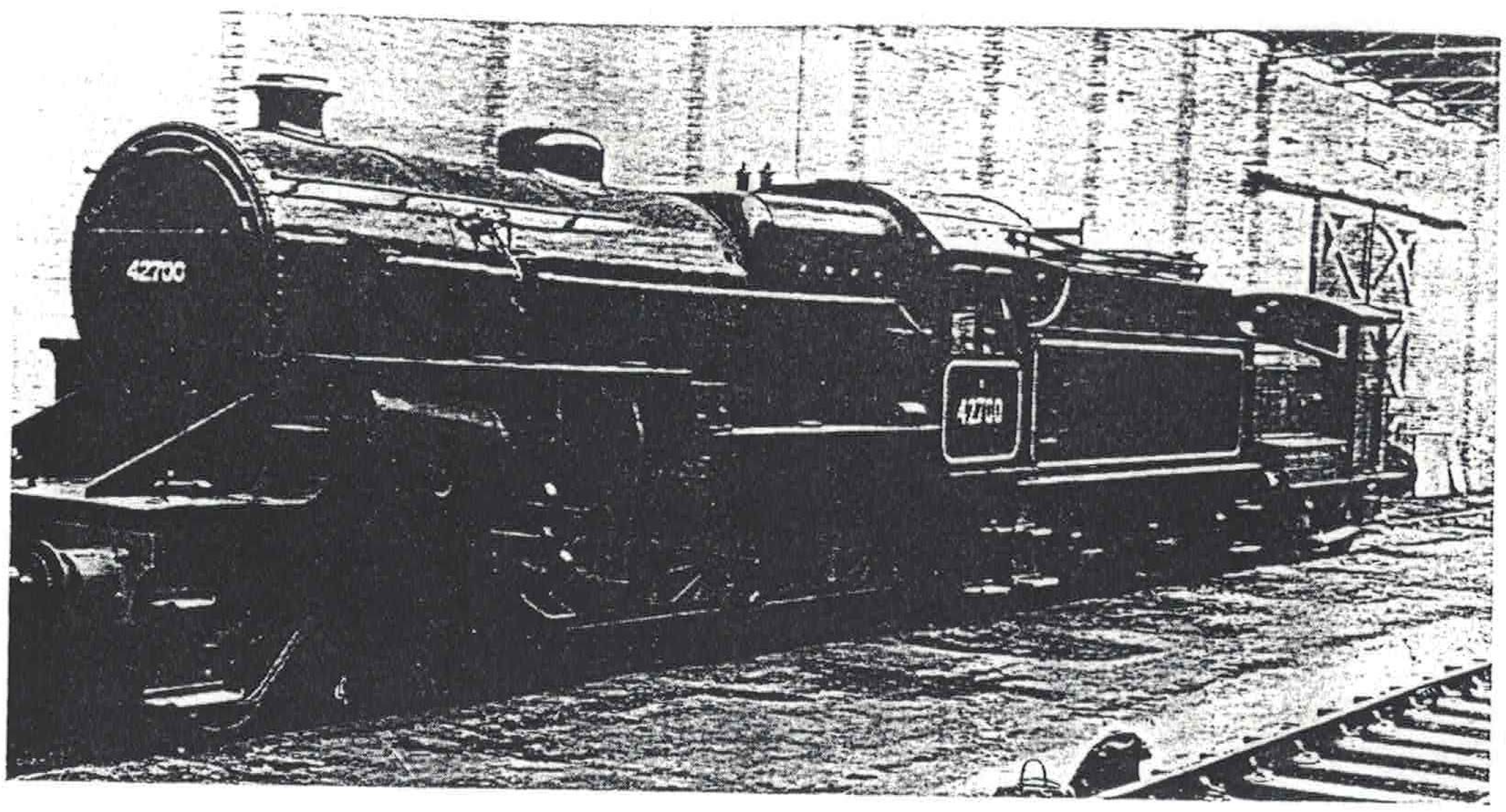
Returning to E. S. COX and the comparisons with BLACK FIVE, many of the machining operations I shall be describing, for intance the piston valve cylinders, are common to both engines, so I will be killing two birds with one stone. Having disposed of the choice, let us see what E. S. COX has to offer. My first step, as always, was a critical appraisal of the information available to me; in this instance the most comprehensive ever. The most vital piece of evidence was a linen print of 1928 origin and at a scale of 1½ in. = 1 ft. unearthed at Horwich. Supporting evidence was the result of a visit by the two Normans, Gregory and Lowe, to the National Railway Museum at York, where in company with Len Hough they produced an almost complete photographic and dimensional record of No. 42700, passing this vast amount of information to me. Strange to relate, the photographic record completely strangled progress on the drawings for almost a whole year, the reverse of what one would expect, as I will endeavour to explain.

I started with the General Arrangement of the engine, which posed not a single problem, but when I came to the tender, I could not reconcile the photographic and full size drawing evidence, it was completely at loggerheads. At that time I was not in contact with John Bellwood, Chief Mechanical Engineer at the N.R.M., so had to rely on my observations and ask others to aid my research, including Dennis Monk who is an authority on Derby designs; I finally came to the conclusion that the tender fitted to No. 42700 was unique. This has since been confirmed by John Bellwood supplying me with a copy of the History Sheet for the tender, which started life in 1896 and was rebuilt in 1927, obviously without drawings, the new body being made to fit the existing chassis. I did proceed with my drawings for the tender ahead of receiving this clarification, but breathed a sigh of relief once I knew the full story. There were however, three factors which kept me going when I might have otherwise given up and left the Horwich 'Crab' to another designer.

First my critical appraisal of the design showed the proportions were sheer perfection. Next, Norman Lowe having built his SUPER LANKY, No. 1538, as being the first Horwich design, wanted to build a 'Crab' as being the last truly Horwich design, though somewhat 'Midlandised' as finally built. But the third reason was the most compelling, for although I already knew that E. S. Cox had been somehow involved in the original design, only when I sent him Sheet No. 1 to inspect did I find out the full extent of same. It transpires that as a 24-year-old junior draughtsman, Stewart Cox did all the initial design work for the Horwich 'Crab', which George Hughes as Chief Mechanical Engineer of the L.M.S. approved without alteration, so the Horwich 'Crab' more even than the B.R. Standard Classes for which he was design co-ordinator, is an E. S. Cox Locomotive. Readers will already know that my own humble work owes much to Stewart Cox, so I was overjoyed when he allowed me to use his name to grace the smokebox of my 5 in. gauge design, though it did increase my responsibility to make E. S. COX worthy to bear the name. Thanks to the enormous help given me, including the drawings being checked both at Horwich and by the original designer, I like to think I have succeeded, and to a greater degree than in anything previous.

In December 1979 came the ultimate pleasure when I visited Stewart Cox at his lovely retirement home in South Devon and was able to discuss the design, many other things too, with the great man. Thus I was able to express my only criticism of the 'Crab' to its creator, this being of the ashpan in way of the rear coupled axle, from which it was fascinating to be told that latterly this was found to be the limiting factor on the full size engines, this towards the end of their long and illustrious career, and that solution would have been in keeping with mine for 5 in. gauge; that really made my day! Stewart Cox told me that he gained the greatest pleasure from seeing his design, more than 30 years after leaving the drawing

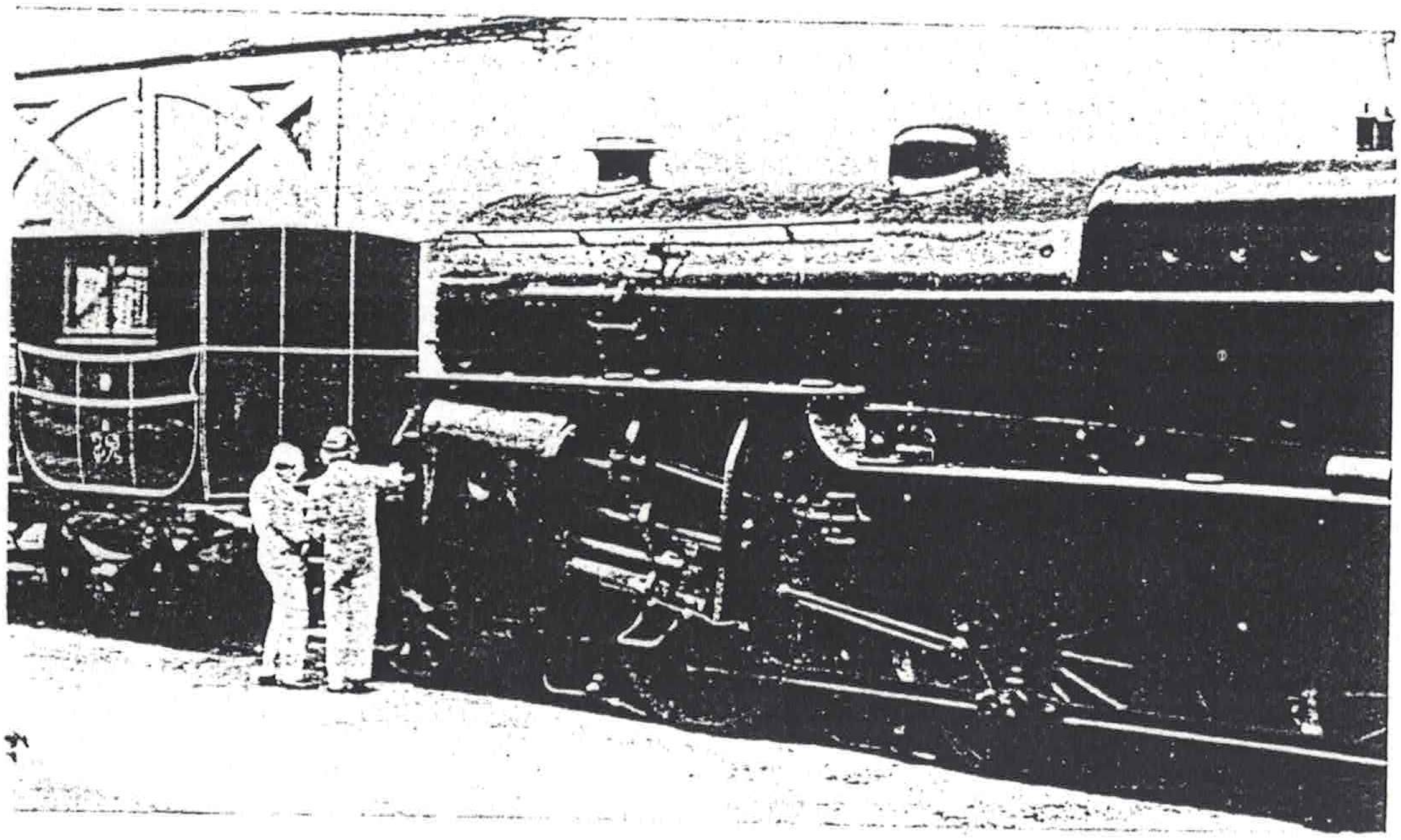
The moment of discovery – Horwich 'Crab' No. 42700 is finally revealed at the National Railway Museum, York



board, still engaged in the most arduous revenue earning service, on anything from unfitted goods, through vacuum fitted and parcel trains, to excursion and even express working. I said at the outset that the information I was provided with was almost complete, the sole exception being the backhead. The drawing information was conflicting in that the end and side views were not compatible, the view from the tender depicting the L & Y arrangement as originally proposed, some of which was incorporated on the first engines built, but by no means all, the firehole door being an example. Gradually I was able to piece together the evidence, and together with some photographs taken by Len Hough, which I trust he will allow me to say were not of his usual standard, in the end it all came out right, so what have we got?

