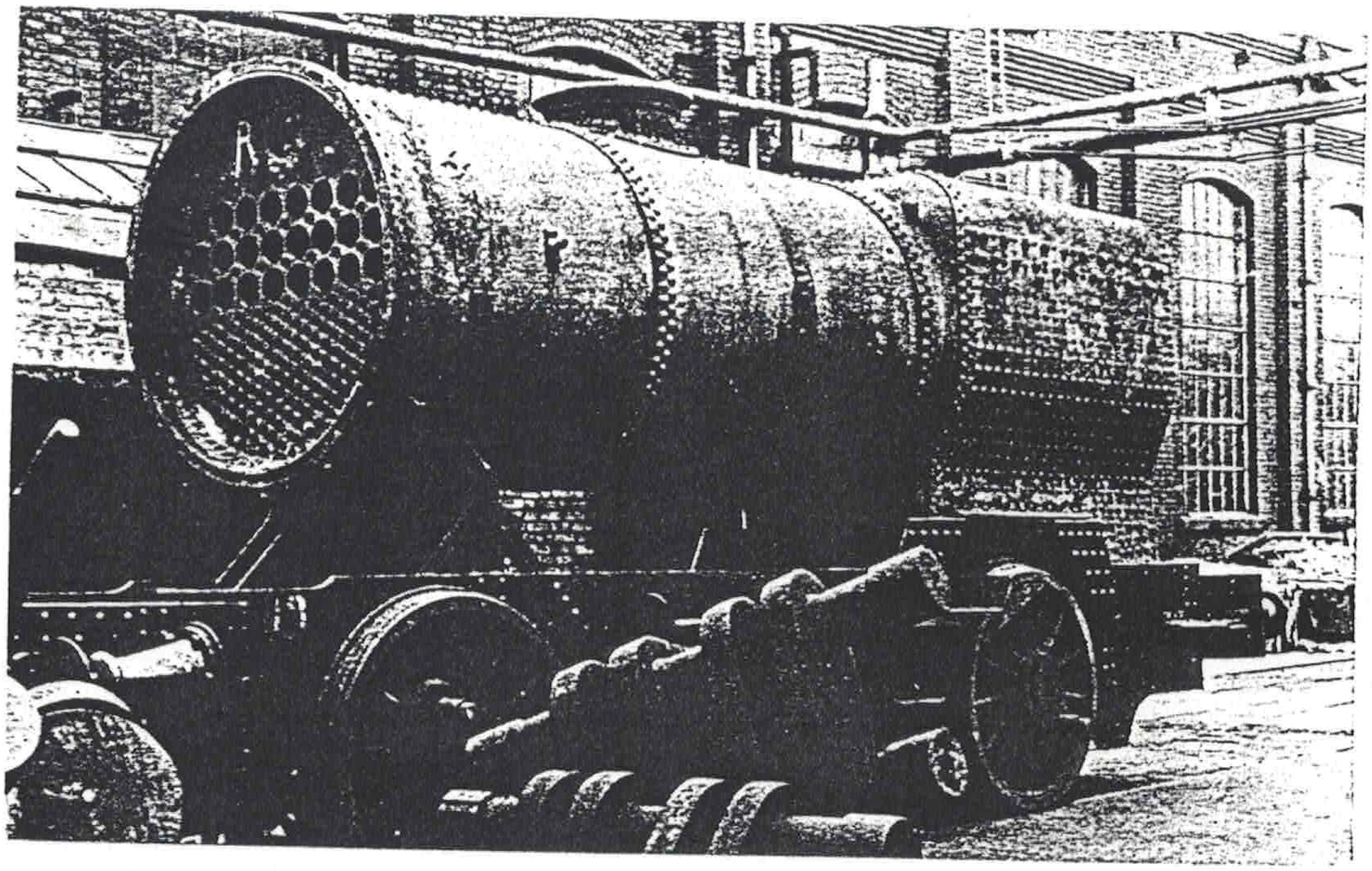
E. S. Cox – The Horwich 'Crab' in 5 in. gauge

by: DON YOUNG

Part 4 – The Boiler

We now arrive at the heart of the matter, the boiler, and I think a first glance will give every confidence that it will be master of the $1\frac{7}{8}$ in. bore cylinders; the proportions are ideal in every respect. Not one feature is new to me, all have been tried and tested, and the parallel barrel means that tube spacing and resulting free gas area is just about perfect, so this session will be brief. Boiler fittings too are based on already developed 'standards', like the blower valve has already been used on LANKY, ASPINALL and BLACK FIVE to good effect, in fact it is by using an existing casting, the regulator body from GLEN, that I have fallen into a trap of my own making, for not only have I employed said casting, but much of the rest of the GLEN regulator design. In doing so I have forgotten to swop the links and ports on the regulator valve, such that to open the regulator as drawn, one has to push the handle towards the fireman, like on the S.R. 'King Arthurs', but definitely never on a 'Crab'. To make such a major alteration to the linen tracing could possibly destroy the surface, so I will cover it by a note here, as in any case no scrappage of parts is involved, you merely turn the valve over to correct my stupid handing error; apologies.
Reverting back to the boiler, at the time it was set down on the drawing board, no tube between 5 and 6 in. diameter was generally available to model engineers in the U.K., nor was any listed by I.M.I., so I was able to arrive at the ideal barrel size of $5\frac{5}{8}$ in. without fear of bringing wrath upon my head; not so in 1983. For in Reeves 20th edition Catalogue is listed $5\frac{1}{2}$ in. o.d. x 10 s.w.g. seamless tube and builders of other of my designs will know that when a tube of slightly different size has become available from Reeves subsequent to publication of said design, then mention is made on the drawing, this to everyone's advantage; Reeves for ease of supply, you and I because it means one less joint in the boiler. Unfortunately in this instance there are a number of major obstacles which preclude its use, among them that the boiler joint ring casting would not clean up to suit the smaller barrel, so we must soldier on regardless.
The size of 3mm copper sheet required to roll the barrel, this with a butt strap joint terminating $\frac{3}{4}$ in. from the front end, is $17\frac{11}{16}$ in. x $13\frac{3}{8}$ in.; add $\frac{3}{4}$ in. to the length if the, far superior, castellated joint is used, said being $\frac{3}{4}$ in. square with interlacing 'fingers'. Anneal and roll to size, if the butt strap is employed then use a minimum of $\frac{1}{16}$ in. snap head copper rivets to hold in place, then braze up with B6 or equivalent spelter. Pickle, wash off and inspect for complete penetration, which is vital here.
Whilst at Boston Lodge in 1982, Warren delved into a locker and came up with wooden building blocks for the firebox and outer wrapper of a 5 in. gauge B.R. Standard Class 9 boiler. Although I have never used this technique, I could see it had many advantages, and when the idea comes from a man highly skilled in sheet metalwork it is to be recommended. I noted also that the wooden blocks were shaped to accept the end plates, so that each wrapper could be folded up to place, clamped firmly and holes drilled through for rivets. All Warren had to do then was remove from the building blocks, bolt the assemblies together and then replace said bolts with rivets, one at a time; simple and effective, so we can do likewise. By this means the front end of the outer wrapper can be shaped to suit both throatplate and barrel, the rear end to fit the sloping backhead; the same applies at the rear end of the firebox wrapper. File the throatplate to fit the barrel, rivet it in place, slide on the wrapper, drilling through and rivetting this in place to both barrel and throatplate flanges. Cut the top corners from 6mm thick copper to be a light drive fit, when no other fixing will be required for brazing. Machine the dome bush from the phosphor bronze casting, parting off a ring for the flange, cut a hole on the top centre line of the barrel to accept same, then scallop the bottom of the bush



This full size 'Crab' boiler was photographed by Norman Lowe at Horwich Works. I cannot identify the origin of the Boiler Truck, but the crank axles are familiar from our LANKY and ASPINALL designs – don't they look forlorn as shown. Pickle, wash off, flux the throatplate/barrel/wrapper joint and around the dome bush, then braze up with B6 alloy, pickle again, wash and inspect.

We have already mentioned assembling the firebox over the building block, though not the flanged end plates. The tubeplate requires attention for said tubes, so mark off and drill for the 15 firetubes to 12.5mm and ream at $\frac{1}{2}$ in. diameter; for the superheater flues you will have to drill as large as possible and complete with a round file to the flue material as gauge. Incidentally, if you use the 'Coulson' method of spigotting the tube ends as positive location in the tubeplate, use 18 s.w.g. tubes and 16 s.w.g. flues to provide the necessary strength. Turn up the firehole ring and cut a hole to suit in the backplate, located $2\frac{5}{8}$ in. below the top edge of the flange; insert and peen over. Now you can assemble the firebox and rivet together.

The front section of the foundation ring is from $\frac{3}{8}$ in. square copper, so cut and shape to fit between the throatplate flanges. Bring up the firebox, sit it nice and central in the outer wrapper and clamp firmly in place over the foundation ring at the front end; measure the depth of the girder stays. Fold these latter up from 2.5mm sheet, positioning carefully as those longitudinal stays will come fairly adjacent later on; fix to the firebox crown with a few rivets, or simply clamp in place for brazing; do this latter with B6 alloy as the next step.

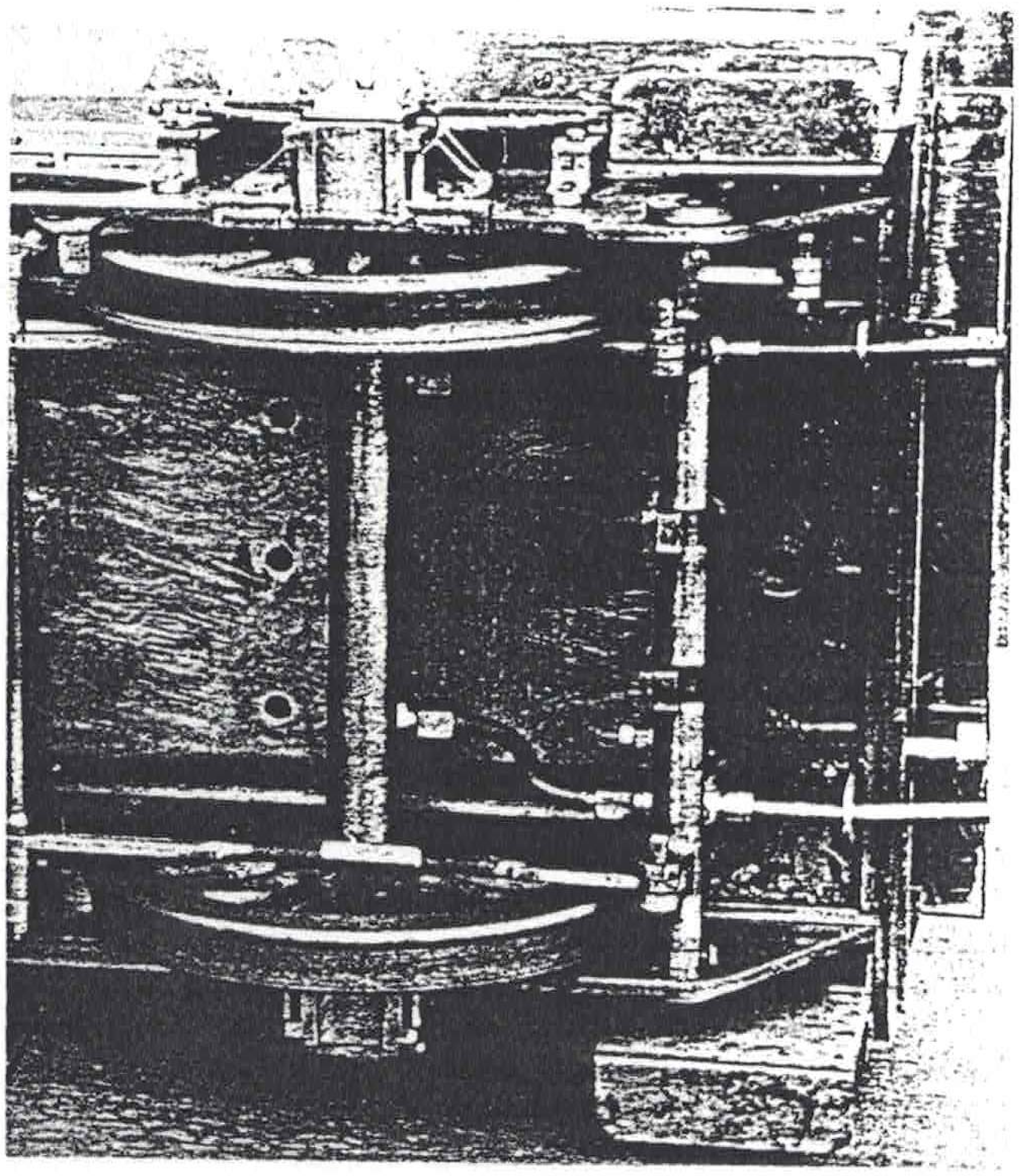
Take the smokebox tubeplate, turn to a close fit in the barrel, turn up the steampipe bush, cut the hole to accept same and braze in with high melting point spelter as a separate operation. Now you can deal with the tube, flue and longitudinal stay holes. Erect the tubes and flues to the firebox, cutting rings of Easyflo No. 2 spelter and dropping over each down to the firebox tubeplate, then fit the smokebox tubeplate over the outer end of the stack. Check said tubestack is square to the firebox tubeplate, flux and heat until the Easyflo runs right through, feeding in more if necessary, then pickle, clean and carefully inspect.