First and foremost there is a boiler of the most excellent proportions, not restricted in tube lay-out as is BLACK FIVE by reason of the taper barrel, though the pair are basically similar, in fact I should say strikingly similar. So we start off with a most superb steam producer, and the means of turning this steam into useful work at the drawbar is equally impressive – the cylinders certainly are! They are of course so sized, and inclined, due to proportioning to suit the 180 p.s.i.g. boiler pressure, inclination being to come within the loading gauge. Steam distribution by the Cox/Walschaerts valve gear is good, another reason for their success, as is the draughting, though its physical shape will raise a few eyebrows when we come to it. The swing link pony truck is a work of art and will give a lot of pleasure in its construction, that I promise! The Midland influence was largely to fit one of the narrow 3,500 gallon tenders, which is less than a perfect match with the engine in width, though the blending in this instance was quite skilful and acceptable, not like the original 'Royal Scots'.

In E. S. COX we have an engine of immense power, and character, one which I can recommend to all experienced builders as a very worthwhile project. Although in this instance I do not have the benefit of a prototype already in steam, Norman Lowe already has his tender and engine pony truck complete and towards the end of January 1982 is almost ready to wheel the chassis, whilst Larry Loughborough has just sent me photographs of his boiler which is close to the hydraulic pressure test, so I am sure there will be more than one E. S. COX on the rails ahead of completion of this series. Photographically E. S. COX is extremely well catered for; those by Norman Gregory of the full size No. 42700 are going to save me many thousands of words in explanation and are gratefully acknowledged. It all adds up to a very exciting prospect; next time we can begin to cut metal.



Norman Lowe and Len Hough caught deep in discussion; yes, the running boards are $\frac{3}{8}$ in. thick!

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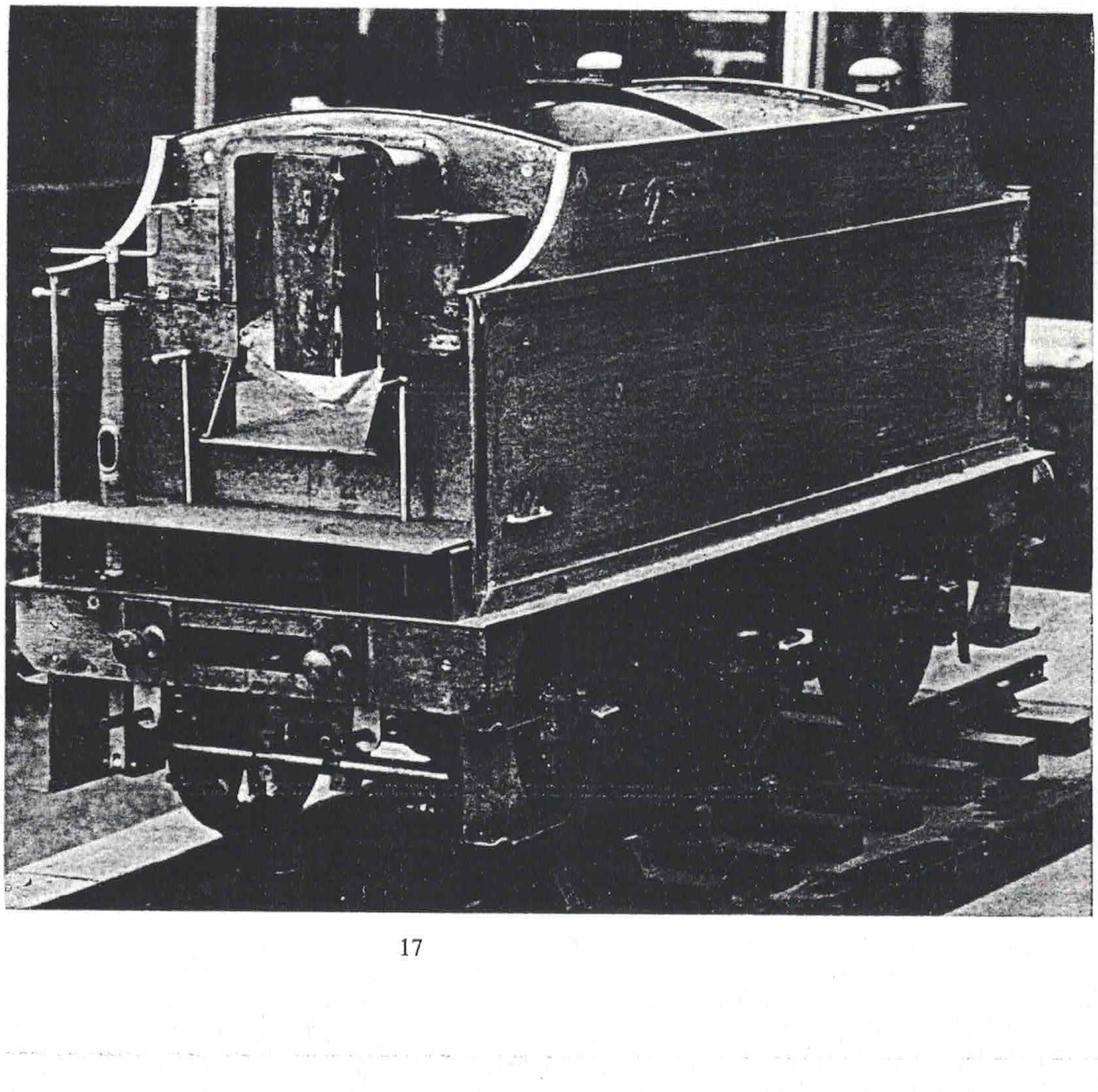
Part 2 – Tender Chassis

The top left hand corner of Sheet 2, the side elevation of the Fowler 3,500 gallon tender, represents almost a year of my life, yet when I set out the hope was the view would be completed in a single day! The two Normans, Gregory and Lowe, had between them supplied me with a complete photographic record of the tender attached to 42700, plus Works drawings, so I should have been in clover. As a draughtsman, I am an artisan rather than an artist, in fact my drawings never come alive at all until Helen has waved her magic pen over them, but whilst I have long given up the struggle to produce respectable isometric sketches, in one aspect I have over the years become very proficient, namely in measuring from photographs. Therefore, when both photographic and drawing evidence is available for any project, I like to check one against the other. I first came unstuck with this procedure on LANKY, the Lancashire and Yorkshire Railway 2-4-2 Radial Tank Locomotive, because No. 1008 as she then rested at Tyesley was vastly different in detail to the Horwich Works drawings produced in 1889. In that instance and after scrutiny of the photographs I took, the alterations that had occurred over the years and the reasons for same could be grasped, so it was a relatively simple matter to concentrate solely on the drawing evidence as being authentic for the first of the Class; No. 1008 as built. So although some still maintain that a few of the details I drew for LANKY never graced a Horwich Locomotive, like elliptical sandbox lids instead of circular ones, the 1889 drawing was absolutely clear on this particular point. When it came to the 'Crab' tender, I had two totally conflicting sets of evidence, all very confusing, and with no immediate logical answer as to the discrepancies. Because the tender had been photographed at York as late as 1977, there could be no doubt that it existed, and such things as tender frames do not change their profile over the years, plus it had all the hallmarks of a Fowler 3,500 gallon tender.

Not being an authority on Derby tenders, hardly any tenders for that matter!, I had to slowly and painfully search a multitude of books for pictures and other information that would provide me with clues; gradually I formed the opinion that the tender fitted to 42700 was very much a 'one off'. In the days of the Transport Museum at Clapham I had a most willing and able contact in Mr. Cogger; when the move was made to the National Railway Museum at York I thought all was lost, and because I no longer had that special contact my early experiences with York were rather disappointing. All that changed when, by a stroke of good fortune, I was put in touch with John Bellwood, Chief Mechanical Engineer at the Museum, and learnt of his Doncaster beginnings. Incidentally, Walter Bossons tells me that as an Engineering



Norman Lowe built this tender in less time than it took me to research and draw it!

Apprentice at Crewe, he was taught that Doncaster was a place out East where Butterscotch came from; I ask you! Anyhow, I was able to ask John Bellwood to check my findings that the tender fitted to No. 42700 was unique and in reply I got a copy of the History Sheet; 12 months earlier and that side elevation might have been completed in a single day. I do not expect E. S. COX builders to spend time comparing the photographs of the full size tender appearing in these pages with the drawing details, but to soldier on in the knowledge that I did get it right in the end, but for other non E. S. COX builders it is a fascinating exercise to spot the differences, though you may well finish up as confused as I was! A year's work compressed into a few lines, but now I could gallop away, as we can with construction of the tender chassis, starting with the frames.

Outer and Inner Frames

I do not propose to give a 'blow by blow' account of the construction of E. S. COX, in fact he/she calls for a measure of skill that means builders could tell me a thing or two!, but will concentrate on specific features. When one is working to a scale of 5:56.5, obviously the 1/64ths do creep in, but I hope I have applied these a bit more intelligently than I did on JERSEY LILY in rounding off to 1/32nds where the manufacturing tolerances allow.

Using the exact scale can also mean more work in that standard material sections, if there are such things in these days of a hotch-potch of imperial/metric sizes, cannot always be employed. An instance of this occurs right at the outset, for whilst $3\frac{1}{2}$ in. x $\frac{1}{8}$ in. is O.K., the nearest metric standard of 80mm x 3mm is a full 1/32 in. shy in width, so one is forced up to 100mm x 3mm. Tidy up the top, datum, edge on two pieces of 2 feet (600mm) length to be perfectly true then mark off one piece, clamp together, drill a number of the $\frac{1}{16}$ in. holes and fix together with copper or aluminium rivets. The two large lightening holes between the axles have a superfluous dimension, the overall depth of 1 13/64 in., this being a check after striking the three radii. I suggest you drill a pilot hole for the $\frac{7}{16}$ in. radius and then make up a $\frac{7}{8}$ in. diameter hole cutter as specified by Jack Coulson for boiler work on Page 10 of LLAS No. 7. You will then be able to insert a hacksaw blade into these holes and saw out most of the surplus metal, completing with files. It is always problematical as to whether to specify fixing holes for horns on the frames or in the horns themselves, especially when there are webs cast into the latter, which can create snags in partially masking a hole. So whilst I have detailed the group for the middle axle, this to establish the dimensions, really the choice can be left to the builder, then I won't be wrong for a change! The purpose of all of the remaining holes is clear from reference to the upper view, so carry on and drill them, then profile the frames. The horns spigot into the frame openings, so if we make the latter exact to drawing our later tasks will be so much easier. Drill $\frac{3}{16}$ in. holes in the top corners of the slots, then saw down the sides. Our woodwork teacher then showed us how to cut from corner to corner, leaving a triangle of metal which could then be further attacked with the saw; although in wood it is much easier, it is still no real hardship with $\frac{1}{4}$ in. thickness of steel, and good exercise! If no milling machine is available to complete the slot to $1\frac{1}{8}$ in. width, revert to the set-up of machine vice and vertical slide on the lathe boring table, slot facing the chuck, and use a large diameter end mill to attack the flanks, taking care not to spoil the 3/32 in. radius at the top corners.

Except for reducing the metal section to $1\frac{5}{16}$ in. (x $\frac{1}{8}$ in. or 3mm), the inner frames are a piece of cake, and are drilled from the outer frames as your gauge; note they are shorter than the outer pair by the thickness of the front beam assembly, our next job.

Front Beam, Box Plate and Diaphragm Plate

Full size Locomotives and tenders did not have stretchers and the like burnt out from 4 or 6 in. steel billets, so I deplore the use of $\frac{3}{8}$ or $\frac{1}{2}$ in. thick stretchers in miniature; to me they spoil otherwise superb craftsmanship. I will admit that those formed from 3/32 in. or $\frac{1}{8}$ in. sheet do call for greater skill and patience, also that some at least are rarely seen after being built-in, but their effect is so superior as to be thought well worthy of the effort, at least that is what I think. Incidentally, the instances of adding weight to improve adhesion in full size were extremely rare indeed; common was the necessity to reduce an 'overweight' engine!

For such items as the front box plate, I make up a flanging block from $\frac{1}{4}$ in. plate to be 1/64 in. greater in dimension than the nominal internal size of the box. Cut the box plate itself oversize and from flanging quality mild steel, the bright variety will crack at the bends, cut away the corners, flange up and braze the joints if there are any gaps; turn up the drawbar pin boss and braze this in at the same time. Drill the holes, bolt directly to the vertical slide table and mill all around the edges to size. Complete by thoroughly cleaning and then use an aerosol can to spray on a thin zinc coating, this to prevent rusting.

The front beam and diaphragm plate call for no special mention, save for their method of attachment to the top and bottom box plates. The front beam I recommend be attached with 3/32 in. snap head iron rivets, heads inside, hammering down into those countersinks in the beam, not forgetting to fit the buffer plates where the plain holes are depicted; these and the front buffers themselves require no description. Feed in the buffers, fit $\frac{1}{4}$ in. o.d. springs of 18 s.w.g. and about $1\frac{1}{4}$ in. free length, erect the diaphragm plate to the box plates with 6BA round or hexagon head screws, then add 4BA nuts and locknuts to the screwed ends of the buffers; you will have to finally adjust the buffer protrusion when attached to the engine.

Rear Beam, Box Plate, Coupler Draw Plate and Stiffener

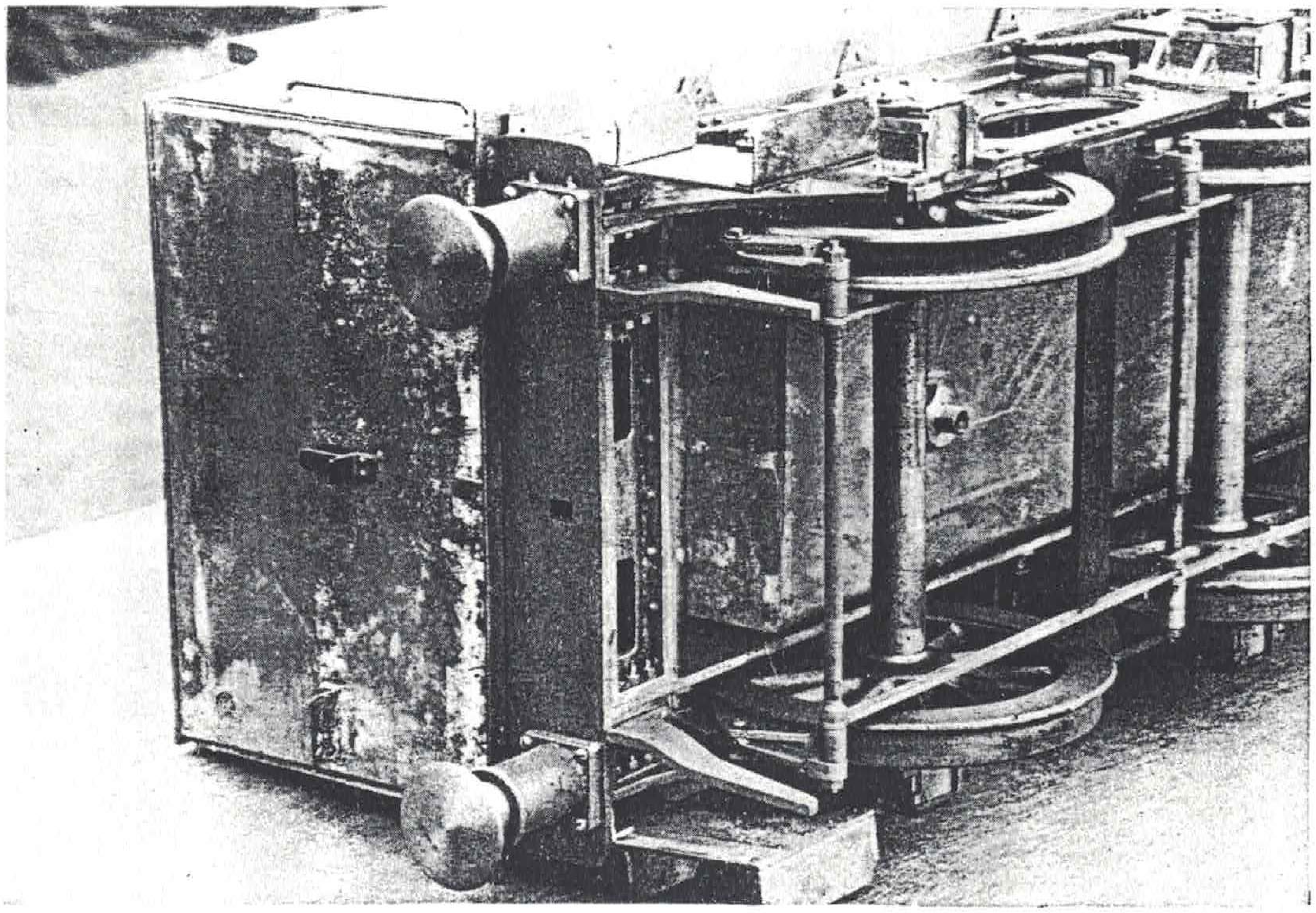
The assembly at the rear end is much the same, save that it fits between the inner frames. This means that if 3mm be the thickness of the latter, then make the stiffeners a little wider to give $6\frac{1}{8}$ in. overall to the outer frames. The pairs of holes at the outer ends of the beams are for attachment of pieces of $\frac{1}{4}$ in. x $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass angle, the other face to attach to the steps to provide extra strength; Norman Lowe tells me I forgot to detail attachment of this angle to the steps, or indeed make mention of same on the drawings – shame on me.

Guard Irons

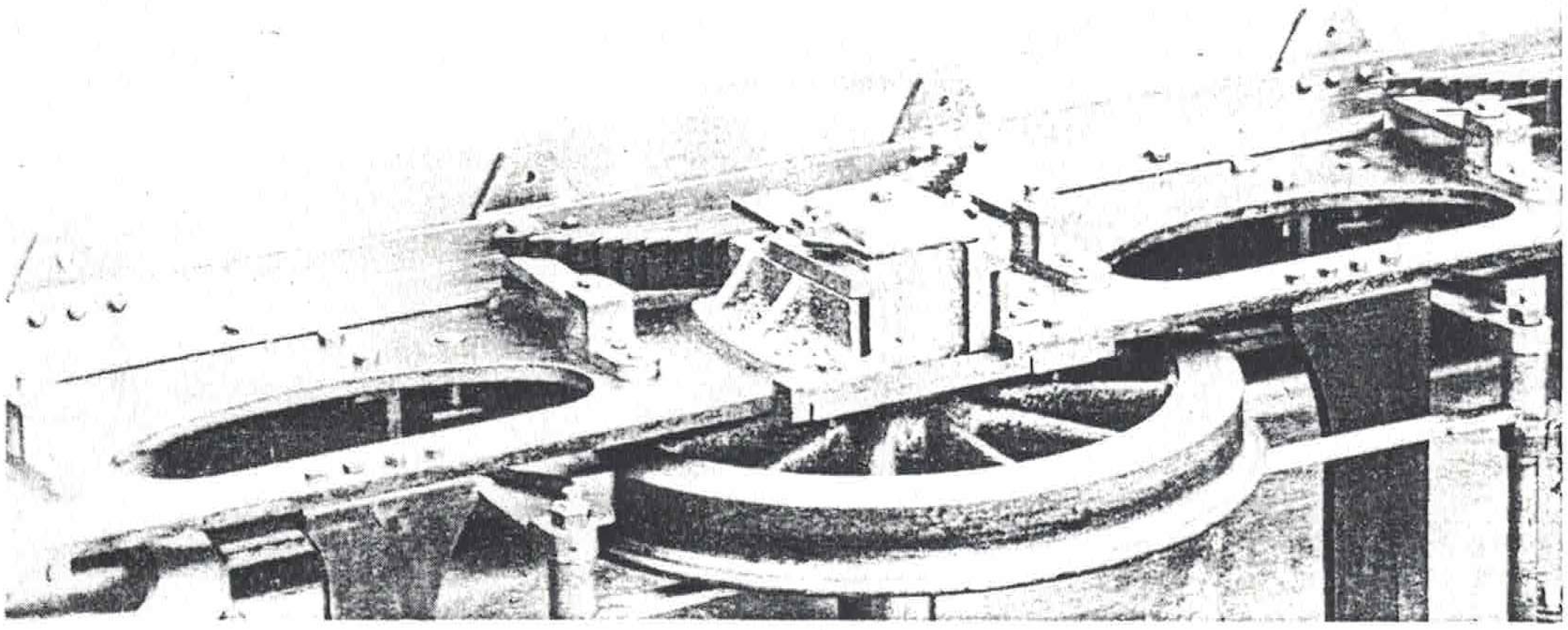
Guard irons can be a menace on small Locomotives, for if attached with scale bolts then the latter are often sheared. In this instance, not only can we use scale fixings, but by making the fit inside the bottom stiffener a good one, the whole becomes a very strong assembly. The guard irons bolt through the stiffeners to the inner frames; this will become clear once the tender is wheeled.