Before progressing the boiler as a whole any further, it is time to stand back and attend to a few of the details. A prominent feature of E. S. COX is the vacuum ejector at the front end, taking steam from just behind the smokebox tubeplate; many builders will want to reproduce this authentically, so let us start by getting steam to the connection in the shell. Turn up the vacuum ejector steam supply bush from $\frac{7}{16}$ in. or $\frac{1}{2}$ in. phosphor bronze rod and drill the $\frac{1}{8}$ in. hole as shown to accept the thin wall copper tube. Drill the barrel 13/32 in. diameter at the position shown, on the L.H. side only, to accept the bush, then bend the pipe up to within $\frac{3}{8}$ in. of the top of the barrel and clear of all obstructions like longitudinal stays; you can slide on the smokebox tubeplate and sight through to check this. I recommend you now braze in this bush and pipe using high melting point spelter at this juncture.

Moving back, we come to the bush for the 'Everlasting' blow-down valve, one of five, nay six, of indentical dimensions which means that we can indulge in batch production. That for the blow-down valve should be located on the boiler centre line and as low as possible, so if you make a wee error in position and foul the foundation ring, file a little flat on the bush itself rather than scallop said foundation ring.

On to the backhead, where we have already dealt with the four water gauge bushes, for which holes can now be drilled to accept, leaving just four more to be tackled; the regulator flange less tapped holes for the gland studs is straightforward. Attached to the inner face of the backhead is the blower steam collector, plain turning from $\frac{5}{8}$ in. bronze rod, and from this projects another length of $\frac{1}{8}$ in. o.d. thin wall copper tube, upwards and towards the top of the steam space as for the ejector steam supply at the front end. Again there are obstructions to avoid, which can best be checked to place, after which turn up a steel bolt to align the $\frac{5}{16}$ x 40T tapping with the plain hole in the backhead itself, coat with marking-out fluid so that the spelter will not adhere and erect. That leaves just the injector facings, which deserve at least a paragraph all to themselves.

A last look too at the standard pattern 3,500 gallon Tender that Norman Lowe will be attaching to his E S COX

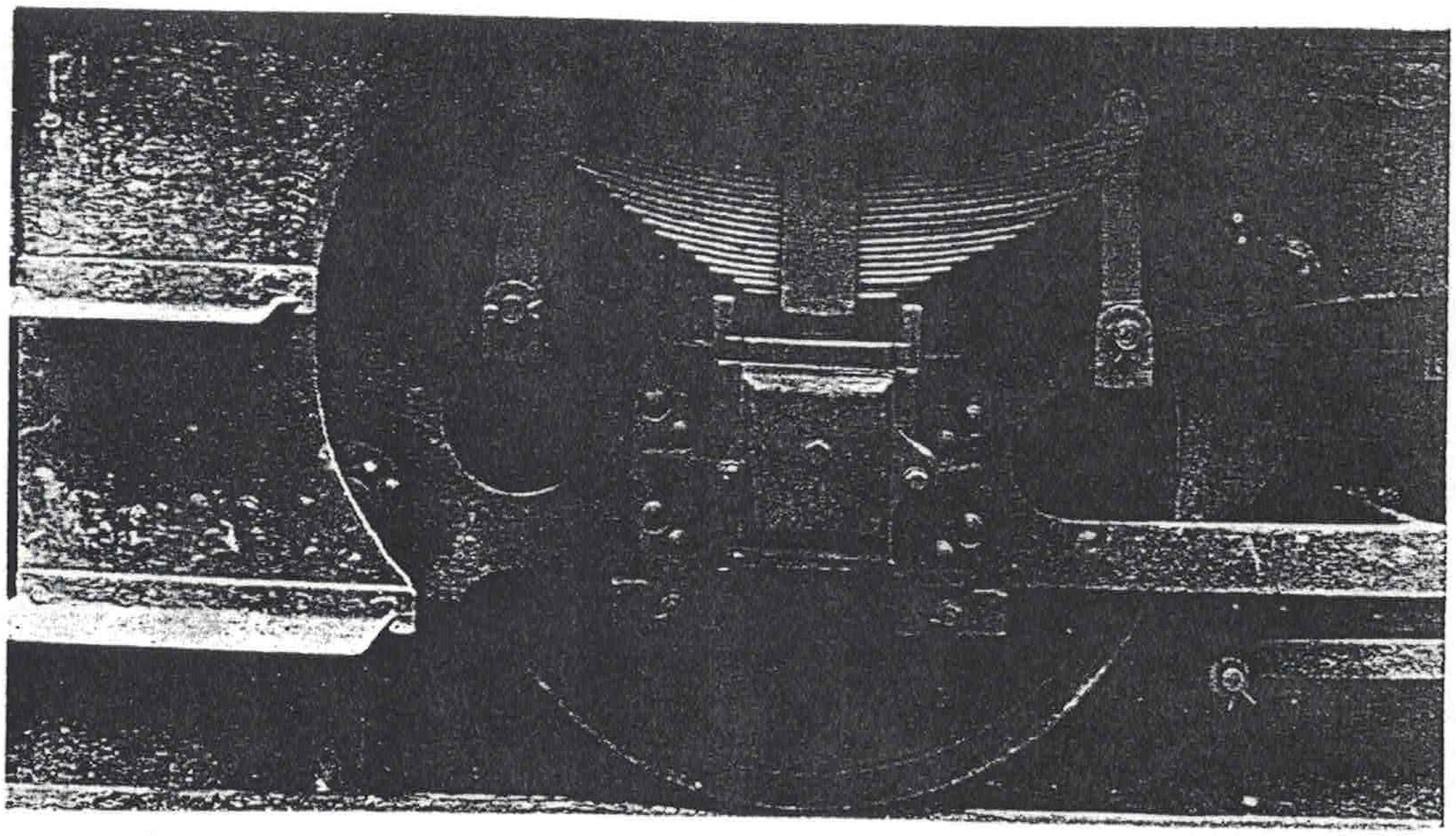


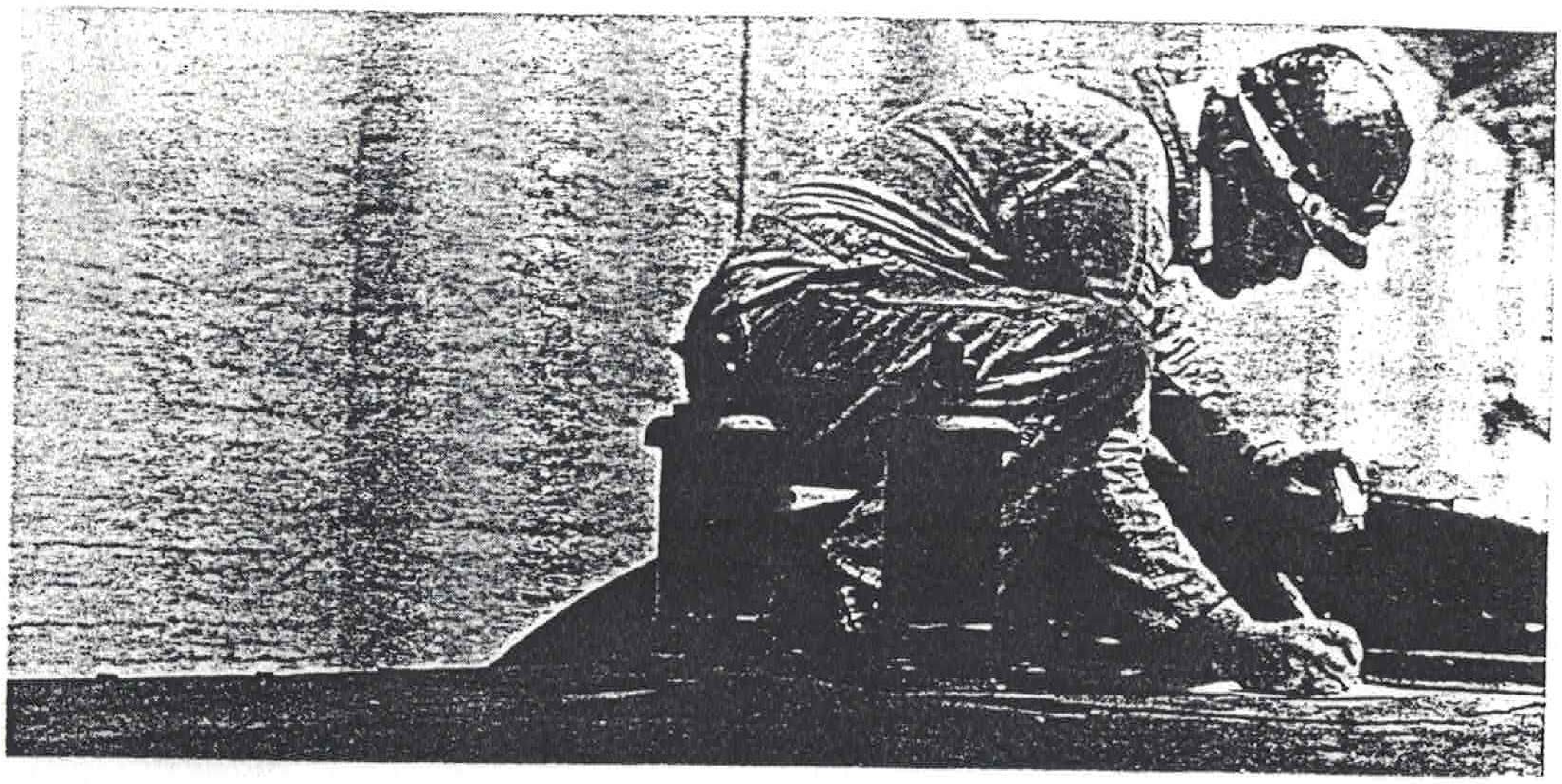
Injector Facings

I first used these facings, with their internal pipes, back in 1964 on my 5 in. gauge L.N.E.R. K1/1 'Mogul', where they proved a most successful and realistic feature. Since then I have specified them many times, on the G.C.R. 'quartet' for instance, and for both LANKY, ASPINALL and now E. S. COX an extra connection has been added to the L.H. facing for steam supply to the brake valve; this time the R.H. facing has an additional outlet, ostensibly for the train steam heating valve, though actually the whistle supply. Incidentally, I do not propose to describe such fittings as the whistle valve, merely to say that its length should be checked to place so that the 7/32 x 40T union connection clears the backhead when screwing the stem into the facing. Although bronze is specified for the facings, it can be difficult to obtain in the required section, and as Reeves now stock $\frac{5}{8}$ in. x $\frac{1}{2}$ in. in copper bar this is perfectly acceptable in lieu; I like machining copper too.

Reduce to $\frac{9}{16}$ in. thickness, this in the machine vice attached to the vertical slide, then mill a $\frac{3}{16}$ in. wide step to 1/32 in. depth along two faces. Reverse in the machine vice, drill through at No. 10 a full $\frac{1}{4}$ in. from one end, following up with a 9/32 in. drill and 'D' bit to $\frac{3}{8}$ in. depth and just entering a $\frac{5}{16}$ x 40T taper tap, about four turns, so the facing can be tapped out squarely later on; move on $\frac{1}{2}$ in. and repeat. For the R.H. facing saw off at around $1\frac{1}{16}$ in. overall; around $1\frac{1}{4}$ in. for the L.H. facing. Chuck a length of $\frac{3}{8}$ in. or $\frac{1}{2}$ in. square BMS bar in the 4 jaw and turn down to a close fit in the 9/32 in. hole over a $\frac{3}{8}$ in. length; centre, drill No. 26 and tap 2BA to about $\frac{1}{4}$ in. depth. Grip this mandrel in the machine vice, slip a facing over it and fit a 2BA bolt as security. Using a $\frac{3}{8}$ in. end mill in the 3 jaw and holding the facing very firmly with a 'Mole' wrench, radius both spigot and ends on the

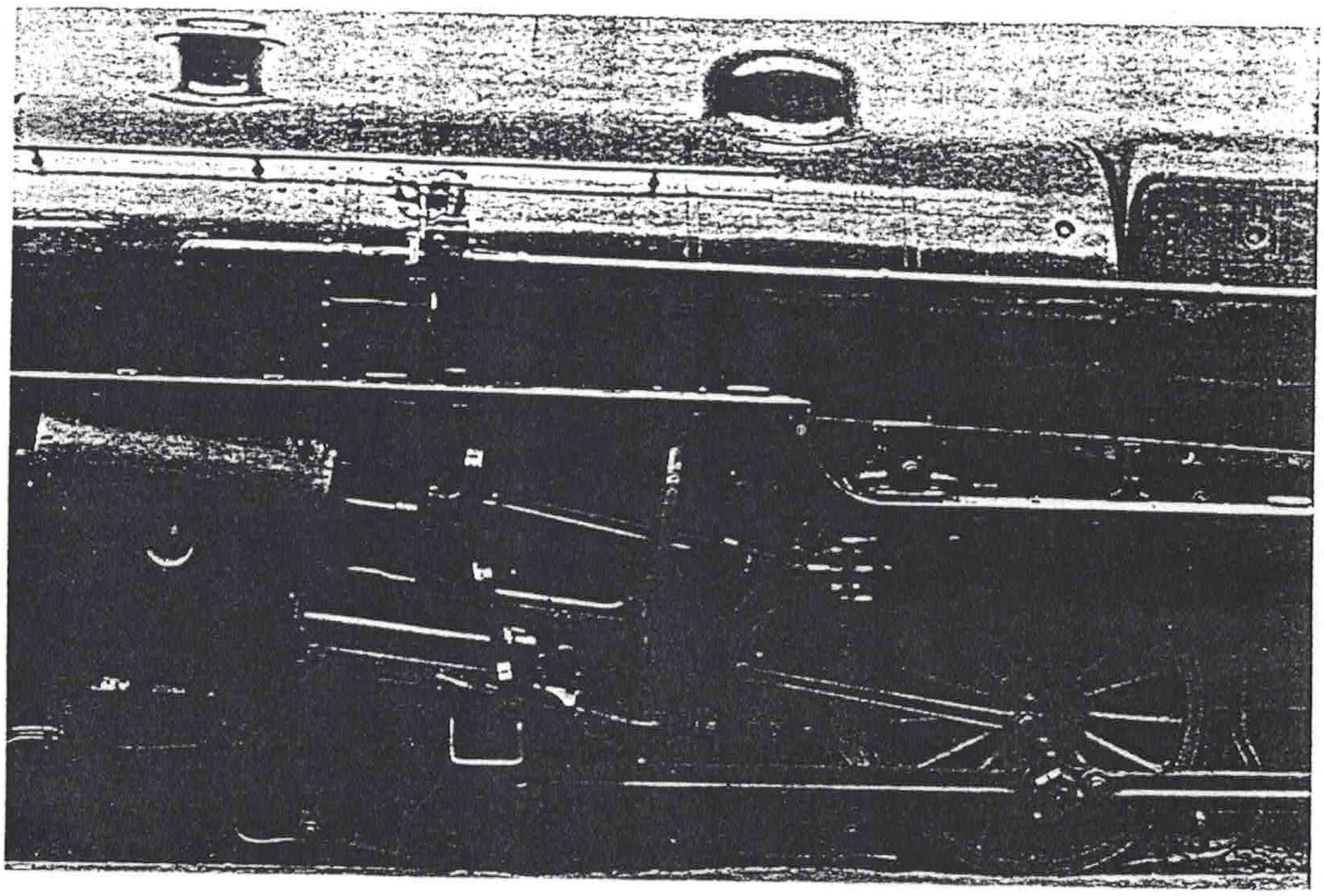
A last look at the rather unique tender fitted to 42700. Note the hexagon head cast onto the axlebox cover for ease of swivelling





A hard hatted Len Hough commits some of 42700's vital statistics to paper, an example of the very complete record made available to me. I wonder if B.R. fitters today go aloft so attired? – shades of modernisation!

Photos by
Norman Gregory



This general view of the boiler on 42700 will come in very handy later on when we move downstairs to the chassis

R.H. facing, taking care on the L.H. one to preserve the upward projection for the brake steam supply union. To provide for this latter, grip again in the machine vice, use an end mill to clean up the top surface, then centre, drill and 'D' bit at 5/32 in. diameter to 5/32 in. depth; tap $\frac{3}{16}$ x 40T. From the outer edge of the tapped hole, continue at No. 60 for $\frac{1}{8}$ in. depth, then connect to the steam, bore with a No. 53 drill, plugging the outer end with $\frac{1}{16}$ in. copper rod; remember to braze this in later on.
The R.H. facing has a simple circular boss extension from the steam bore, lightly scored to make it look like a pair of flanges, and to hold it in place for brazing I would turn up a steel peg and coat with marking out fluid. Cut slots in the backhead to accept the facings, when you can braze in all the backhead bosses with high melting point spelter as a separate operation; we are ready to make wider progress again.

Boiler Assembly

To complete the firebox ready for erection, we need clearance holes for the cross stays to be drilled in the crown girder stays. For this you can either mark out and drill the holes in the outer wrapper, $\frac{3}{16}$ in. diameter and countersunk, or carefully mark out directly on the girder stays, in which case use the larger $\frac{7}{16}$ in. clearance size as additional insurance that all will be well.
Final positioning of the firebox within the outer wrapper is very important, to be central within same with girder stay flanges in good contact throughout their length, as also should the front section of the foundation ring be firmly in place. In this instance we have an extra aid for keeping things in their rightful place, the athwartships safety valve facing, I recommend you make this latter initially with $\frac{1}{4}$ in. clearance holes at the correct centres, mark through onto the wrapper and then drill this and the girder flanges, bolting right through to hold firmly together. You can now put two or three rivets through throatplate/foundation ring/firebox tubeplate, then make up and fit the side sections of foundation ring, which I would personally mill from $\frac{3}{8}$ in. square bar. Fit the smokebox tubeplate and we are ready for the penultimate brazing operation, for which I recommend the use of Easyflo No. 2, or equivalent specification.
Fitting the backhead is somewhat more difficult than usual due to the firehole tube being angled slightly upwards, which calls for a little ovality in the mating hole in the backhead, so that the latter can be pushed up to snugly fit the outer wrapper before peening over the projecting spigot. Fit the little bush on the boiler top for the pressure gauge union, the back section of foundation ring, then braze up with Easyflo No. 2, not forgetting the longitudinal and cross stays, plus firehole ring of course. If I have gone too fast for any builder, please refer to one of my earlier and fuller descriptions of boiler-making, better still to Jack Coulson's fine article on the subject in LLAS No. 7. Tap out all the bushes, plug them, apply about a dozen pumpfuls of air from a bicycle pump and immerse – I trust there will not be a single tell-tale bubble, so on with the staying and fitting out.

Firebox Stays

Both cross and longitudinal stays should have a projection of at least 1 in. before brazing; this can now be trimmed off to be about $\frac{1}{16}$ in. proud, not flush. It is a great pity that having standardised most of my boilers to use 4BA screwed copper stays that this studding is no longer obtainable from Reeves, so if you cannot obtain phosphor bronze screws from which you can cut the heads after insertion, then use $\frac{1}{8}$ in. snap head copper rivets in plain holes, heads inside the firebox, and secure them with Easyflo No. 2, heating with a small neck burner, and locally; again crop off the rivets after brazing to be around $\frac{1}{16}$ in. proud.

Inner Dome

The inner dome is a simple fabrication of tube, 3mm thick top plate with bush in same, and the joint ring from the casting which we have already, rough, machined. Braze up then chuck by the tube and face the flange flat, lightly marking the pitch circle of the bolts, marking out and drilling No. 34. Make cheesehead screws from $\frac{3}{16}$ in. phosphor bronze rod, spot through, drill and tap the dome bush 6BA and complete with a 1/64 in. CAF gasket, or one made from stiff brown paper soaked in linseed oil.

Regulator

The regulator is that for GLEN, so that description can be used to save repetition, using the dimensions on the drawing detail where they vary – get it working the right way though! The steampipe too is straightforward; insert same in the steampipe bush, a couple of turns only, enter the regulator through the dome opening, engage on the end of the steampipe and screw the latter home. Drill the boiler shell roughly in the position shown for a pair of 4 or 5BA countersunk screws, spot through, drill and tap the regulator body to suit. At the front end we can machine up the superheater flange, offer up to the end of the steampipe, spot through, drill and tap the latter 4BA for cheesehead screws from $\frac{1}{8}$ in. bronze rod. Make the regulator rod overlong for the moment, leaving the 9/64 in. square at the outer end for the regulator handle. Turn up the collar and neck ring, slide the collar on the rod, slide the whole into the boiler and engage the regulator, then fit the neck ring to locate the collar. Braze the collar in place then chuck in the 3 jaw and clean off any excess spelter, to arrive at about 1/32 in. clearance between collar and neck ring. The gland is either from a casting or turned from $\frac{3}{4}$ in. diameter bar, brass is permissible here. Drill the No. 43 holes and shape the oval flange, then offer up to the regulator gland housing, spot through, drill and tap 8BA. Make studs from stainless steel screws and pack the gland with PTFE or graphited yarn.

Internal Piping

When building the boiler I should have mentioned the injector delivery pipe supports, brazed to the shell in way of the dome, but they can be bent up to angle form and secured with bronze countersunk screws if forgotten; braze them though for preference. The delivery pipes themselves can be up to 20 in. long, to take feed water right to the front of the barrel, and are either brazed directly into the banjo bolts, or collars fitted as for the injector steam pipes, the latter going forward and turning up into the dome. The blower union is straightforward and if you have any problem with the blower valve, then Gordon Chiverton specialises in such little masterpieces, the same applying to the safety valves, where I cannot positively describe how to make them really 'pop' and then reseat almost immediately, save that it is a combination of pop recess and spring characteristics – we have fun and games at times with them!

Hydraulic Test

I recommend the hydraulic test be delayed until all the fittings are in place, so that you can prove the whole rather than just part of the total 'boiler package'.
This session has been rather skipped over as every E. S. COX builder will, I am sure, have several boilers under his belt and his own ideas on procedure, which may well vary from what I have described. In any case, those wishing to skip this part altogether can do no better than contact LLAS advertiser Reg Chambers, in the sure knowledge of making a sound purchase, as a growing number of unsolicited letters from satisfied customers bears witness.

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

by: DON YOUNG

Part 5 – Cylinders, Pony Truck and Coupled Wheels

I am personally very much in favour of piston valve cylinders and although by no means a first class craftsman, simply an artisan, getting steamtight piston valves presents not the slightest problem for me, indeed they are both simpler and superior to the slide valve in my opinion. It has taken 15 issues to reach one of my favourite topics, so I will waste not a second more and get stuck into the description.

Cylinder Block

I must say I am extremely pleased how well these potentially awkward blocks have turned out, with very little machining required and nothing too exacting. The steam passages, apart from my K1/1 fabricated cylinders, are the shortest yet and allied to the generous $1\frac{7}{8}$ in. bore should make for an exciting performance; let me bring that day a little closer.

Rub a file over the two outside flanges so the block will sit nice and square on your surface plate, which can be the lathe bed; apply marking off blue to gunmetal blocks, red to cast iron, and scribe on the machining allowances. For the main and steamchest bores, fit hardwood bungs at what will be the rear end and mark on the centres, scribing back on to the casting at the finished bore sizes. The first job though is to chuck in the 4 jaw and machine the bolting face to line.

Readers will know by now that for any machining operation I try to use the simplest means available, which for cylinder boring has meant chucking in the 4 jaw and using a boring tool. This evening I tried valiantly for around 15 minutes to do just that, and failed, so had to look for salvation elsewhere. The block was rested on the boring table of my ML7 and of course this as the very name suggests, is an ideal solution, though first we need another register or datum, for accurate location; those drain valve bosses will be just perfect.