Frame and Intermediate Stretchers

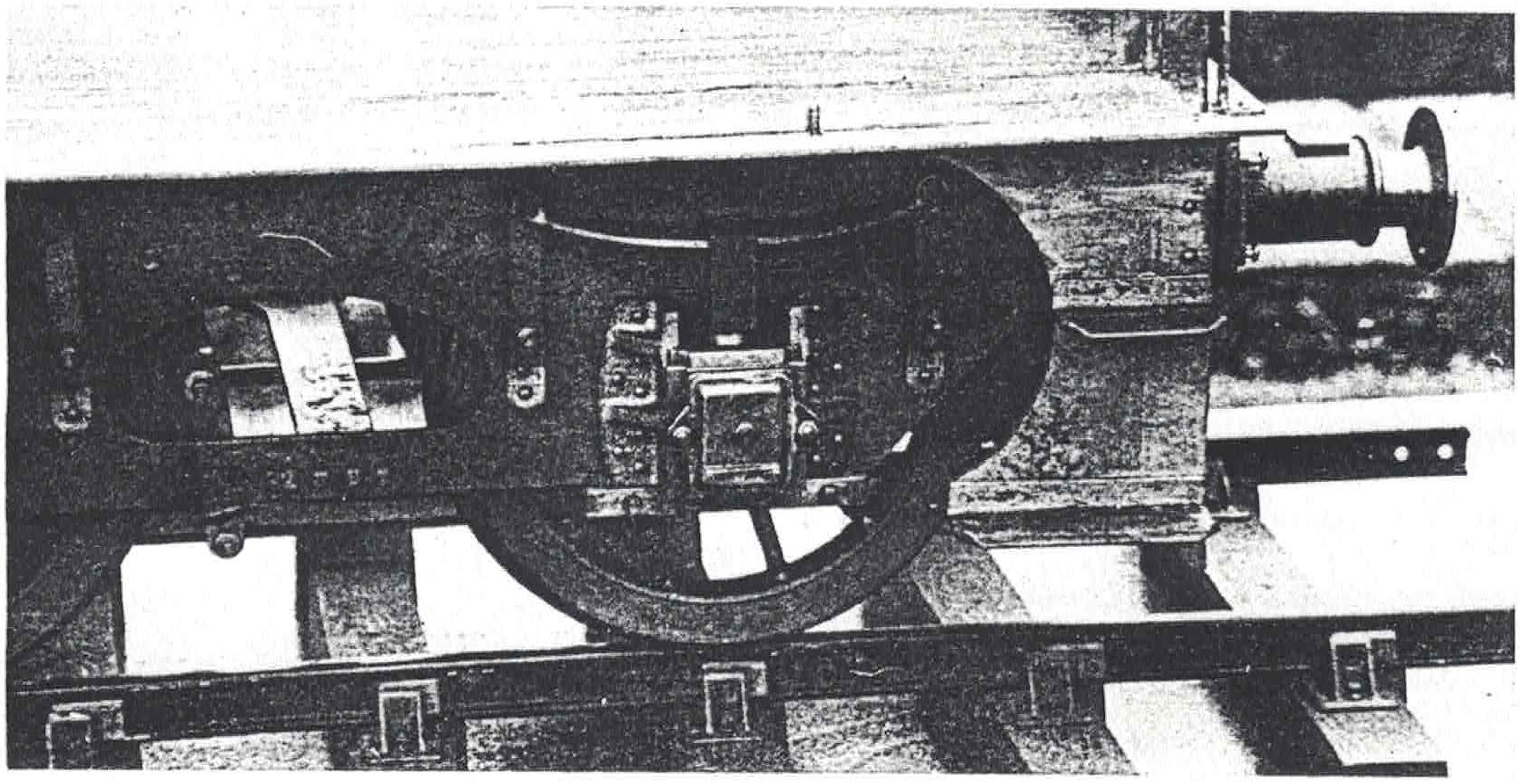
The frame stretchers are bent up from $1\frac{1}{16}$ in. x $\frac{1}{8}$ in. flanging quality mild steel, ends milled to $6\frac{1}{8}$ in. overall and then shaped as shown, the double-relief in the rear stretcher being to clear the scoop if one were fitted. Thus far I have jibbed at detailing this ultimate refinement, probably because I admit to being rather frightened of them full size. Most of my footplate work was done at night and although the ends of the water troughs were well illuminated, it was always a relief to get the scoop down into the water without damaging it, or the end of the trough. More important was getting the scoop out again, before either the tender overfilled, or the end of the trough was reached; a scoop never came out as easy as it



This view is particularly useful in showing both the attachment of the guard irons, and steps to the rear beam.



Bare metal is difficult to photograph and this shot highlights both cameraman Len Hough's skill and the fine workmanship of Norman Lowe.



The chaired track is not to my specification, but the rest is! Note the bent up corners on the steps – crude but completely authentic went in. Invariably when we took water, we were ahead of an express train, so the rule was not to take too much water, just enough to allow the trough to refill before the express arrived on the scene. The bottom extremity of the scoop has a thin plate, about 16 s.w.g. as far as I can remember, this to offer a fine line of attack to the water and to be sacrificial in case of striking an obstruction; you should have seen what happened to some of them. I doubt if many readers have experienced the thrill of travelling on water at 60 m.p.h., something to get the adrenelin flowing and the one thing I miss from my days spent with power boats, but it did give me an insight into the tremendous forces which were generated and I could imagine what would happen had I dipped a scoop into the water at that speed! Enough of the chat, for we are ready to assemble the frames.

First cut two $1\frac{15}{16}$ in. lengths from $\frac{1}{2}$ in. x $\frac{1}{2}$ in. x $\frac{1}{8}$ in. steel or brass angle and attach to the front end of the inner frames with 6BA bolts. Clamp the front and rear end boxes and frame stretchers in place, lay upside down on a flat surface and check before drilling and tapping for a few bolts in each part. Measure between the outer and inner frames and make up the intermediate stretchers, brazing the two pieces together and then machining to width; again assemble each with a few screws.

Tank Holding Down Angle and Brackets

The angle fits the whole length between beams and must first be trimmed to $\frac{1}{2}$ in. x $\frac{1}{4}$ in. x $\frac{1}{16}$ in. section. Cut the brackets from $\frac{1}{16}$ in. (1.6mm) brass strip or sheet, the back pair are slightly different in shape, and attach to the angle in the positions shown with $\frac{1}{16}$ in. copper rivets. Hold the angle against the outer frames, $\frac{1}{16}$ in. below the top edge, and drill through the No. 44 holes for the intermediate stretcher fixings. These will be insufficient to secure the angle to the frames and really it will require holes at about $\frac{1}{2}$ in. pitch and equally spaced along its whole length. It is a pity that attachment cannot be by rivets, but this would mask the holes at the end of the frames.

Buffers and Coupler

Only buffers and couplers to complete this session and the latter might raise a few eyebrows on what is supposed to be a true scale version. However, we have yet to have the luxury of a forged hook as in full size, and cut from bar there is the certainty of cross grain in at least one plane, so our E. S. COX would be at risk when performing as she is capable. For those wishing to exhibit completed engines in competition, the answer is to make another and proper screw coupling from the detail when it appears with Sheet No. 11 and substitute same at the proper time. For the moment, make the coupler as shown from $\frac{7}{16}$ in. square bar, checking against the drivers truck coupling that my $\frac{3}{16}$ in. jaw dimension is adequate, completing this end with a $\frac{3}{16}$ in. split pin or 2BA bolt. Fit to the rear box, cut and fit the spring, then tension with a pair of $\frac{1}{4}$ x 32T nuts.

Buffers are one of the most difficult items to present in miniature, especially if they are to function properly, which means fitting a very stiff spring, in fact my specified wire diameter at 16 s.w.g. could well be increased to 14 s.w.g. Again many stocks are extremely slender in section, which is perfectly O.K. when a direct axial load is applied, but in miniature with our less than scale track radii, side loading is a more than distinct possibility. From this I can only hope that my slight juggling with the scale dimensions will find favour, this in the sure knowledge that 99.0% of all E. S. COX's will first and foremost be working engines.

The stocks comes first in line for treatment, the initial step being to reduce to 31/32 in. from 1 in. square steel bar, in about 2 in. lengths. Chuck one piece truly in the 4 jaw, face and centre the outer end and then bring the tailstock into play before turning the profile to drawing. Drill right through to 35/64 in. diameter, drop the speed, feed in plenty of cutting oil and ream out to $\frac{9}{16}$ in. diameter. Part off, then repeat for the other stocks before reverting to the 3 jaw chuck to face off the flange to finished thickness.

For the socket, start either with a length of $1\frac{3}{8}$ in. diameter bar and mill on four flats to $1\frac{1}{16}$ in. overall, or use the nearest section square bar and mill down. Whichever material is chosen, chuck truly in the 4 jaw, face and then turn down a 7/64 in. spigot to $\frac{5}{16}$ in. diameter, a close fit in the rear beam. Change to a knife edged tool and scribe the bolting circle at 1 3/32 in. diameter. Rough out the profile at the other side of the flange, within say about $\frac{1}{16}$ in. of finished sizes, then centre and drill No. 30 to about $\frac{11}{16}$ in. depth. Follow up with a $\frac{1}{4}$ in. drill to $\frac{3}{8}$ in. depth then 'D' bit to $\frac{7}{16}$ in. depth before parting off. Chuck a length of $\frac{1}{4}$ in. steel rod in the 3 jaw, centre and drill No. 40 to about $\frac{1}{4}$ in. depth before tapping 5BA; bolt the embryo socket to this mandrel to complete turning to fit the stock. Mark off for the four fixing holes, scribe the corner radii from these and file to line, then drill the No. 44 holes. Offer up to the stock, drill through the No. 44 holes then radius the corners on the stock flange to match those on the socket.

There is always the temptation to use an exotic stainless steel for the buffer heads, though in most climes a highly polished mild steel, lightly oiled, will stay rust-free for many years; it is all a question of surface finish. Chuck a length of $1\frac{1}{4}$ in. diameter bar in the 3 jaw and if you set your top slide over 10 deg. and use a round nosed tool, then you will be able both to turn down to $\frac{9}{16}$ in. diameter over the shank and produce the taper at the back of the head at the one setting. Face off to the 1 in. length shown after completing the previous operation then centre and drill No. 40 to $\frac{13}{16}$ in. depth. Follow up to $\frac{7}{16}$ in. diameter at $\frac{9}{16}$ in. depth and 'D' bit to complete the spring housing, tapping the remnants of the No. 40 hole at 5BA. Part off, reverse in the chuck, turn the head down to $1\frac{3}{16}$ in. diameter and form the face; files and emery cloth are best for this after the majority of the metal has been turned away. Although a template can be used for the face, I prefer to turn up one head and use this as a visual template when dealing with the others; the eye is a wonderful inspection aid. The spindle requires no description; fit it to the head, insert the spring, assemble over stock and socket, squeeze in the vice, soft clams please, and fit a 5BA nut to the protruding end of the spindle, in the $\frac{1}{4}$ in. diameter housing. Offer the complete buffer up to the rear beam, spot through the No. 44 holes, drill the beam No. 50 and tap 8BA; secure with hexagon head screws, ones with heads one or two sizes smaller than standard.

In the next session I hope to complete description of the tender, which will then give the necessary incentive to get cracking on the engine itself.

Right on the publication day for the May issue, only it was a few days late in printing, came the awful news of the impending closure of Horwich Works. I class this as an act of folly equal to that of the closure of the world famous shipyard of John Samuel White at Cowes on the Isle of Wight back in the 1960's, something I experienced at first hand and from which the Island has yet to recover. This is supposed to be the age of the microchip and high technology, and heavy engineering is being ignored to our future peril; the pool of skilled labour that exists at Horwich should not be allowed to disperse, or rather stagnate, for this is already an area of high unemployment with little prospect of alternative employment. Let E. S. COX not be a memorial to a Works that in its 93 years history always built fine Locomotives, and many other things besides, but a pointer that Horwich has a great reputation, one that deserves to continue.

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Part 3 – Tender concluded

Horns & Hornstays

The horns are cast in sticks of four, which although economic from a casting point of view, are a little unwieldy for machining, so first cut into pairs. Set up the machine vice and vertical slide and clamp a pair of horns in place, with working face towards the chuck and using small pieces of packing between the ribs to give a good purchase on the top, moving vice jaw. Use a $\frac{3}{4}$ in. end mill for preference, as it gives plenty of lap over the working face, and machine down to line, then reduce the edges to give the $\frac{9}{16}$ in. overall dimension and tidy up the ends of the casting. Now sit the working face on the bottom, fixed jaw, fit the pieces of packing again, tighten up and machine the frame face to leave the $\frac{1}{8}$ in. spigot, which engages the frames, standing $\frac{1}{16}$ in. proud. Saw into individual horns, mill to length, then tidy up the rest of the profile and either file or mill the end relief on the working face; lay aside for the moment whilst we tackle the hornstays.

For these latter we need six $2\frac{5}{16}$ in. lengths of $\frac{1}{2}$ in. square steel bar; clamp first to the frames and scribe on the lines to represent the slots to accept said frames. Back to the machine vice and pack out the embryo stays from the back of the vice to stand 5/32 in. proud of the jaws, then rough out the slots to full $\frac{1}{8}$ in. depth, but bare on width. Concentrate next on one slot only and open out to a tight fit over the frame; deal with the second slot likewise. Now you can deal with the ends to arrive at the $\frac{1}{8}$ in. dimension, then turn the bar over to mill the $\frac{1}{8}$ in. relief on the outer face. Tidy up with files to remove all the sharp corners, then clamp to the frames to drill through the No. 41 holes and secure with 7BA hexagon head bolts.