Cut two 6 in. long strongbacks from $\frac{3}{4}$ in. x $\frac{1}{2}$ in. or similar section bar and drill $\frac{3}{8}$ in. holes at 5 in. centres, this to suit the slots in the boring table. Pack up the block on the table, fit the strongbacks and bolt down into the 'T' slots; set the drain bosses square to the chuck and mill them to dimension. Swing the block through 90 deg. and pack up until the bore is at centre height, including in the packing pieces one of $\frac{3}{8}$ in. thickness. Fit a between centres boring bar, I commend the Arrand version as advertised in LLAS No. 8, and first bring it up to the two drain bosses to get the block properly aligned. Transfer the boring bar into the main bore, after removing the bung, and trace the scribed line with the tool, adjusting any height discrepancy with shims and in the other direction with the boring table feed screw. When satisfied, tighten everything down well, apply a 1/32 in. cut and pass this right through the block. For iron, the books tell us to use a slow speed and coarse feed, the reverse for gunmetal, but I recommend for both that you run the lathe at the lowest direct speed and set the changewheels to give the finest feed; your gearbox if you have this luxury. Allow the tool to pass twice at each feed increment, and as you approach finished size increase this to four or even six passes per cut, until the finish is mirror-like. Unless you are going to use 'O' rings on the piston heads, the actual finished size is not vitally important – the surface finish is. If you have an Arrand or Dore boring head, change to this and machine the rear cover flange; if not then grip a cranked round nose tool in the 4 jaw to swing $2\frac{1}{2}$ in. diameter and use as a fly cutter to deal with this face, then withdraw the block by $\frac{1}{4}$ in. and deal with the steamchest rear facing. Turn the block through 180 deg. and deal with the front cover faces, stamping the block to denote the rear end.

We now have to set up for the steamchest, so remove $\frac{3}{8}$ in. of packing to obtain the correct height, go back to the drain bosses and boring bar technique to set the block square, then transfer said boring bar into the steamchest. Bore right through to $1\frac{3}{16}$ in. diameter, checking carefully with an internal micrometer, this is important, then deal with the rear end with a square ended tool to open out to $1\frac{1}{4}$ in. diameter by rule, to $\frac{9}{16}$ in. depth by vernier depth gauge.

Next take a 3 in. length of, say, $\frac{3}{8}$ in. x $\frac{1}{8}$ in. BMS and mill away $\frac{1}{8}$ in. for $2\frac{1}{2}$ in. at the centre; again the $2\frac{1}{2}$ in. dimension must be accurate. Now bore back from the front end at $1\frac{1}{4}$ in. diameter until the gauge just fits over the two spigots. You can open out the central portion between the liners to $1\frac{1}{4}$ in. diameter if you wish, this over a $\frac{5}{8}/\frac{3}{4}$ in. length, and also clean up the cast in steam belts to size, but neither is mandatory. We had better tackle the cylinder covers and flange as a next step.

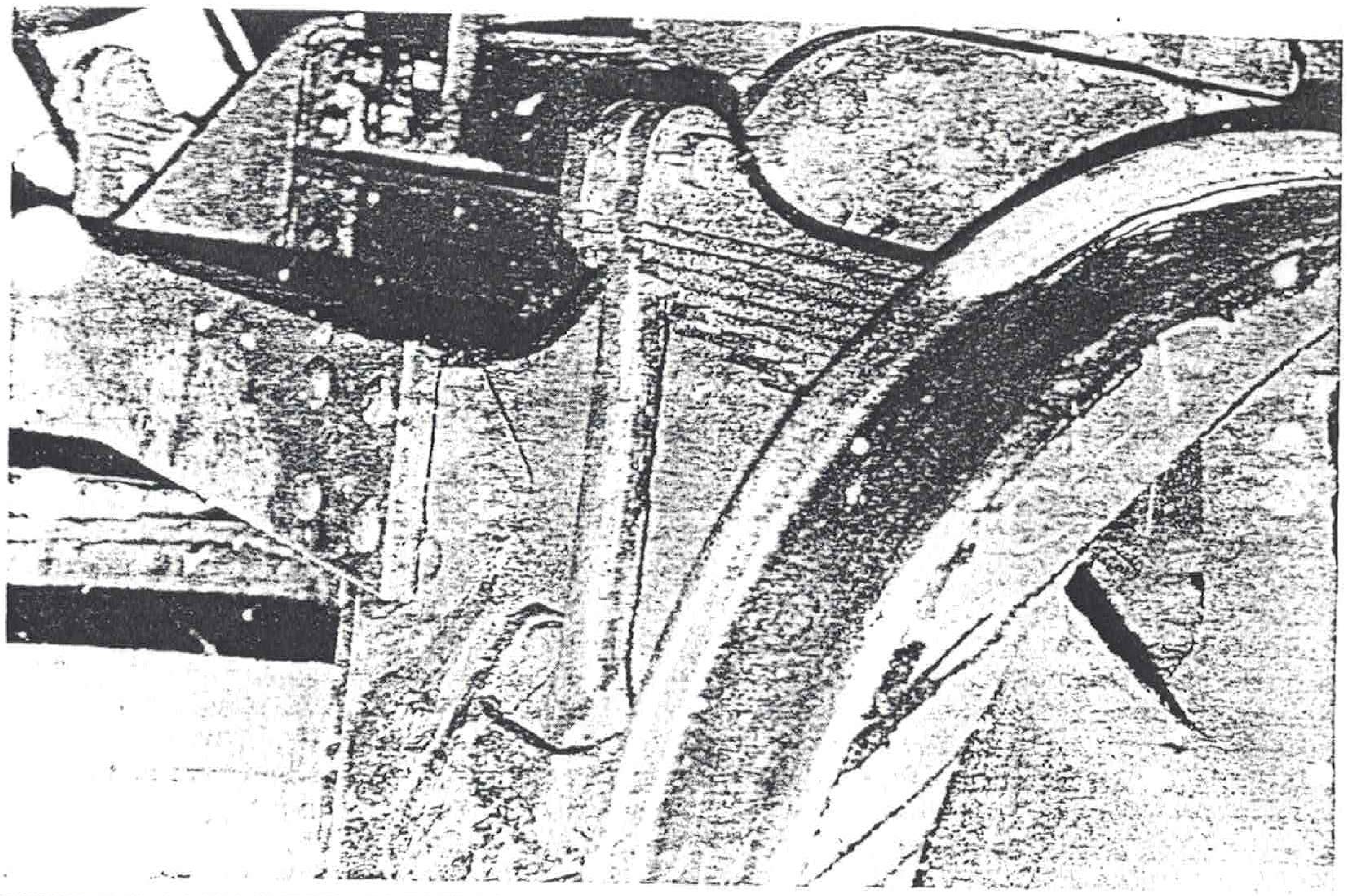
Cylinder Covers and Flange

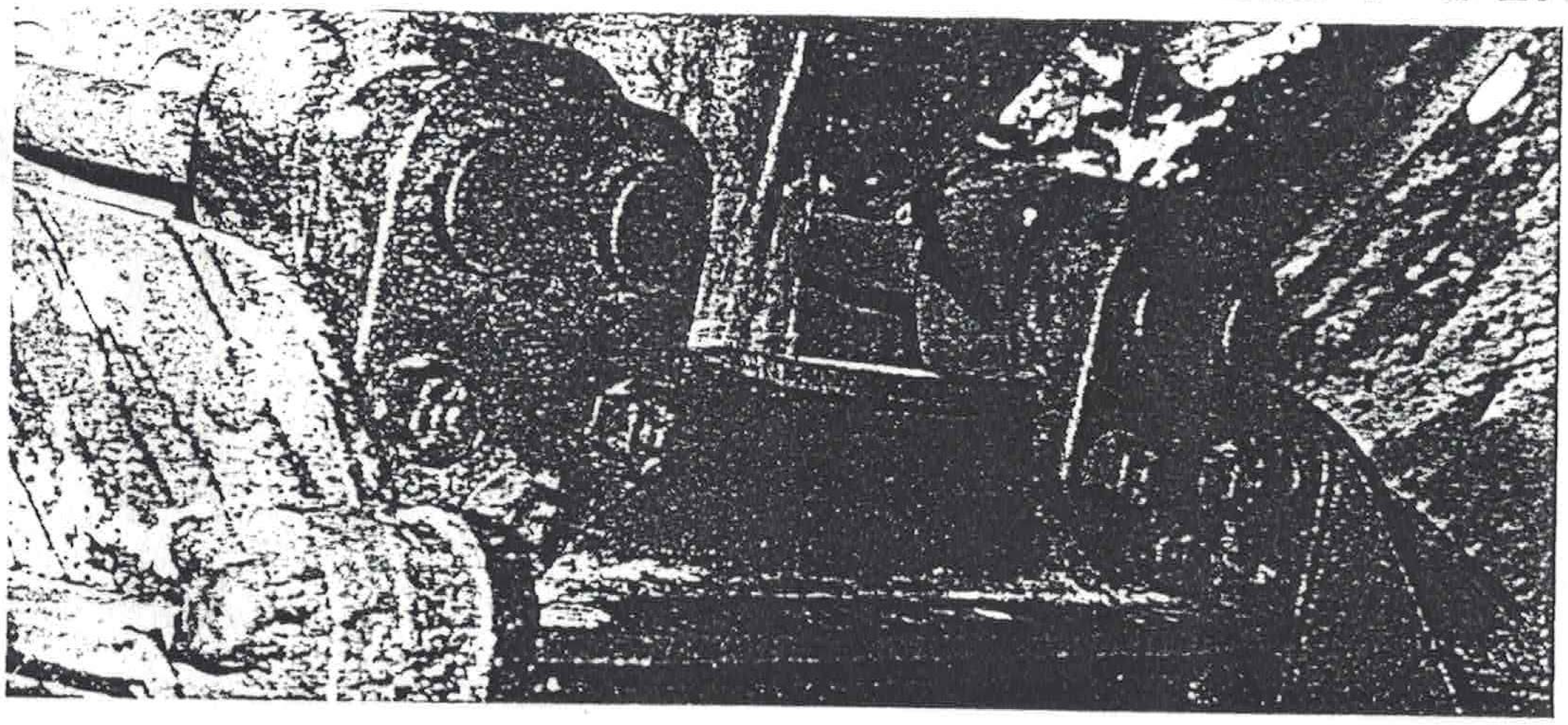
Chuck the front covers by their periphery and clean up the chucking spigot, then re-chuck by the latter and turn down to $2\frac{7}{16}$ in. diameter. Face across, turn the $\frac{1}{16}$ in. spigot to a close fit in the bore, then change to a knife edged tool to scribe on the bolting circle. To complete the turning, face across the back of the cover to thickness and part off the chucking spigot. Mark off and drill the twelve No. 30 holes then offer up to the block and either mill or file on the two flats to be just clear of both cylinder flange and steamchest; spot through, drill the block No. 40 to a good $\frac{3}{16}$ in. depth and tap 5BA. I have shown the fixing immediately under the steamchest and between the passages as a countersunk screw, this for ease of assembly, the remaining bolts being hexagon head from 6 or 7BA bar.

On to the rear cover, where the first operations to clean up the chucking spigot, reverse, machine both periphery and step to repeat the front cover. Face off the back of the cover to thickness down to $1\frac{1}{8}$ in. diameter, getting a good finish on the step, then part off the chucking spigot. Chuck by the periphery in the 4 jaw and set the step just machined to run true with a d.t.i., then face off and machine the spigot to 1 in. diameter. Centre, drill right through to $\frac{5}{16}$ in. diameter; to machine the gland housing I recommend a $\frac{1}{2}$ in. home made 'D' bit from silver steel with the corners ground to a bare 1/32 in. radius for the 'O' ring; if you fit a collar to the 'D' bit you will then be able to produce the 'O' ring groove to depth without problem. Deal with fixing to the block as for the front cover and we can pass on to the slide bar support.

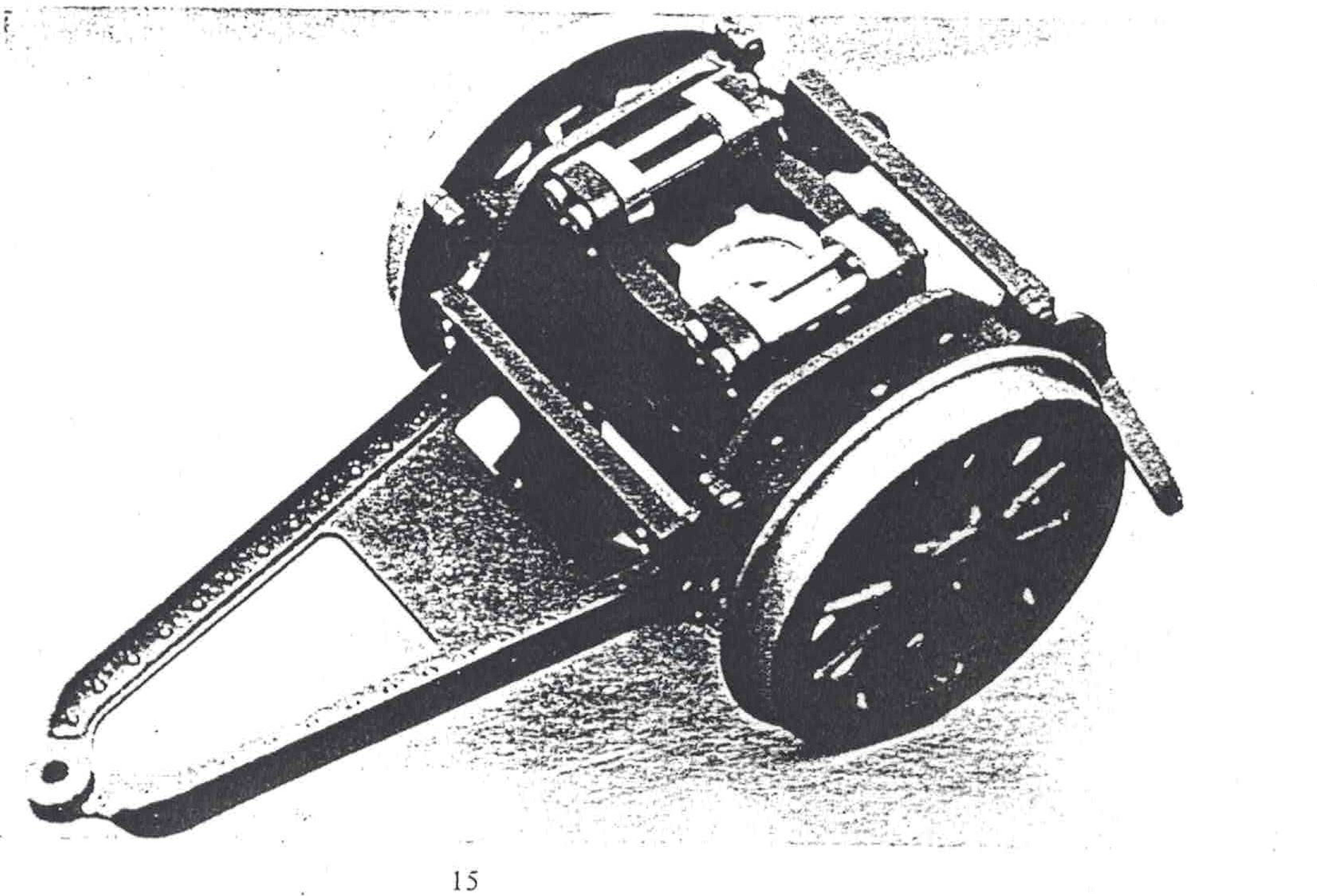
Cut a $1\frac{13}{16}$ in. disc from 4 or 5mm thick steel plate and drill a $\frac{1}{2}$ in. hole through its centre. Chuck by the bore and turn down to $1\frac{3}{4}$ in. o.d., then by the periphery and bore out to around $\frac{7}{8}$ in. diameter. The next job is to cut slots 180 deg. apart, $\frac{5}{8}$ in. wide x $\frac{1}{4}$ in. deep. Bend up the slide bar lugs from $\frac{5}{8}$ in. x $\frac{1}{8}$ in. steel flat and shape them to fit into the slots, as shown, then braze up. Chuck carefully in the 3 jaw and face right across to thickness, then bore out the centre to a nice tight fit in the cover spigot; reverse and turn down the lugs to size, tidying up with files. The little slot now showing is to

This view, despite the snowflakes, is particularly useful to E. S. COX builders in showing the pony truck spring hanger, its bracket and detail of the top leaf spring end
Photo by Len Hough





The 3-bolt fixing for the swing link supports as against 2-bolt fixing specified for E. S. COX



With just a little background, this fine pony truck by Norman Lowe could be taken for full size
Photo by Norman Gregory

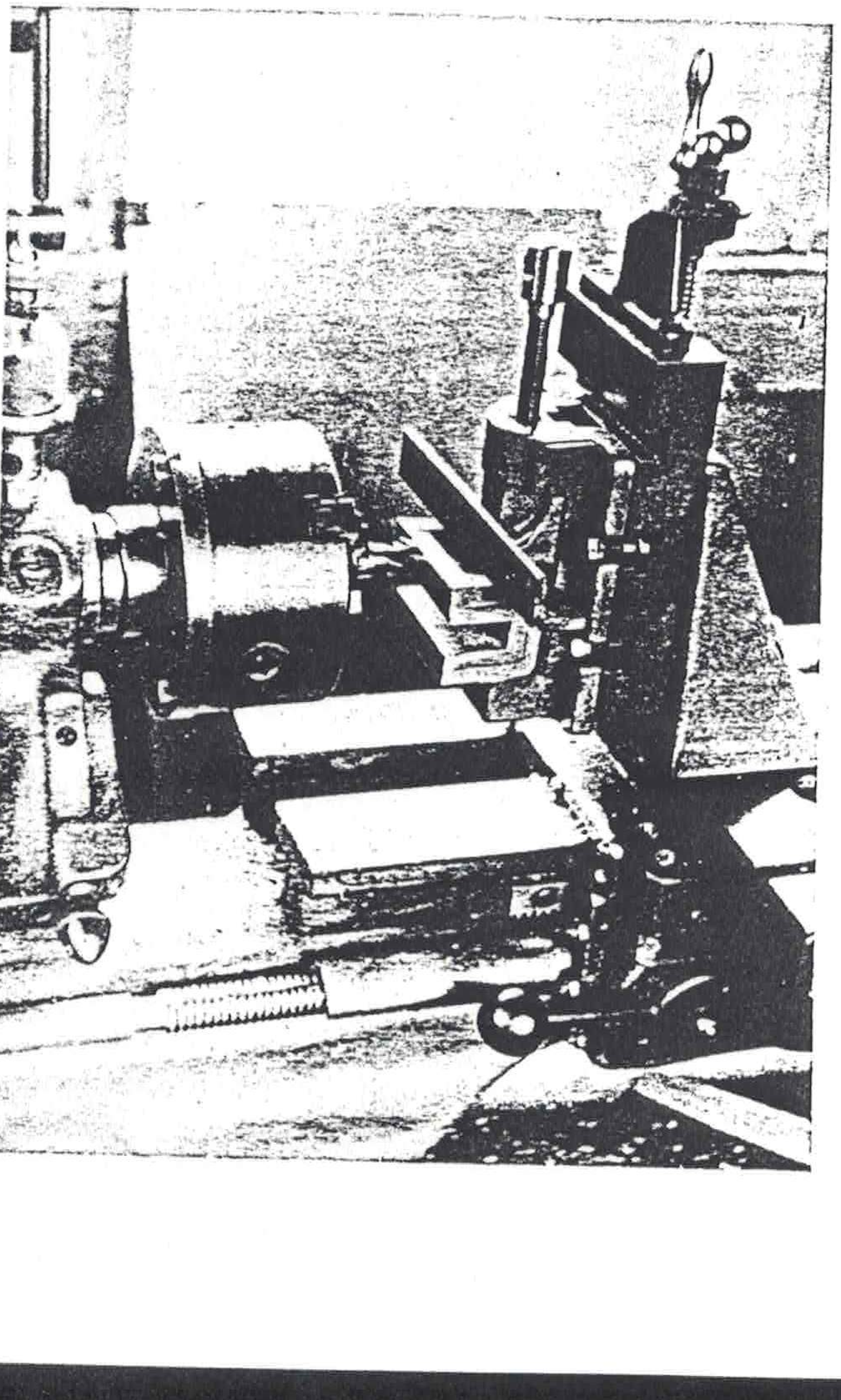
allow for milling or shaping the slide bar lugs to dimension, when you can drill and countersink the fixing holes. Whether you decide to fix the support to the cover at this stage or leave until the assembly is complete, I will leave this decision to builders; when you do come to tap the holes in the cover they should be no more than 5/32 in. deep.

For the piston rod gland, chuck a length of 1 in. diameter brass or gunmetal bar, face, just clean up the outside, then scribe on the bolting circle with a knife edged tool. Centre, drill and ream 5/16 in. diameter to at least 1/2 in. depth, rough out the boss, finish it if you can, then part off to length. If you did not manage to complete the boss, rechuck by the flange and tackle it now, before marking off and drilling the six No. 50 holes. From these holes, mark off for the six flats and either file or mill these to complete. Offer up to the back cover, using a length of 5/16 in. silver steel rod for alignment, then drill and tap the cover to suit, securing with 10BA hexagon bolts.

The only real requirement for the cylinder flange is that it be flat, on this all depends, so if your material is sheared, then make sure you have a big enough piece to lose any buckling. Other than that it is simply a case of profiling, marking out and drilling to drawing detail, plus the exhaust passage and steam inlet tapping. Offer up to the block, using the locating dimensions as given, clamp firmly in place, spot through, drill and tap 6BA for countersunk socket screws, the latter so that you can really tighten the flange hard on to the block.

Back to the cylinder blocks, where we are now in a position to virtually complete same. From the tapped holes for the covers you can see the positions for the steam passages, so file flats at the entrance to the bore, centre pop and drill 1/8 in.

My standard set-up of Machine Vice and Vertical Slide, utilised here for milling the combined Horn/Stay for the 2 1/2 in. gauge S.R. 'King Arthur' ELAINE



pilot holes into the belts. Set up the vertical slide, fix an angle plate to same, and dog the cylinder flange to the angle plate, with a passage facing the chuck. Putting a drill in the pilot hole and sighting from this along the lathe bed by eye will provide the accuracy of setting required, amazingly so. Use a centre drill or countersink to open out the mouth of the hole so a 3/16 in. end mill will just enter and then mill out the passage to size. The second passage will be at a slightly different angle, so do not forget to set up again before tackling same.

As I wrote this I was working out that it was 11 years ago when I bought my last 3/16 in. end mill from Reeves, in fact I bought two in quick succession having suffered the misfortune of snapping one off; I cannot remember how, only that the air turned blue! The reason for mentioning this is that the shank is the same diameter as the cutter itself, so by careful use I can produce oval passages to at least 1 1/4 in. depth; on this is based my standard specification. All went well until towards the end of 1982 I began to get a string of queries from builders with end mills whose shank diameter was greater than that of the cutter, which restricted depth of milling to around 3/4 in. or even less. The first 1983 Tool Catalogue to arrive illustrates end mills as I know them, so it would seem those I use are still available and I am sure Reeves will still be able to look after your needs in this respect.

Remove the angle plate and dog the cylinder flange directly to the vertical slide table, this to mill across the boss for the snifters and cylinder oil connection. Mark off, drill and 'D' bit at 5/32 in. diameter to 7/32 in. depth for the snifters and tap 3/16 in x 40T. If you do not like the idea of drilling into the cylinder bores, especially if you are fitting 'O' rings to the pistons, which is why I specified soft packing, then if you continue at No. 30 for another 3/32 in. depth, you will then be able to drill back from the steam belt at No. 50 to arrive at the No. 30 hole without too much trauma. After this the oil passage to the steamchest is far easier and neither the actual snifters or oil connection call for comment, save they have to be assembled in that order. Apart from drilling the No. 55 drain holes from the bosses into the bores, that is about the end of the blocks for now.

Piston and Rod

The gunmetal piston blanks are individual whereas the iron ones are cast as a pair, it makes no real difference. Clean up the chucking spigot, chuck by same, face and then turn down over a 5/8 in. length to approximately 1 29/32 in. diameter. Centre the outer end, bring the tailstock into play and rough out the packing groove with a parting off tool, leaving a very minimum of material to be removed. Drill 9/32 in. diameter to 5/8 in. depth, follow up at 7.9mm to 1/4 in. depth and tap 5/16 x 40T before parting off at a full 1/2 in.

Chuck a 5 in. length of 5/16 in. stainless steel rod and check carefully with a d.t.i. that it is running true; use the 4 jaw if there is any doubt. With about 9/16 in. projecting, face off and screw 40T for a full 1/4 in. length. Enter the piston and start facing it off, when this will screw it hard on to the rod and you will be able to complete facing to thickness. Now concentrate on getting the outside to a close sliding fit in the cylinder bore, before finishing the groove to suit a sample of your packing; it wants to be a good fit widthwise and stand about 1/64 in. proud so it can be compressed into the bore. Assemble with an 'O' ring on the piston rod and this section is complete.