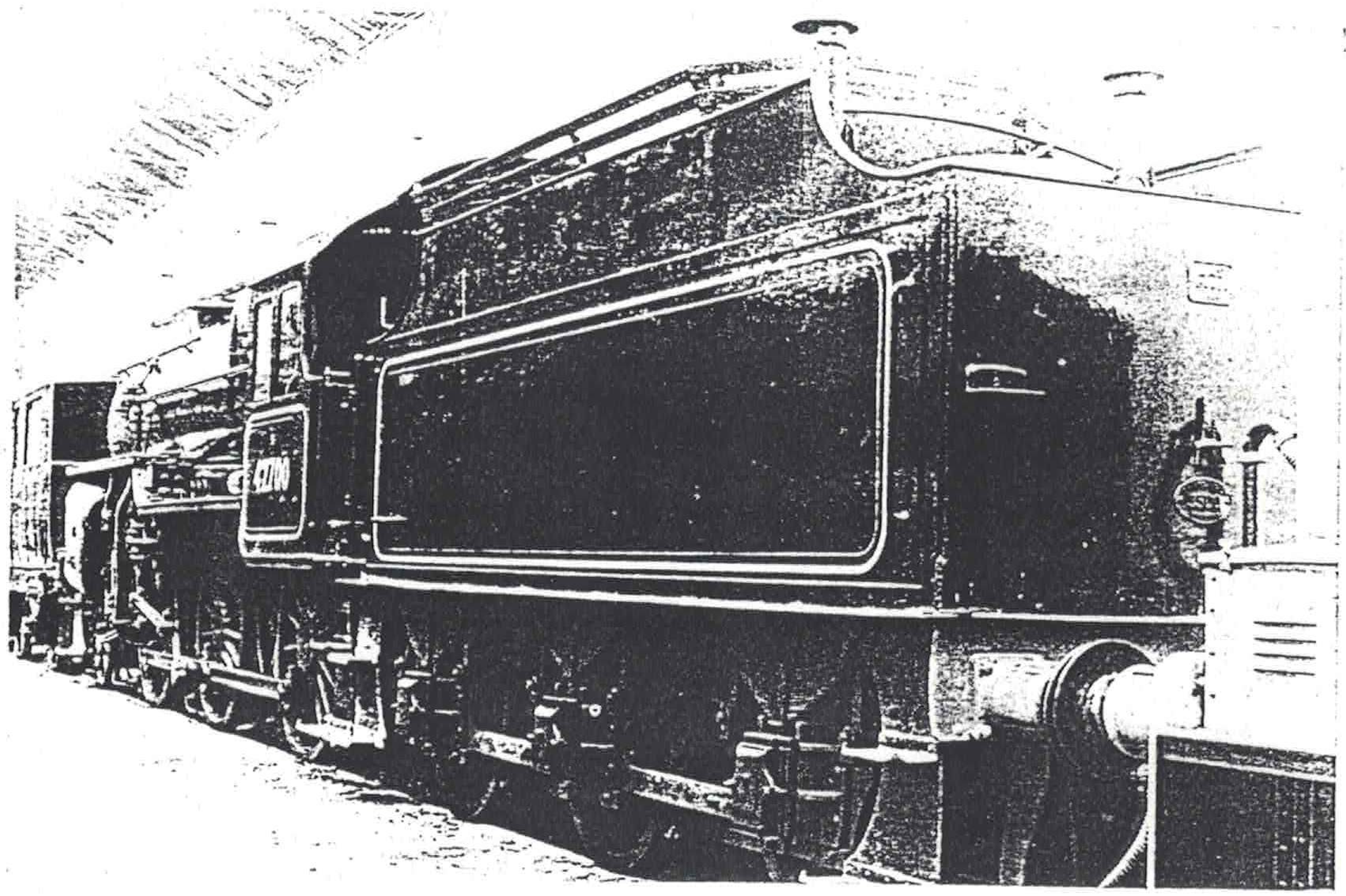
With the hornstays now in place, you can erect the horns, clamping them to the frames, then take 2BA bolts, with nuts fitted, insert them top and bottom between the working faces and unwind the nuts to firmly hold the horn spigots in the frame gaps. Drill through the $\frac{1}{16}$ in. holes and fit snap head soft iron rivets to complete.

Wheels & Axles

I do not propose to describe wheel turning for E. S. COX builders, in any case suitable notes have already been published for GLEN and others, so I can simply express the hope that you will really enjoy turning the beautiful cast iron.

The requirement for the axles is three $7\frac{3}{8}$ in. squared lengths of $\frac{3}{4}$ in. diameter steel bar; first chuck in the 3 jaw and deeply centre each end. Fit centres to both head and tail stock, mount the axle between centres, and although tradition is to use a drive plate and carrier as the means of propulsion, I find it much easier to use the 4 jaw, tightening carefully onto the bar. Ease the tailstock centre back a fraction and apply a blob of grease to prevent seizure, then reduce about half the length of bar to $\frac{11}{16}$ in. diameter, concentrating next on the outer end and reducing for $\frac{3}{4}$ in. length to a bare $\frac{9}{16}$ in. diameter, to be a very easy running fit in the axlebox. Usually with this type of 'plain' axle it is impossible to provide positive axial location for the wheels when fitting, but the shape of this axle in way of the wheels for the Fowler tender means we can provide a wee collar both to give said positive location and the correct appearance on completion, so turn down over the next 19/32 in. to $\frac{5}{8}$ in. diameter, either a press fit for the wheel or clearance for use of Loctite No. 601, as you prefer. Leaving $\frac{1}{16}$ in. for the collar, which has a radius as per drawing, turn down over a length to $\frac{5}{8}$ in. diameter, parallel for the moment; reverse in the chuck and repeat.

The tapered, central portion of the axle is a very slight one and I very much doubt if I gave you an accurate setting for the top slide whether you could achieve it, trial and error is



Builders of E. S. COX should not look too closely at this photograph, showing the Tender attached to 42700, for reasons already explained. Other readers can enjoy themselves comparing the differences with my drawings as they appeared in LLAS No. 12 and this issue in any case the better approach here. Bring the last axle up to the above stage, then set the top slide over just a touch. Mark on the centre of the axle and starting from this point, traverse the tool towards one end until it breaks clear of the $\frac{5}{8}$ in. turned bar. If you do this a little at a time, ease the top slide bolts and lightly tap with a mallet to move same by the merest fraction, you will get very close to the stated dimensions, when all you have to do is leave the setting well alone, turn this axle end for end and repeat, ditto for the remaining duo; fit the wheels.

Axlebox, Cover and Studs

Reeves have cast stick very suitable for the axleboxes, so I must remember to order some from them in case I get requests for same, though of course there will be no complaint from this end if your order be direct with my friends in Birmingham, especially as there is a large material requirement on Sheet No. 3 which I cannot supply, like the vast area of brass required for the tank!

Take the cast sticks and first reduce the thickness to the required 59/64 in. overall, taking care to leave the cast-in recesses in the right position. Back to the machine vice and vertical slide to mill along one side of the casting and then produce the 37/64 in. wide slot to $\frac{1}{8}$ in. depth. Make a note of the settings at which the final cuts were taken to achieve the correct width of slot, then rotate the casting through 180 deg. and repeat, taking very light cuts in conclusion until the axlebox will just enter the horns; the final, easy fit you will best secure with files. Once the slot is completed you can then mill the flanks on this, second side, to get the required $\frac{1}{8}$ in. dimension. Next job is to cut into individual boxes and true the ends to give the required $1\frac{1}{16}$ in. overall height, then back to the machine vice to mill the $\frac{1}{16}$ in. recess in the bottom face, which I see is undimensioned, so I can correct my omission by stating the width at $\frac{5}{8}$ in. Bring the front face towards the chuck and mill to give the $\frac{1}{16}$ in. raised face. Mark off for the two 8BA tapped holes, drill these at this setting and for the r.h. one, after drilling change to a $\frac{1}{4}$ in. end mill and relieve the raised face to accept the cover stud. Full size, both cover studs are plain, but to achieve the necessary robustness in miniature I had to increase their size just slightly and offset the r.h. one to arrive at a proper appearance. It does mean an awkward turning job, but the loss of material if scrapped the first time round is not costly, and with a screwed adaptor in the 4 jaw, once the required offset is achieved, you will be able to churn out studs by the dozen, to make sure you end up with six which tighten up with correct orientation.

Back to the axlebox proper, which is very close to completion; we must now deal with the bore to suit the axles. For this operation I now prefer to fit an angle plate to the vertical slide, bolt a pair of axleboxes back to back on said angle plate, after marking the axle centre on the outer face, lock everything solid once the setting has been arrived at and then simply drill right through to $\frac{9}{16}$ in. diameter; no blind journal holes this time thank goodness! To complete, poke a stub of $\frac{9}{16}$ in. material into the bore, chuck in the 4 jaw and get the stub running true with a d.t.i., then machine the 1/32 in. raised face to 1 in. diameter as shown.

For the cover, start with the base from $\frac{1}{16}$ in. (1.6mm) brass sheet and carefully mark out to drawing. Drill the two No. 44 holes and at the position shown for the 8BA hexagon head, drill and tap 8BA, then profile to drawing, checking for ease of assembly over the cover studs. The main portion of the cover starts life as a $\frac{15}{16}$ in. length of $\frac{3}{4}$ in. x $\frac{1}{8}$ in. brass strip and although with a swivelling vertical slide it is possible to set over and mill the edges, this with a round nosed end mill, my instinct is to file them to drawing. Drill a No. 44 hole, use an 8BA bolt to secure to the base and either sweat or silver solder together. Now you can wheel the tender chassis and check that all is well thus far.

SPRING GEAR

Spring Socket, Buckle, Hanger, Link, Spacer and Pins

The requirement is that the spring socket be an easy fit between the horns, so as to pose no restriction, so mark these out on 1 in. x $\frac{1}{8}$ in. BMS flat and profile to suit. Mark on the centre for the spring buckle and chuck to run truly in the 4 jaw; drill through at No. 22, then start to form the socket with a $\frac{3}{8}$ in. drill, completing with a home made ball ended 'D' bit.

For the spring hanger, start with a length of $\frac{1}{2}$ in. x $\frac{5}{16}$ in. BMS bar and first cross drill No. 22 at a full 5/32 in. from one end. Mill out the fork, reducing at the same time to 27/64 in. overall depth, then radius the end over a mandrel with an end mill. Locate to the frames with a length of 5/32 in. rod, drill the $\frac{1}{16}$ in. holes then mill away the bottom portion to 3/32 in. thickness before sawing off and filing the bottom radius to complete; secure to the frames with soft iron snap head rivets.

For the spring link, I would make up a master to be correct in all respects and then case harden it. Clamp the links to the master in turn to drill through and then simply profile with a file. The spacers are straightforward turning and for pins such as those detailed, I make in two parts, shanks being from plain rod to which oversize heads are brazed, then chucked in the 3 jaw and heads finished to drawing to give a very neat result for little effort. Now for the spring buckle and leaves.