Valve Chest Covers, Spindle and Gland

All these parts either use techniques which I have already covered, or are so simple as to require no comment, save to recommend the use of a tailstock die-holder when dealing with the long thread on the valve spindle, so at last we arrive at the heart of the matter.

Valve and Liner

My specification is for plain bobbin heads in both cast iron and gunmetal alternatives, with no labyrinth grooves; nothing. It may raise a few eyebrows, but it is the result of 34 years of good experience, starting in 1949 when Gordon Chiverton as a fairly raw gas fitter apprentice, produced a set of cylinders for his 5 in. gauge Fowler 0-6-0 Dockyard Tank. These were still totally steamtight when 20 years later the engine was scrapped, things like axleboxes, horns and the boiler all being life-expired. Vindication for plain bobbin piston valves if ever there was an instance. Gordon though has since established a reputation for his very fine machining, so what about an 'ordinary builder' like yours truly? I tackled a pair of fabricated cylinders for my 5 in. gauge L.N.E.R. Class K1/1 'Mogul' back in 1964, using the exact techniques I will be describing here. The standard of machining was no more than average, just an understanding of what was necessary, the results superb. We also have a long line of successes in providing fully machined piston valve cylinders for our customers, none of which have given the slightest trouble, and will no doubt produce a few finished cylinders for E. S. COX builders in due course, these with the same confidence. To those who would query the suitability of plain bobbin piston valves, I would refer to the plunger type of diesel engine fuel pump, where the set-up is identical and expected to give around 40,000 hours service life, this at a higher sliding velocity than our piston valves, and in diesel oil which is by no means the ideal lubricant. Also our bobbins have the advantage of completely passing over the ports on each cycle, being lubricated in the process, so there is no need for alarm, provided we achieve the correct initial fit, this is the secret of success, so let us proceed to meet that specification.

For the liner, chuck a $1\frac{3}{4}$ in. length of $1\frac{1}{4}$ in. diameter cast iron or bronze bar in the 4 jaw, face and turn down over a $1\frac{5}{8}$ in. length to 1.24 in. diameter, an easy fit in the steamchest end. Check the steamchest bore for which the liner is intended by internal micrometer and turn down over a $\frac{7}{8}$ in. length to a .003 in. interference fit in said bore, lightly chamfering the end for ease of entry. Carry out this and subsequent machining operations with the workpiece as cool as possible, for a 'hot' dimension will differ from a 'cold' one. Now centre and drill right through in stages as large as you are able, with $\frac{7}{8}$ in. as the upper limit, then bore out in easy stages to $1\frac{1}{4}$ in. depth with at least a double pass per cut, until you are within 1/32 in. of finished size. Now set the topslide over about 3 deg. and open out the mouth of the bore until your 1 in. reamer enters comfortably, not by any large amount but enough so that it is properly supported. Carry on boring until you reach a point where you feel the 1 in. reamer is trying to enter the bore. In this I am assuming that you will be using a hand reamer, this is one where there is no taper at the business end and a square at the other. Bring the tailstock up to the centre in the reamer end, fit a spanner over the square and let it rest on the lathe bed, then pull round by hand and feed in the reamer, applying paraffin as cutting fluid. Keep turning whilst you withdraw the reamer, then part off at a full 1 in. overall, reverse and face off the flange to length and bell-mouth this end of the bore also.

We now have to deal with the ports, for which a couple of simple jigs are required. Chuck a length of $1\frac{1}{4}$ in. diameter steel bar, face, centre and drill $\frac{1}{2}$ in. diameter to $\frac{1}{2}$ in. depth. Bore out to $1\frac{1}{4}$ in. diameter, a fairly good fit over the flange of the liner, to $\frac{5}{16}$ in. depth, this by gauge, for which I suggest you bore a little deeper and then face across the edge of the thimble to arrive at the correct dimension; part off at $\frac{7}{16}$ in. overall. Face, drill again to $\frac{5}{8}$ in. depth and bore out to a full $1\frac{3}{16}$ in. diameter to 15/32 in. depth, parting off at 19/32 in.; caseharden both these thimbles. Erect to each end of a liner and you will see a 7/32 in. belt, which indicates the exact axial position of the ports. I suggest you mark off and drill the eight ports initially at about No. 6, so you stay clear of the thimbles, cramping over them, when you will now be able to put a square file right through a pair of holes and gradually file them down to the thimble edges, concentrating first on the port you can see, then turning through 180 deg. and tackling its opposite number; finish the other two edges of the square hole by eye, using if you like a No. 3 drill as gauge. Deal with all eight ports, then put the liner over the reamer and turn by hand to remove any burrs.

We now need the assembly tools, the first item being a 6 in. long bolt, about $\frac{3}{8}$ in. diameter, or a similar length of studding. Next chuck a length of $1\frac{1}{4}$ in. diameter steel bar and reduce for about $\frac{3}{8}$ in. length to 1.24 in. diameter after facing across. Turn on a $\frac{3}{16}$ in. spigot to an easy fit in the liner, centre and drill to a clearance hole for the bolt to $\frac{1}{2}$ in. depth and part off at $\frac{5}{16}$ in. For the other end we need something that looks like the front steamchest cover, drilled centrally for the bolt. Enter the liner in its bore, fit the spigotted washer, feed the bolt through, fit the dummy end cover, followed by washer and nut. Now all you have to do is tighten the nut and draw the liner into the steamchest, just like we used to do full size; apply a drop or two of oil to aid the process. Fit the second liner, then take the 1 in. reamer and feed it right through both liners, this by hand. This part does sound a wee bit crude, in fact I remember it worried me at the material time, but there is so little metal to remove, and most of it will be found to be around the port area, that I found it was completely self-aligning and finished up with a mirror-like finish where it mattered; use paraffin again as tool lubricant.

For the valve, chuck a length of $1\frac{1}{8}$ or $1\frac{1}{4}$ in. diameter bar, gunmetal or cast iron to suit the liners, face and centre, then with about $2\frac{1}{2}$ in. projecting from the chuck jaws, bring the tailstock into play. Rough out the centre, then start parting off at a full 2 in. length, but only reduce to about $\frac{7}{16}$ in. diameter as at the centre. Now get the central portion right down to $\frac{7}{16}$ in. diameter and with the same round nose tool, concentrate on the outer head, getting the $\frac{3}{8}$ in. dimension exact to micrometer. Move to the bobbin periphery and reduce a small amount at a time, this is the critical bit, until one of the loose liners will get go over the head by the very smallest amount when tapped with a mallet; not by hand pressure alone. Next concentrate on the second bobbin, getting the overall 2 in. length and $\frac{3}{8}$ in. head dimensions correct in the first instance, then turn the bobbin down to the same micrometer dimension as the first. Drill No. 10 to about $2\frac{1}{8}$ in. depth, then part off the completed valve.

Take the valve to its steamchest and smear both liner and valve heads with molybdenum disulphide grease, 'Rocol' anti-scuffing is a fine example of this though there are several others equally as good. With a soft faced mallet, drive the head through the first liner, don't get nervous at the tightness of fit, then enter both heads into their respective liners and with a piece of hardwood dowelling, drive through again, only this time not quite out of the other side if you can help it, say leave the head sticking about half out of the liner. Repeat the process about half a dozen times, applying more grease as you go, and I think you will be surprised how much easier the fit becomes, though still a stiff one. Remove the valve completely and inspect, when you should begin to see a mirror surface developing, with no scoring, so apply more grease and carry on until you can just about push the valve through its liners by finger pressure; that is the result you require at this stage.

That really is the secret of sweet fitting piston valves, getting things right at the start, for even your very best turning, when viewed under a magnifying glass, looks like a ploughed field, with ridges and hollows. Of course, with an initially superb running fit, once the ridges wear off, and this happens very quickly, the result is a sloppy fit with steam leakage. Although it is just possible to assemble the valve 'dry' in the liner, the molybdenum disulphide additive, besides eliminating the risk of scoring and even seizure, impregnates the metal surface, so the mating surfaces are partly lubricated for life. I found after valve setting and a first track outing that the valves were a perfect fit, the loading had come off the valve gear such that reversing required no effort, and both liners and valves had a glassy surface; they still have nearly 20 years on, though I wish I had time for a bit more running.

The K1/1 has been the test bed for many features which I have since adopted as standard, like for instance ball-type drain cocks which leaked abominably at the first outing such that I almost scrapped them, since when and without attention they have never given a moments bother. Arising from this, on one of her outings, I took her off the track at the conclusion and drove her into the steaming bay. After dropping the fire, blowing down the boiler, sweeping out the tubes and smokebox, which took around 30 minutes, I screwed her into reverse prior to pushing her round to the car; on reversing though there was one very distinct exhaust beat; not bad for steam which had been trapped for about half an hour and an unrehearsed demonstration of plain bobbin piston valves, one which any builder who follows the above instructions can emulate. Indeed, with but minor variations, this description applies to all my piston valve designs, so in this respect those BLACK FIVE builders who were disappointed by losing out to E. S. COX over the matter of a series, have the most vital feature covered; many others too I am sure you have discovered by now.

Coupled Wheels and Axles

Little needs to be said about the driving and coupled wheels, though I will run briefly through the machining operations. Chuck a wheel by the tread in the 4 jaw and set to run true, then face across the back, remembering that the centre boss stands $\frac{1}{16}$ in. proud, turn down the flange to size and radius the corner with a file. All except the last operation is with the lathe in back gear; change to direct drive and at the lowest speed, centre, drill through at $\frac{11}{16}$ in. diameter, bore to within a few thous. of $\frac{3}{4}$ in. diameter and finish with a reamer.

Now cut crescent shapes from stiff cardboard for the balance weights, mix up some Isopon P38 and press between the cardboard formers. Allow about an hour to cure, remove the cardboard and attend to any blemishes, then leave another couple of hours or more before tidying up to the correct profile, plus getting flush at the back of the wheel; this latter may be turned.

Take a scrap $\frac{13}{16}$ in. drill and saw away the shank just to the rear of the flutes, clean out the headstock mandrel and tap in the drill shank. Face off and then turn down to within $\frac{1}{8}$ in. of the mandrel to $\frac{3}{4}$ in. diameter, a good fit in the wheel centre. Fit the faceplate, then a wheel, inserting packing pieces if necessary at the back of the rim to keep the centre boss clear, then bolt to the faceplate through the spokes in about four positions, using $\frac{5}{16}$ in. countersunk screws and $\frac{3}{8}$ in. washers, this so the screw heads don't get in the way of subsequent machining.

Face off to thickness, for the drivers you will have to complete the balance weights pulling round by hand, then deal with the raised crank boss. Grind up a little parting off type tool with a lot of back rake, so you can cut the little groove between balance weight and rim, continuing right round of course. Rough out the tread to within about .010 in. of finished size, dealing with the root radius, pulling round by hand if necessary to stop tool chatter, and complete the flange radius.

Bring all the wheels up to this stage, leave the last one in place and take a final cut across the tread to size; repeat at this setting for the remaining five wheels. To complete the turning, deal with the $\frac{1}{16}$ in. x 30 deg. chamfer, again pulling round by hand if there is tool chatter.

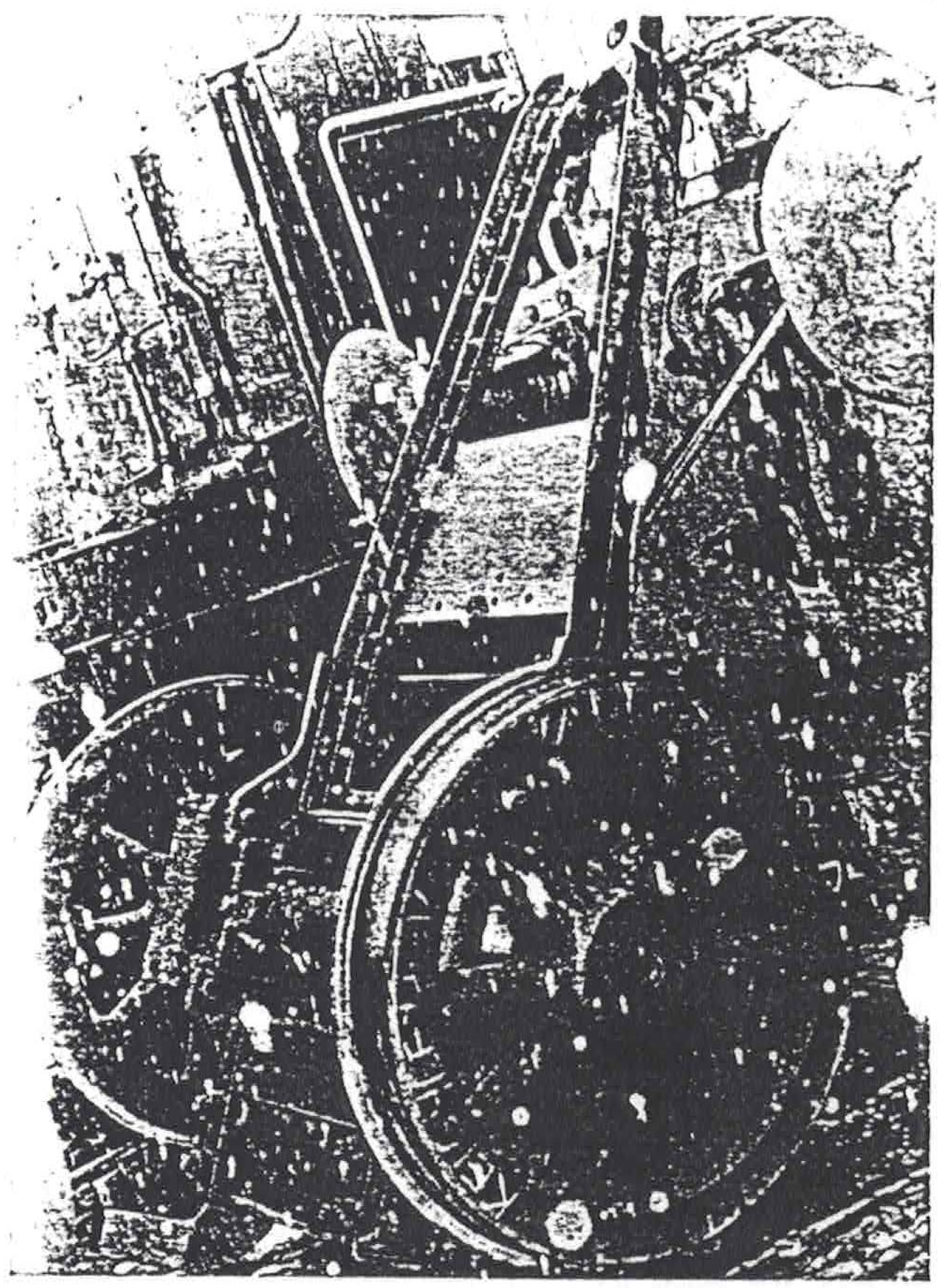
To drill for the crankpins we need a simple jig, starting with a 2 in. length of 1 in. x $\frac{3}{8}$ in. BMS flat. Grip in the machine vice, on the vertical slide and on the centre line of a 1 in. face, at $\frac{1}{2}$ in. from one end, centre and drill through in stages to $\frac{5}{8}$ in. diameter. Move on 1.156 in. by micrometer on the cross slide, centre and drill through to $\frac{9}{16}$ in. diameter. Chuck a 1 in. length of $\frac{3}{4}$ in. mild or silver steel bar in the 3 jaw and turn down for $\frac{3}{8}$ in. length to $\frac{5}{8}$ in. diameter, either a press fit into the plate, or a close one to which a drop or two of Loctite No. 601 is applied.

Scribe on the centre line of the crank boss, fit the jig to a driving wheel, clamp firmly in place and tackle the crankpin hole in the drilling machine. Make up and press in a drill bush, $\frac{9}{16}$ in. o.d. x $\frac{1}{2}$ in. bore, before dealing with the coupled wheels at the smaller size.

The leading wheels have a 3/32 in. undercut to $1\frac{1}{2}$ in. diameter in way of the crankpin, this to clear the coupling rod oil boss; poke a length of $\frac{1}{2}$ in. rod into the crankpin hole, bolt the wheel to the faceplate for this rod to run true by d.t.i. and turn the undercut to size.

Axles I find best turned between centres, so get some nice bright pieces 20mm in diameter, set to run true in the 4 jaw, face one end and centre deeply; reverse, face to length and centre again. Mount between centres, grip carefully with the 4 jaw, then turn down over a .66 in. length to $\frac{3}{4}$ in. diameter, either for a press fit or more likely a close fitting one for Loctite No. 601. The secret with Loctite is for the mating surfaces to be clinically clean and dry, so spray liberally with Primer 'T' before assembly, don't touch or wipe the surfaces, but simply apply a drop or two of Loctite No. 601 and push the wheel home; all this though is in the future.

Snow, Snow, Snow in mid April !
View showing underside of Pony Truck assembly



Turn the centre section of the axle to size, then reverse and deal with the second wheel seat to complete.

Pony Truck

Whilst I was at Doncaster, pony trucks came under a cloud, this after two nasty incidents, and although subsequently the engines were largely exonerated, a question mark remained as to their suitability for high speed work. For me a pony truck with swing link suspension is a classic piece of design and although it gave a livelier ride than trucks fitted with side control springing, riding a K3 'Mogul' at speeds up to 80 m.p.h. was thrilling! Looking through my reference books, swing links were probably more widely used at the front end of Locomotives worldwide than any other form of suspension. I found swing link suspension enthralling on my K1/1, especially through the sharp 'S' bend on the Isle of Wight M.E.S. track, where you could see the outer wheel really dig into the curves, lifting the inner wheel clear of the rail at speed; never once has there been even a hint of derailment. The swing link on the 'Crab' has the added advantage of being heart-shaped, giving a better geometry, so I have no qualms whatsoever in specifying same. George Kay of Nottingham, who is building E. S. COX in retirement, has loaned me the Master Drawing List for the '2-6-0 No. 4 Superheater Goods – Parallel Boiler', which is the official title for the Horwich 'Crabs' and curiously it lists Drawing No. C32873 for side control springing. We feel this to be a wrong entry, possibly for the Stanier 2-6-0's which followed, as a glance at the pony truck arrangement will show that it is virtually impossible to fit side control springing, plus it would be of doubtful value allied to swing links.

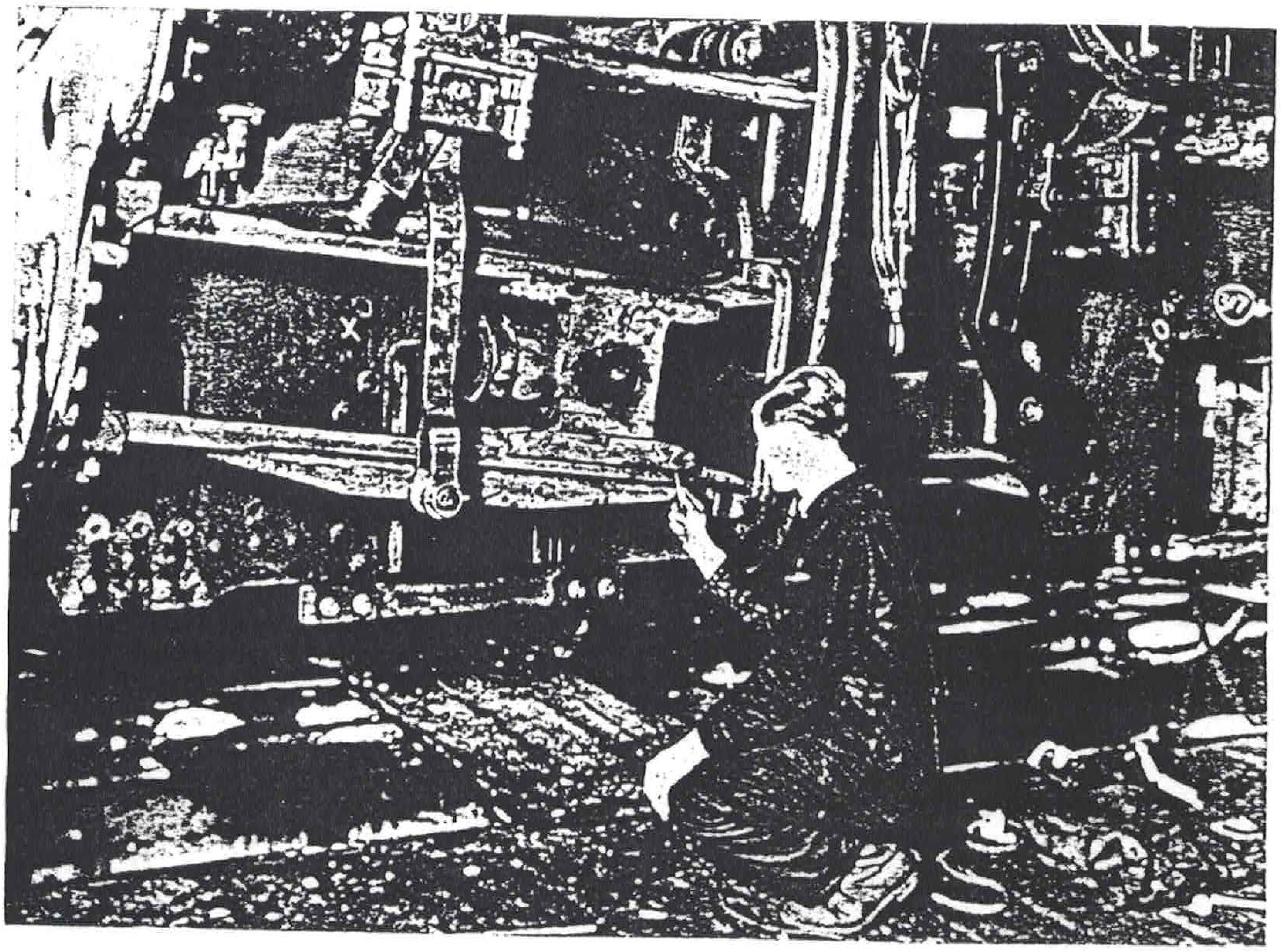
Turning to the construction, things like frames, stays, wheels and axles have already been covered in slightly different form, as have leaf springs, so that takes care of a large chunk. The horns are also fashioned from $\frac{5}{8}$ in. x $\frac{5}{8}$ in. x $\frac{1}{8}$ in. bright steel angle, requiring a minimum of machining.

The pair of axleboxes are from cast gunmetal stick, so first arrive at the $1\frac{1}{16}$ in. x $\frac{3}{4}$ in. finished section and turn the ends to give the raised bosses to accept the spring buckle ball ends. Mill the slots, mark off the axle centres, drill them to about $\frac{1}{2}$ in. diameter, then cut into individual boxes and turn to length. The keeps can be from $\frac{3}{4}$ in. square brass bar; mill down to size and roughly scallop the bore with a $\frac{1}{2}$ in. end mill, then cut away metal at the bottom of the axlebox and mill to accept the keep, a tight fit. Drill for and fit the keep pins, then chuck as a pair to complete boring to size; turn the raised face on the outer box. Chuck the other box on its own to deal with its raised face, when you can assemble to the axle, fit to the frames, bring up the horns, drill through the latter and rivet in place. Ease the axleboxes, including the important relief on the side flanges, then make up and fit the hornstays.

The guard irons are straightforward, as are the spring link, spacer and pin, which brings us to the spring hanger. This latter will just come out of $\frac{5}{8}$ in. x $\frac{5}{16}$ in. BMS bar, so first mark off and drill the four holes, then mill away to give a 3/32 in. flange with those two little, 5/32 in. long, side lugs projecting. Braze a piece of 3/32 in. steel to same, fashion to drawing and drill the $\frac{1}{8}$ in. hole through from the flange; bolt to the frames to complete the springing.

The yoke is a bit special, from 3/32 in. or 2.5mm steel sheet, so first cut out the centre a bare 3/32 in. less all round than the outside dimensions, save in way of the pivot, turn up the boss and bolt it in place, then put $\frac{1}{2}$ in. x 3/32 in. strip all the way round, silver soldering in place. Now you simply cut away at the front corners, and on the bottom at the rear, milling the two side faces to fit between the frames and bell-mouthing the pivot hole as shown.

The pony truck stay is a steel fabrication, something we have dealt with several times now in these pages, so mill the flanges to fit between the mainframes, these come in the next installment, then chuck in the 4 jaw and bore out the centre to $\frac{3}{4}$ in. diameter. The centre I originally intended to be a casting, but it works out best as a steel fabrication. Take a length of 1 in. diameter steel bar, face and then turn down for $1\frac{3}{16}$ in. length to 25/32 in. diameter, finishing with a nice blending radius. Cut an octagonal flange from $\frac{1}{8}$ in. plate and bore centrally to a tight fit over the centre piece, then add four 3/32 in. ribs, which can be simply $\frac{3}{8}$ in. wide at this stage; braze up. Now fashion the ribs to drawing before chucking the bar in the



The 'Horwich Bible', somewhere I made a note of its official title, contains a number of excellent photographs of 'Crabs' receiving attention. Here feeler gauges are being used between crosshead slipper and bottom slide bar, but the cameraman elected a wider and more useful view as far as we are concerned

3 jaw and turning the top spigot down to $\frac{3}{4}$ in. diameter, a good fit in the pony truck stay, and facing lightly across the flange. Centre and drill No. 2 to $1\frac{1}{4}$ in. depth, following up with $\frac{3}{8}$ in. drill and 'D' bit to $1\frac{3}{16}$ in. depth. Part off at the bottom, then chuck again in the 4 jaw to clean up the parted off face and radius the corner. Mark off and drill the No. 44 holes, offer up to the stay, spot through, drill and tap the latter 8BA for hexagon head bolts.