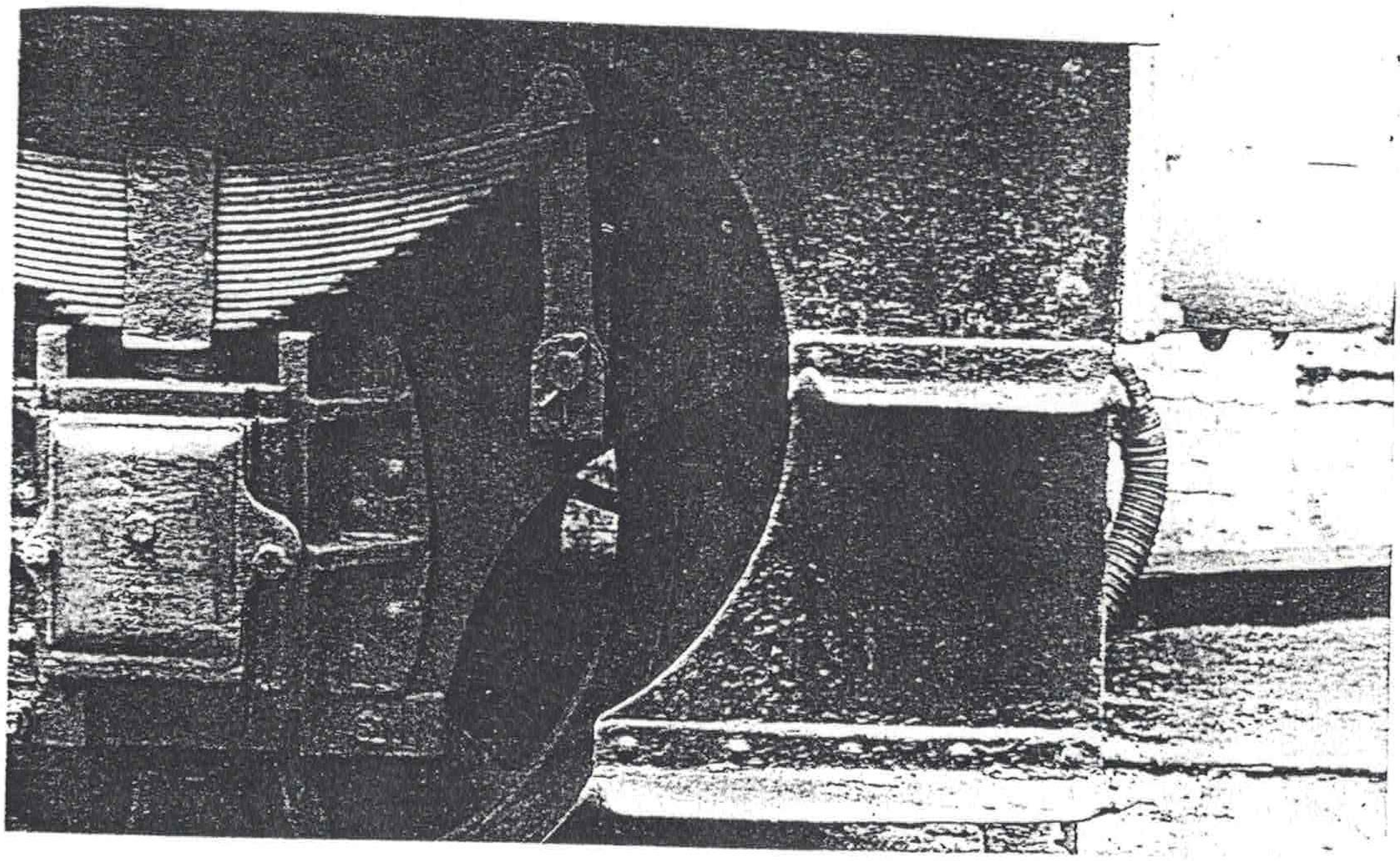
It really depends on the accuracy to which you are able to chuck the BMS spring buckle material in the 4 jaw as to what section of bar to use, for although $\frac{1}{2}$ in. x $\frac{3}{8}$ in. gives the least amount of work, it can lead to a small flat on the $\frac{3}{8}$ in. spigot if one is not particularly careful, when $\frac{1}{2}$ in. square bar is best substituted. Turn on said spigot for 7/32 in. length, then produce the spherical end to mate with the socket; centre, drill No. 34 to at least $\frac{1}{2}$ in. depth and tap 4BA. Next mark out for the slot in the buckle, drill a couple of $\frac{1}{4}$ in. holes on the centre line, then back to the machine vice and vertical slide to mill out as much as possible to the spring steel material as gauge, completing the corners with files. Saw off and finish turn to length, also turning off the surplus if $\frac{1}{2}$ in. square bar was the chosen material.

For the top spring leaf ends, take a length of $\frac{3}{8}$ in. square bar and at 9/64 in. from one end and 9/64 in. from one side face, cross drill at No. 31. Radius over a mandrel using a $\frac{1}{4}$ in. mill to arrive at the profile shown, then saw off the required piece and file it flat. Poke the cut length of spring steel through a large potato with only about $\frac{7}{16}$ in. projecting, sit on the end piece and silver solder in place; the potato will help the spring leaf retain its, and your(!), temper. Complete either with a saw cut and key cutting file, or use a 3/32 in. thick slitting saw to achieve the same end result.

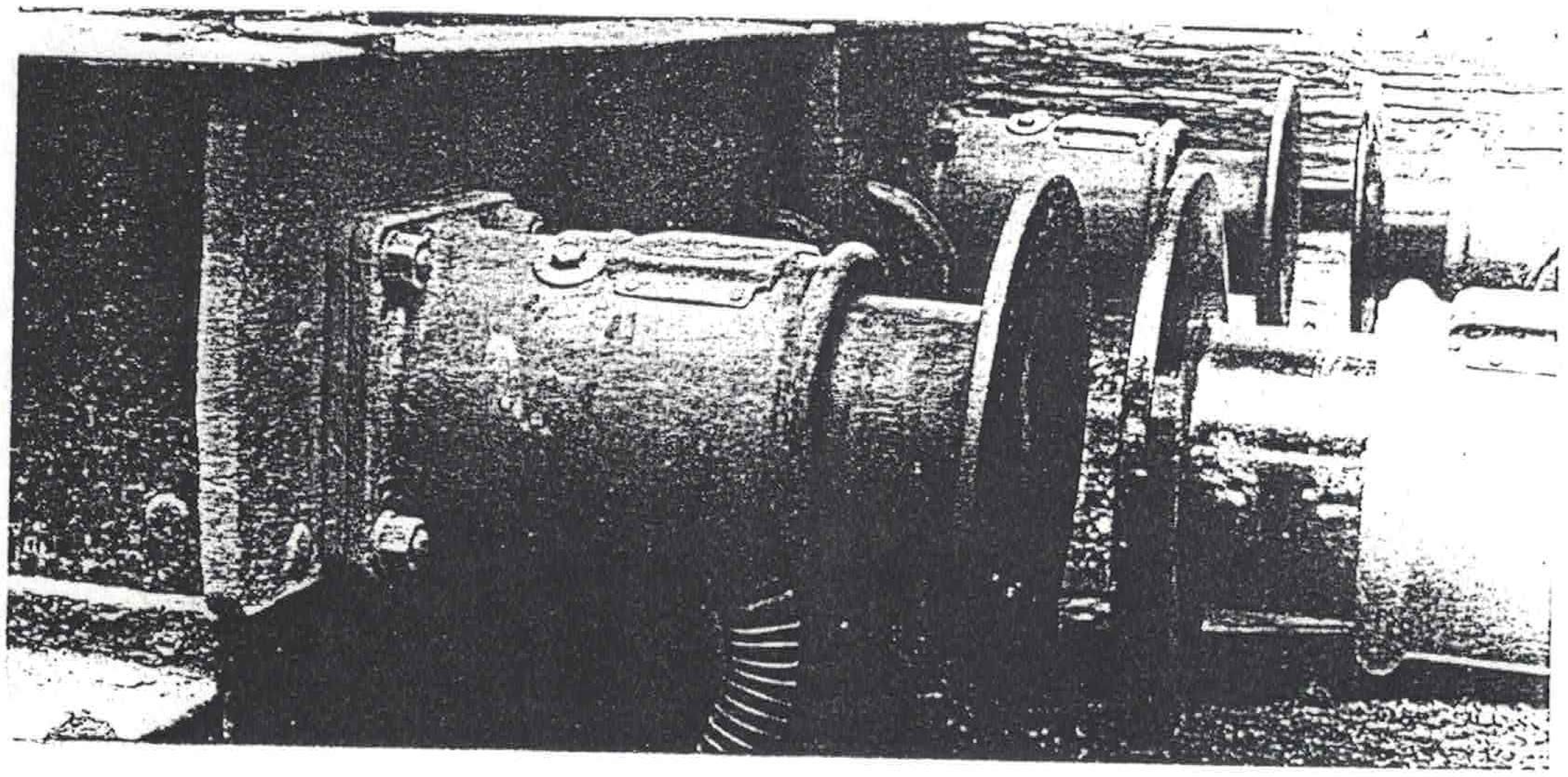
Fit the top leaf in its buckle, followed by intermediate 'Tufnol' leaves and complete with another spring steel leaf, holding the lot firmly in place with a 4BA cup point socket grubscrew; erect the whole of the spring gear. Incidentally, one of the most persistent requests over the years, particularly from overseas builders, concerns 'Tufnol', which of course is a trade name and as such is not recognised in many countries. The simple answer is that A. J. Reeves & Co. (Birmingham) Ltd. stock the material in a wide range of sections and to the required specification, again there is a wide choice of the latter so beware, though of course an order placed with Reeves will bring the correct material – no problem.

BRAKE GEAR

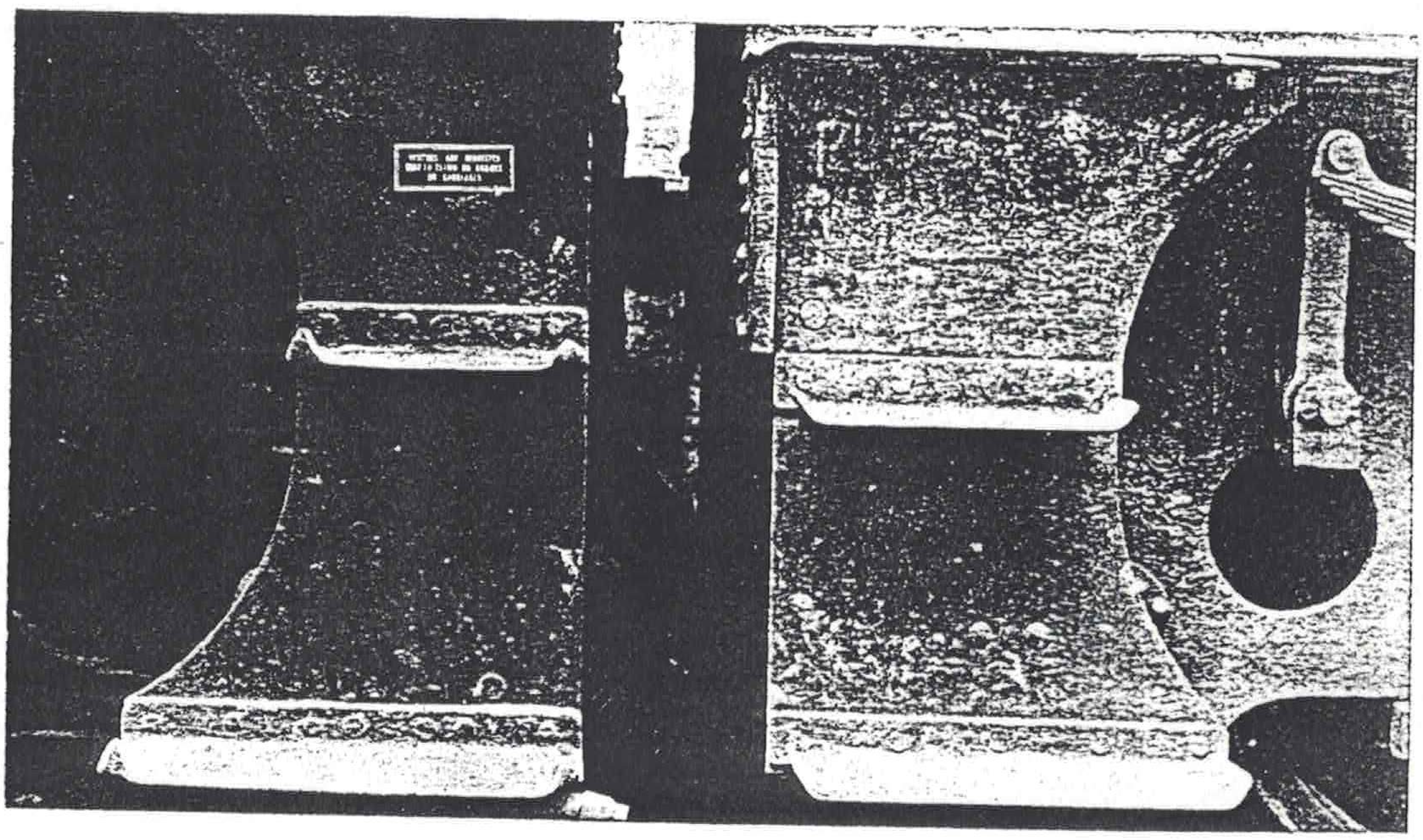
On the surface, the Fowler 3,500-gallon tender is very straightforward, with hardly a frill, indeed for the $3\frac{1}{2}$ in. gauge pair DERBY 4F and 2P, I was able to take a number of short cuts and still arrive at a result that had the appearance of the real thing, at least I like to think so. However, looked at from the point of view of producing a design of equal authenticity as E. S. COX the Locomotive, then there are amazing com-



This and the bottom view show the bewildering variety of steps as they appeared on the Horwich 'Crabs'; this again is 42700



Any builder wishing to add an extra touch of realism can add the wee step on top of the buffer stock



Readers are requested to obey the instruction as it appears on the cab steps! All photographs by Norman Gregory plications, some of which will become apparent when we come to the Tank. For brake gear, much use was made of forgings full size, which does make a useful saving, but the 4-bearing brake shaft is certainly a luxury. Such things are O.K. for internal combusion engines, where all bearing housings are machined at a single setting, but on the Fowler tender the outer bearings are in the main frames, whilst the inner pair attach to what is virtually a dimensionally unrelated diaphragm plate, such must have caused a few headaches for the erector. Our main problem, however, is to reproduce the full size forgings by machining from bar, which is rather-time consuming, but very rewarding in conclusion, so let me start the ball rolling again with one of them, the brake beam.

Brake Beam

Saw three 6 in. lengths from $\frac{5}{16}$ in. steel rod and square off the ends to $5\frac{15}{16}$ in. overall. Chuck with about $\frac{1}{2}$ in. protruding and turn down to 5/32 in. diameter, further reducing the end $\frac{1}{16}$ in. to a bare 3/32 in. diameter; the next $\frac{1}{8}$ in. to $\frac{1}{8}$ in. diameter and screw 5BA. Move on in approximate $\frac{1}{2}$ in. increments, producing the beam to drawing and noting the different lengths of spigot, until you reach the centre of the beam, then reverse and repeat the procedure.

Brake Hanger, Trunnion and Shoe

The brake hanger is quite complex for such a simple component and I recommend marking it out on $\frac{3}{16}$ in. steel plate, drilling the holes and then roughly sawing to line. Radius the ends over mandrels with an end mill, then complete the profile with files. One of the most useful fixtures you can have is a plain length of bright steel angle, with holes drilled at about 2 in. intervals to accept the bolts used with the tee slots in your vertical slide table; in the other face you just drill holes as required, in this case a couple of No. 27 for 4BA bolts at 2 17/32 in. centres. Bolt the hanger to the angle, the latter to the vertical slide, set true and you can end mill the relieved portions on the hanger, reducing to 5/32 in. thickness in way of the brake shoe.

The brake hanger trunnions are a two-piece construction, a boss turned from $\frac{1}{2}$ in. steel rod and a 1 in. length of $\frac{3}{16}$ in. rod as pin, screwed 2BA for 5/32 in. at one end. At the other, plain, end of the pin you can make a slot to accept a screwdriver for ease of assembly, which can be filled with Isopon or plastic metal on final erection.

For the shoes, start with $3\frac{1}{4}$ in. lengths of $\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS bar and first reduce to 11/32 in. thickness. Next mark out the profiles and drill the No. 31 holes, then use a 5/32 in. thick cutter to mill the slot to accept the brake hanger; saw and file the profile to drawing. Assemble to the hanger with a No. 31 drill, erect on the trunnion, then bring the shoe up to the wheel, checking it fits snugly and easing with a file if necessary. The idea is that the shoe should be free to follow the wheel, but not with excessive 'rock', otherwise the end of the shoe can dig into the tyre with the brakes released, this with disastrous results. As final attachment you can either turn up headed pins as to the left of the brake shoe detail, or use plain 11/32 in. lengths of $\frac{1}{8}$ in. steel rod.

Spacers and Pull Rods

The spacers are easy and their purpose will become clear when we assemble the brake gear, so on with the pull rods. Reeves stock BMS strip in $\frac{3}{8}$ in. x 3/32 in. section, which takes care of the material for the rear and intermediate pull rods; all we have to do is make them. Pack the tender wheels into their running position, clamp over the brake shoes onto the wheels and measure the centre distances at the bottom holes in the hangers, evening out if necessary so both sides are identical. Drill the pull rod ends at No. 22 at said centres, radius them over an end mill, then mill or file away the central portion to arrive at $\frac{3}{16}$ in. width.

The flat portion of the front pull rods is made the same way as above, the front piece being $\frac{1}{8}$ in. thick; slot one end of four lengths of 5/32 in. steel rod to accept the flat portions and braze together. To complete, the rods have to be screwed 5/32 x 32T and although you can use r. and l.h. if you have the screwing tackle by you, this is by no means essential. The adjusters are $\frac{7}{8}$ in. lengths of 4BA hexagon steel bar, drilled through at No. 29 and tapped 5/32 x 32T; locknuts $\frac{1}{8}$ in. thick from the same material. Now you can assemble all the pieces made so far; from the rear view of the tender on Sheet 1 you will note that the beam with the short spigots is used here, with spacers outboard of the pull trods, so build forward from this.

Brake Shaft and Bearings

As one whose training was all about working with metals, I have nothing but admiration for the skill of the blacksmith and mourn his passing. To watch such a craftsman take a steel billet, heat it and then fashion under a Nasmyth hammer into an accurate forging, this with a minimum of dies and gauges, was really something and I still cannot countenance that fabrication and welding is more economic, or as versatile an art form. It was on such things as brake shafts that the blacksmith excelled, such that machining was confined to the bearing surfaces and holes for the brake gear pins, nothing else. Without the aid of a forging, our task is the greater, but let us begin by cutting a length from $\frac{3}{8}$ in. steel rod and squaring it off to $6\frac{5}{8}$ in. overall. I suggest for machining the bearing surfaces you make a parting off type tool, with blade about $\frac{3}{16}$ in. wide and ground perfectly square. Tackle an end journal first, turning down by micrometer to $\frac{1}{4}$ in. diameter. Now let the shaft protrude further from the chuck so that you can deal with an intermediate journal, using the same cross slide collar reading as previous to arrive at identical diameter; reverse and repeat.

The hand brake arm, from $\frac{3}{8}$ in. x $\frac{1}{8}$ in. BMS flat, is simple to form; the two brake arms not so easy. For these latter, take a fairly long length of $\frac{3}{8}$ in. square steel bar and cross drill at No. 22 a full $\frac{3}{16}$ in. from one end. Next saw and file, or mill, the $\frac{1}{8}$ in. slot to accept the pull rod end, then radius over a 5/32 in. mandrel with an end mill. File or mill the flanks as shown then saw off overlong and repeat; poke a No. 22 drill through the two embryo arms, clamp in the machine vice and scallop the ends to accept the brake shaft. Carefully clamp all three arms to the shaft then silver solder, clean and paint matt black before rust starts to form.

The outer bearings are simple turning from $\frac{3}{4}$ in. diameter bar and after experience of a brake shaft seizing in steel bearings, this due to water ingress, I always use brass ones and recommend same to other builders. Mark off and drill the five No. 44 holes, offer up to the frames, spot through, drill the latter No. 50 and tap 8BA; secure with hexagon head screws, heads one or two sizes smaller than standard.

Cut four $\frac{7}{8}$ in. lengths from $\frac{5}{16}$ in. square brass for the intermediate bearings and square off to $\frac{13}{16}$ in. overall; sweat together in pairs. Mark off and drill the $\frac{1}{4}$ in. and two No. 44 holes, then grip in the machine vice and reduce one face to 13/64 in. thickness, this by rule. Unsweat the joint, cleaning off any stray solder, then offer up the machined piece to the diaphragm plate, when chances are it will be a slack fit. This is of no consequence, so use feelers to judge the gap and machine the mating half bearing to a close fit, a micrometer dimension. Repeat for the other intermediate bearing, erect and drill through the diaphragm plate, securing with hexagon head bolts.

Hand Brake

Only the hand brake to complete the brake gear, starting with the column, turned from 1 in. diameter mild steel bar. Although there is a lot of metal to be removed, only the four 7/32 in. slots require mention, and to be correct these want to be edged with beading, sweated in place. The cover also is plain turning, secured to the column with 10BA hexagon screws. For the screw, take a 5¼ in. finished length of 5/32 in. steel rod and screw 32T for 1¼ in. at one end. Next chuck a length of ¼ in. brass rod, centre and drill No. 23 to about ¼ in. depth and part off a 3/16 in. slice; position this collar on the screw. Change to steel rod and repeat the dose to produce the centre boss at the handle to 5/16 in. length; press this on also. Cross drill No. 42, bend up the handle itself, fit and silver solder together, including the brass collar. Chuck in the 3 jaw and first turn the brass collar to an easy fit in the housing at the top of the column, only unlike me make sure that the column cover is fitted on the screw before the handle, or you will have a spare part! To complete, turn 1/32 in. off the handle boss as per drawing; that extra 1/32 in. was handy when you cross drilled for the handle I trust?

The brake nut, from 5/16 in. square steel bar, is so easy after all that has gone before that I can safely leave this to builders, when you can complete erection of the brake gear and check its operation.

Steps

The step supporting plates, for want of the correct terminology, are straightforward from 1.6mm steel or brass sheet; the steps themselves gave me quite a headache. Those drawn 'Front' are as per the full size drawing details, but I found them very difficult to verify from photographs, with their lovely turned up ends. More common were completely flat steps, these for unwary feet to slip off, and it seems that coal hammer treatment as per my 'Back' detail was commonly resorted to. As one who slipped off a greasy bottom step at Eastleigh, resulting in a nasty knee injury, I find this lack of attention to safety first detail quite distressing; clambering over engines was not the world's safest occupation.

TENDER BODY

One LLAS reader who called to see me just before I started to pen these notes, mentioned how costly seemed the castings and fittings for E. S. COX as against those for the MARIE E he is currently building. The two are of course in completely different categories; one a beginners exercise (though many more experienced builders are tackling MARIE E as something completely different), as against an attempt with E. S. COX at maximum realism. MARIE E uses as many standard parts as was possible, both castings and fittings, whereas virtually everything is new for E. S. COX and calling for a high degree of patternmaking skills, exceptional ones for such items as the motion plates. Again on the fittings, Gordon Chiverton is able to express his skills to the full – even the number of jigs and fixtures involved is impressive! Why all this preamble to the tender body?, well the feeling is that it is not worth spoiling the ship for a hap'orth of tar and that E. S. COX deserves a brass tender body, especially as the work on the tank is somewhat involved and fibreglassing the interior to prevent rusting will not be easy.

Let us commence work again with the soleplate, a piece 22 19/32 in. x 8½ in. from 1.6mm thick material. Mark off and cut the well opening 14 13/16 in. x 4 in., then six more cut-outs 2⅞ in. x 13/16 in. for the wheel splashers. Fold up the well to a tight fit in the opening, this again from 1.6mm material, and make the ends a tight fit also as they will help hold the whole in place; I have made both end plates 3mm thick on occasion to good effect. Cut strips 13/16 in. wide and a tight fit in the soleplate for the splasher tops, bend or roll to shape, sit in the slots and trim off the ends. Cut the side plates to suit and cramp them in place. I recommend silver soldering both the well and splashers in place, it being tricky to leave them to the soft solder sealing stage, and being only the soleplate, the distortion that occurs can be rectified by careful use of a wooden, or soft faced, mallet, checking against the frames. I suggest you now deal with the holes to suit the brake column, tap those in the well for the injector water suctions, and position the 3/16 in. injector water cocks, standard pipe mounting ones of our supply, before adding more of the body; you can also deal with the slot at the back end to accept the vacuum brake pipe, be the latter dummy or working.

99% of injector problems, in our not inconsiderable experience, occur with water suction, either by air or 'foreign body' ingress. Often it is not realised that one of our injectors can pull 20 in. Hg in the suction line, this for automatic restart after interruption of feed and this high vacuum does require efficient sealing. The tip that Reg Booth gave us two years back to detect any air leakage is worth repeating. Fill an oil can, or plastic washing-up liquid bottle, with water; start the injector and squirt water onto all the joints – when it strikes the faulty one it will form a, temporary, seal and the injector will pick up. Reg, you have solved countless injector problems for us with that simple, practical tip.

The foreign body menace is the other main cause of failure, or in mild cases a lowering of top pressure at which the injector will deliver, the annulus between steam and draft cone being the smallest clearance within the injector, smaller even than the delivery cone hole by a large margin. We can combat this problem most effectively for E. S. COX by covering the well opening completely with 100 mesh gauze, checking that it will pass water as 100 mesh is only half the story; wire diameter obviously also has an effect on the size of aperture in the gauze. The filter will also have to be made removeable for cleaning, so make up a frame from 1.6mm brass strip, wrap the gauze over it and tack in place with soft solder. Make the whole a close fit between the splashers, then no other fixing will be required, though if the frame refuses to lay flat, teach it manners with a few 8BA screws, heads underneath the soleplate where you can get at them later.

Side sheets next and this is where I learnt something in that those lovely sweeping curves are not true radii but eliptical; that was an eye-opener! I guess the platers had a template for these curves, so could we, but with only four of them to tackle I recommend you mark them off on one sheet and then use french curves to marry up the points into a, pleasant(!), curve. Attached to the side sheets, on the outside, are doubler strips as shown on Sheet 2, made from ⅜ in. x 1.2mm section and held in place with a minimum number of 3/64 in. countersunk copper rivets for the moment; you don't have to take out membership of the R.C.A. (Rivet Counters Association) when making this tender!

Make the back sheet a little over 5 in. depth initially so that the side flanges can be trimmed off to suit the side sheets, flange up, then fit lengths of ¼ in. x ¼ in. x 1/16 in. brass angle along the bottom of the side and back sheets. Stand on the soleplate, clamp in the correct position and drill a few No. 51 holes through angle and soleplate, also between side and back sheets; secure temporarily with 10BA bolts and nuts. That overlap of the back sheet beyond the limit of the side sheets was something that 'Derby Tender Authority' Dennis Monk queried with me when he was kind enough to vet the drawing for me; Dennis was later able to confirm that what I saw on the full size tender tank drawing was correct, so thank you Dennis for seeing I stayed on the straight and narrow.

We can next turn our attention to the front end, starting with the plain front plate, size 7⅜ in. x 4¼ in., with the coal gate cut in same; the coal door surround is an upward extension of this plate, but can be better made as a separate piece, as I have shown. The front coal bulkhead is 'L' shaped, the short leg being $1\frac{11}{16}$ in. long and the upright $3\frac{1}{8}$ in. initially and before adding the top curve, a $\frac{3}{8}$ in. radius separating the two legs. Cut a strip $1\frac{5}{8}$ in. wide and 8 in. long to form the 'tunnel' between front coal bulkhead and door surround, bend this up to place and silver solder to the door surround itself, only don't cut the opening in the latter until after brazing; cut the coal bulkhead to suit the tunnel. Tool/food boxes can now be bent up, again from $1\frac{5}{8}$ in. wide material, when you can begin putting the front end together with $\frac{1}{4}$ in. brass angle, though not on the outside or you will spoil the appearance.

Right at the front end there is a platform which will make for a very solid structure, so cut the platform itself, secure to front and side sheets with $\frac{1}{4}$ in. brass angle, again temporarily with 10BA bolts, then make up the two intermediate supporting stools to place, locating $2\frac{3}{4}$ in. apart as per drawing.

We now come to the part which will make or mar your whole tender, the tank top. Here Norman Lowe was able to give me the benefit of his actual experience in making the self-trimming sloping side pieces separately and I think readers will agree as to its realistic effect. First though let me deal with the easy and removeable section at the back end which is $7\frac{3}{8}$ in. x $6\frac{1}{16}$ in. and trimmed to fit between the side and back sheets. I would very definitely cheat on the water scoop bonnet and braze a $\frac{5}{16}$ in. thick brass plate to the top of a $1\frac{3}{8}$ in. length of $2\frac{3}{4}$ in. o.d. x 16 s.w.g. brass or copper tube, then turn the outside to drawing, probably leaving the interior well alone. Square off the filler tube then sweat both into the tank top.

I have been avoiding the fixed tank top long enough, so for one-piece construction, cut a piece $15\frac{1}{2}$ in. long and $8\frac{1}{4}$ in. wide from 1.6mm brass sheet. At 5 in. from one end, scribe across and make the start of the $2\frac{1}{8}$ in. radius bend, checking the slope against the actual drawing detail. This can also be the reference point for the start of the second bend, the horizontal portion which becomes the coal plate being located $2\frac{1}{4}$ in. below the rear of the tank top. From the front end, draw lines $3\frac{1}{4}$ in. apart to the start of the first bend, then angle them outwards to $7\frac{3}{8}$ in. width at the start of the second bend, these are our folding lines. Well anneal the portion of plate outside these lines and starting from the front end, grip in the vice and begin to pull the plate round. All blows should be aimed at the inside surface of the plate, especially in way of the first bend and with luck, nay, your superb skill(!), you will finish up to drawing; if not then please use the three-piece construction and silver solder the joints. Trim any excess off the sides to be a snug fit between the side sheets and cut away to form the coal plate at the front, bending up gussets to support same at the sides. Because of the sloping sides to the tank top, $\frac{1}{4}$ in. brass angle is not much help for attachment, so bend up short pieces from $\frac{1}{2}$ in. x 1.6mm brass strip to fit, ordinary angle in way of the flat top, and rivet all to the side sheets.

The rear coal bulkhead is initially $7\frac{3}{8}$ in. x $2\frac{7}{8}$ in. from 1.6mm material, the top curve matching that of the front coal bulkhead. Bending brass angle for the two stiffeners is not easy, as it tends to twist, though a thorough annealing can help, but if all else fails you can make each in two pieces from strip and braze together. Because of attachment of the rear coal bulkhead to the removeable tank top, unless you make the break between bonnet and filler tube, the rear coal bulkhead also has to be made removeable. Talking of fabrication, the tee bar section will probably have to be arrived at in this way too, in which case you can pre-form the leading piece to suit the tank top; all the pieces can now be permanently assembled. using rivets where you can get at them, 8BA countersunk screws in all other places. Plug any holes, put some bits of soft solder into the tank plus some Bakers fluid, warm up the whole tank gradually until the soft solder begins to melt, then swill it about to seal all the joints. Wash out with warm soapy water, dry and then refill to check for any leaks. Small ones I ignore, always preferring to paint the tank internally gloss white as this tends to show up any foreign bodies; you may swill the paint around just like the solder if you like, pouring away any excess.

Talking of preferences, mine is for the use of correct tee bar section around all the edges, rather than $\frac{3}{16}$ in. half round beading, though the problem today is in locating the brass curtain rail that I used to pick at Woolworths at a few pence a foot; now it is all plastic rubbish. A caller some weeks back told me he had then just moved into an old house where brass curtain rail abounded by the yard, so that maybe is your solution too, though a very drastic one! With either material, tin both mating faces and bring together with a soldering iron.

Full size the filler lid hinged back onto the bonnet, which is not very good for paintwork and in any case I much prefer a lid which is removeable on a working engine. Turn it up from 2 in. diameter brass bar, or cut a circle from $\frac{3}{8}$ in. plate, the handle being bent up from $\frac{1}{16}$ in. wire, with two little collars brazed to same, and located as per Sheet 2. The rear handrail is again bent up from wire, 3/32 in. diameter this time, with collars brazed on and ends screwed 7BA. That reminds me that we can now sit the body on the chassis and use 7BA bolts, or 3/32 in. rivets as preferred, to attach to the outriggers. The front handrail stanchions are turned from 7/32 in. diameter nickel silver, or stainless steel, using the latter material for the handrail itself. Coal and locker doors, plus positions of hinges, can be lifted directly from Sheet 1, with additional useful information on the photographs, though in miniature, Norman Lowe's coal door construction is slightly different to my detail, hinging at one side only.

All this brings me to the last item in this session, the air escape pipes. These pipes are again variously positioned on 'standard' tenders, some within the coal space as per the photographs, though after what I have said concerning foreign bodies and injectors then coal should be kept as far away from water as is possible, they don't mix very well!

The escape pipes are, however, the most handsome of adornments, so start by squaring off the $\frac{9}{16}$ in. o.d. copper tube to length, the same size incidentally as for MOUNTAINEER firetubes, and turn up the bottom flange from 1 in. brass bar. The top, shield, can again be turned up from the 1 in. bar, the final piece being a full $\frac{1}{2}$ in. length of $\frac{5}{8}$ in. o.d. x 20 s.w.g. tube bored to accept the air pipe and then slotted as the actual air holes; braze together. Erect to the tank top and if you want to add the final touch, secure with 4 in No. 10BA studs and nuts.

Talking of final touches, there is one that I have deliberately omitted but which shows clearly on Norman Lowe's tender, support for the fireirons. As I look on E. S. COX first and foremost as a working engine, I refuse to include a feature which I am certain at the very first steaming will catch a sleeve and get bent or broken, especially when it plays no functional part in 5 in. gauge. Actually the large fireirons, slice and shovel, were dangerous items to have on the footplate full size as they could never be kept within the confines of the cab, they caused numerous accidents and injuries. Also, after using the slice to break up clinker, one had at least 8 ft. of red hot metal to handle, something to be avoided if at all possible.

All this brings me neatly to the final comment in this session, successful completion of two E. S. COX boilers. (I think Larry Loughborough won by a very short head), and the point made that the firehole door is located very low, though accurately to scale. E. S. COX to my mind is a Locomotive which is going to particularly benefit from a thin fire, so the position of the firehole is very much an asset – next time with any luck at all we won't just be talking about the firehole, but among many other things actually fitting it!