The cradle is a gunmetal casting requiring little machining; first chuck in the 4 jaw, face, centre and drill the No. 2 hole, then bore out to 5/32 in. depth to accept the centre; the wee pin holds the two pieces together on assembly. Those 5.5mm holes are best dealt with using the vertical slide and machine vice set-up, when the ends of the bosses can be lightly milled to thickness.

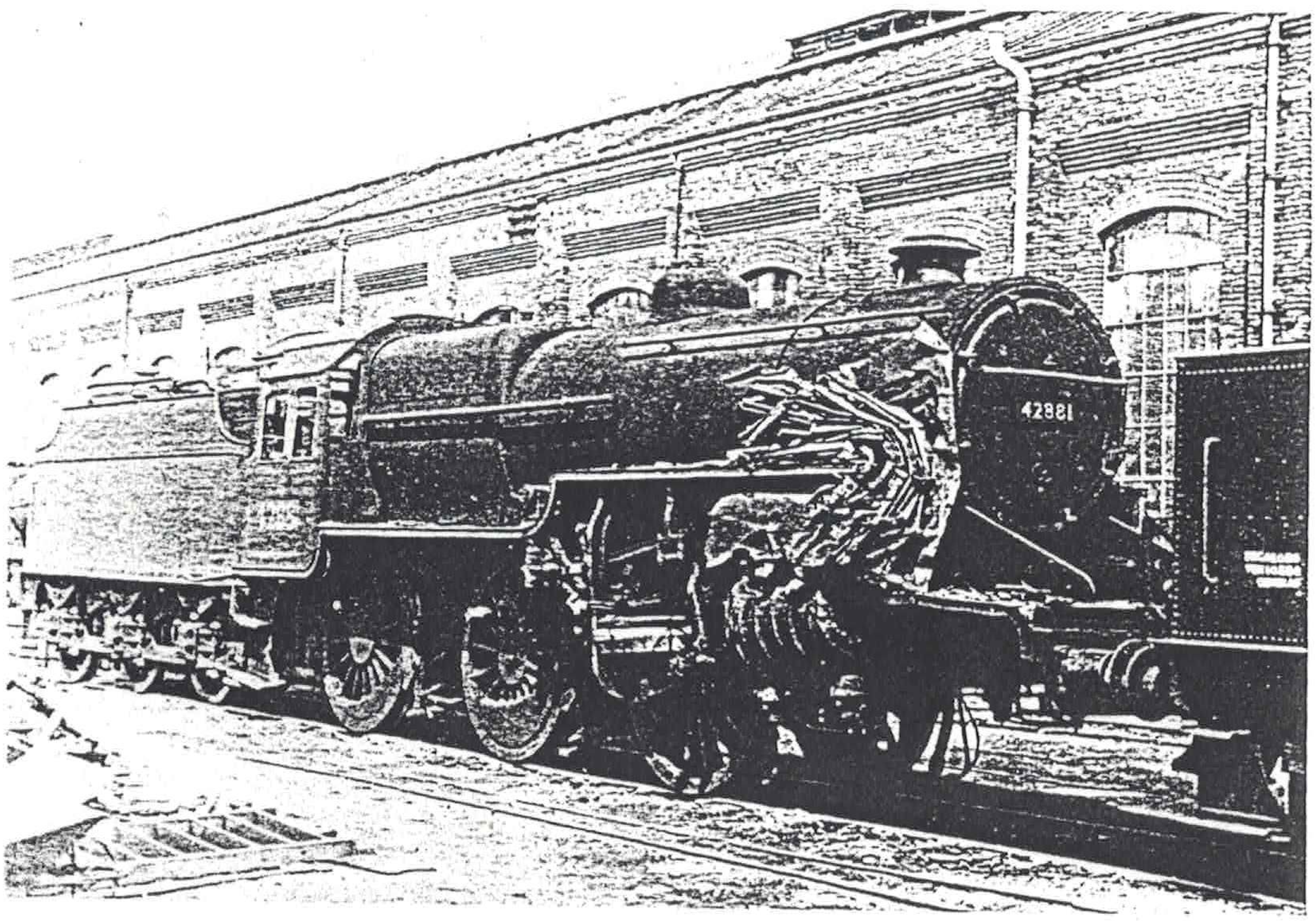
That leaves only the swing links, pins and their supports, the latter calling for just a little comment. All drawings I have seen show that each swing link support, or bracket as it is termed full size, being secured by two rivets, yet when some photographs arrived of a 'Crab' pony truck being removed at Haworth on the Keighley & Worth Valley Railway, the brackets are clearly shown as being secured with **three** rivets. There is nothing in the Master Drawing List to cover this change, so it is a matter for conjecture and to how and when it occurred. The reason would, however, appear to be that two rivets proved insufficient to hold the support/bracket firmly in place – the rivets must have worked loose. I don't for one moment think this will occur in 5 in. gauge so have left the detail to Works drawing, but if any builder should be in doubt, you know exactly what to do. The main thing though it to ensure the spigot on the support is in firm contact with the top of the guide stay, then the rivets will not be troubled.

The links themselves are from $\frac{7}{8}$ in. x $\frac{1}{4}$ in. BMS bar and I recommend you make one the 'master' first marking off, drilling and reaming three $\frac{3}{16}$ in. holes, two of them at the top to start the heart, or is it kidney? shape. You can then do some of the external profiling over a mandrel with an end mill, completing with saw and files, then drill a $\frac{1}{4}$ in. hole on the centre line at the top before abrafiling out nearly to line and filing to complete.

Assembly I think is virtually self-explanatory from the drawings, especially the front view for the swing links; the cradle pins press into the casting, though you can also use a taper pin through boss and pin as additional security if you wish, just like full size. Those two lugs shown at the $1\frac{3}{8}$ in. dimension on the drawing fit snugly between the guide stays, which you can now mark off from said stays and mill to line, just in case there is a wee discrepancy in the accumulation of dimensions between pivot and centre. Turn up and fit the four upper swing link pins, the heads can be silver soldered to $\frac{3}{16}$ in. rod for preference and then tidied up, when your pony truck is complete.

. . . .

Probably the best photograph showing cylinder detail is that of 42881, though the circumstances which produced it were tragic. In the early hours of a snowy December morning in 1957, the Glasgow/St. Pancras sleeper with a 'Britannia' up front was running downhill from Ais Gill, when suddenly the crew experienced very rough riding. This lasted for some moments, then eased off, but the driver thought it prudent to stop and examine. Just as he braked to a halt, there came into sight No. 42881 hauling a fast fitted freight, so the driver thought it wise to stay on the footplate until the freight had passed. However, as No. 42881 came level with the first sleeping coach behind the 'Britannia' tender, she heeled over to the right, causing considerable damage to the two leading coaches and the death of some passengers. What had happened was that the slide bar retaining bolts on the 'Britannia' had come adrift and left the crosshead with very little in the way of guidance. The piston rod then worked about to such an extent that it broke. When brought to Horwich Works for testing, the rod was seen to be quite blue from the heat it had experienced. With the piston rod broken, the crosshead and connecting rod were freed and flailed around, causing damage to the other track which led directly to the accident. All of us make wee mistakes as we go through life, but most of us are lucky to avoid such serious consequences, for the steam Locomotive could be a most unforgiving beast on occasion.



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

by: DON YOUNG

Part 6 – Mainframes

With tender, boiler, pony truck and cylinders all successfully completed, we can now turn our attention to the chassis; it is almost a classic example of good plate frame design, being in effect an 'I' beam from front buffer beam to driving axle, providing massive rigidity where it really counts. The drag box too, by coming forward as close to the trailing axle as possible, ties up the complete structure, with just that hint of flexibility between driving and trailing axles by wasting of the top and bottom edges, plus the large lightening hole. The extra depth in way of the trailing axle shows the beginnings of the feature that was to grace the B.R. Standard Classes, a genuine E. S. Cox feature. Drawing Sheet 6 gave me a lot of pleasure, though Sheet 7 is another matter!, so let me express the hope that all builders are going to enjoy this session, especially after the 'summer break' in proceedings to introduced DONCASTER.

Mainframes

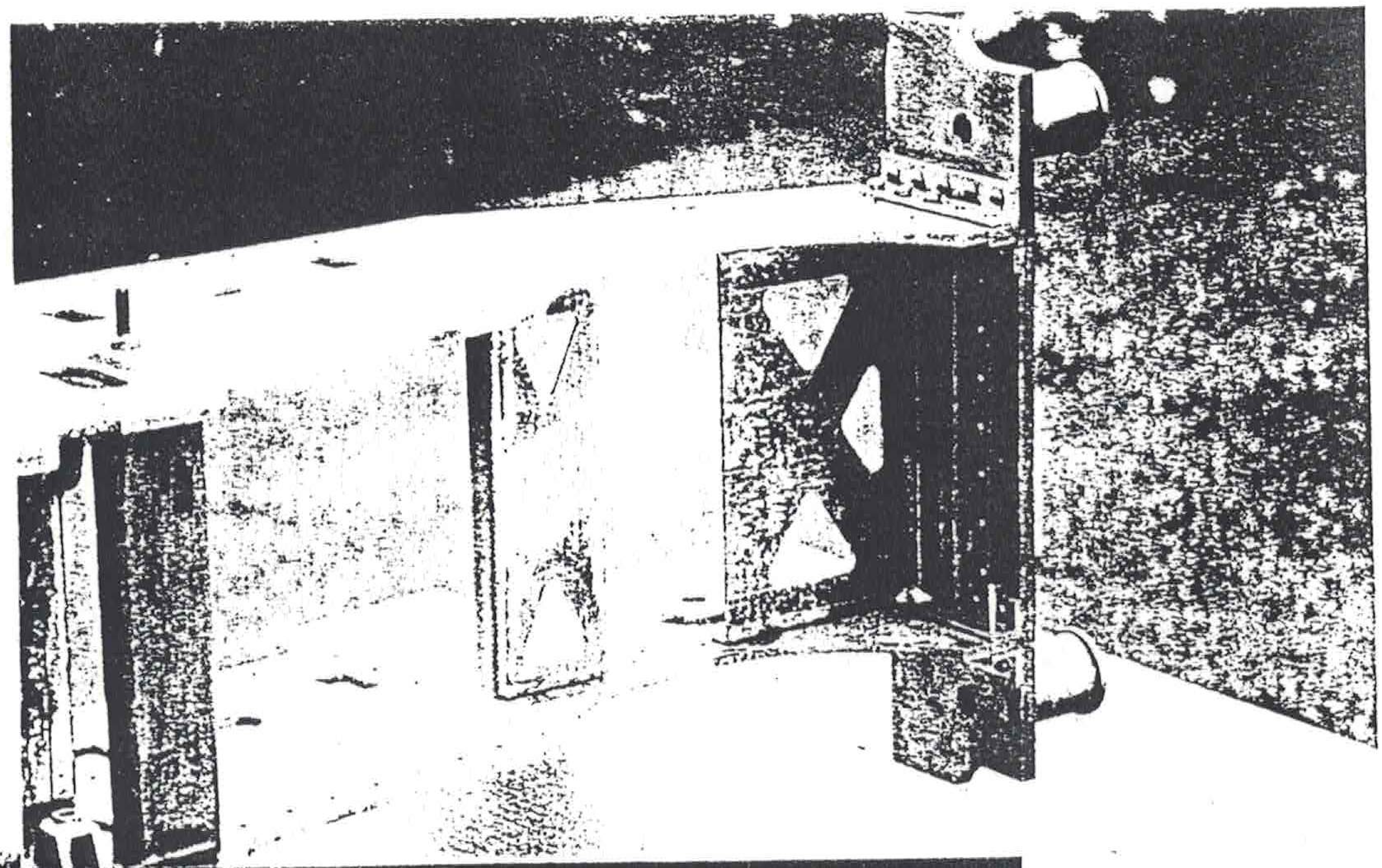
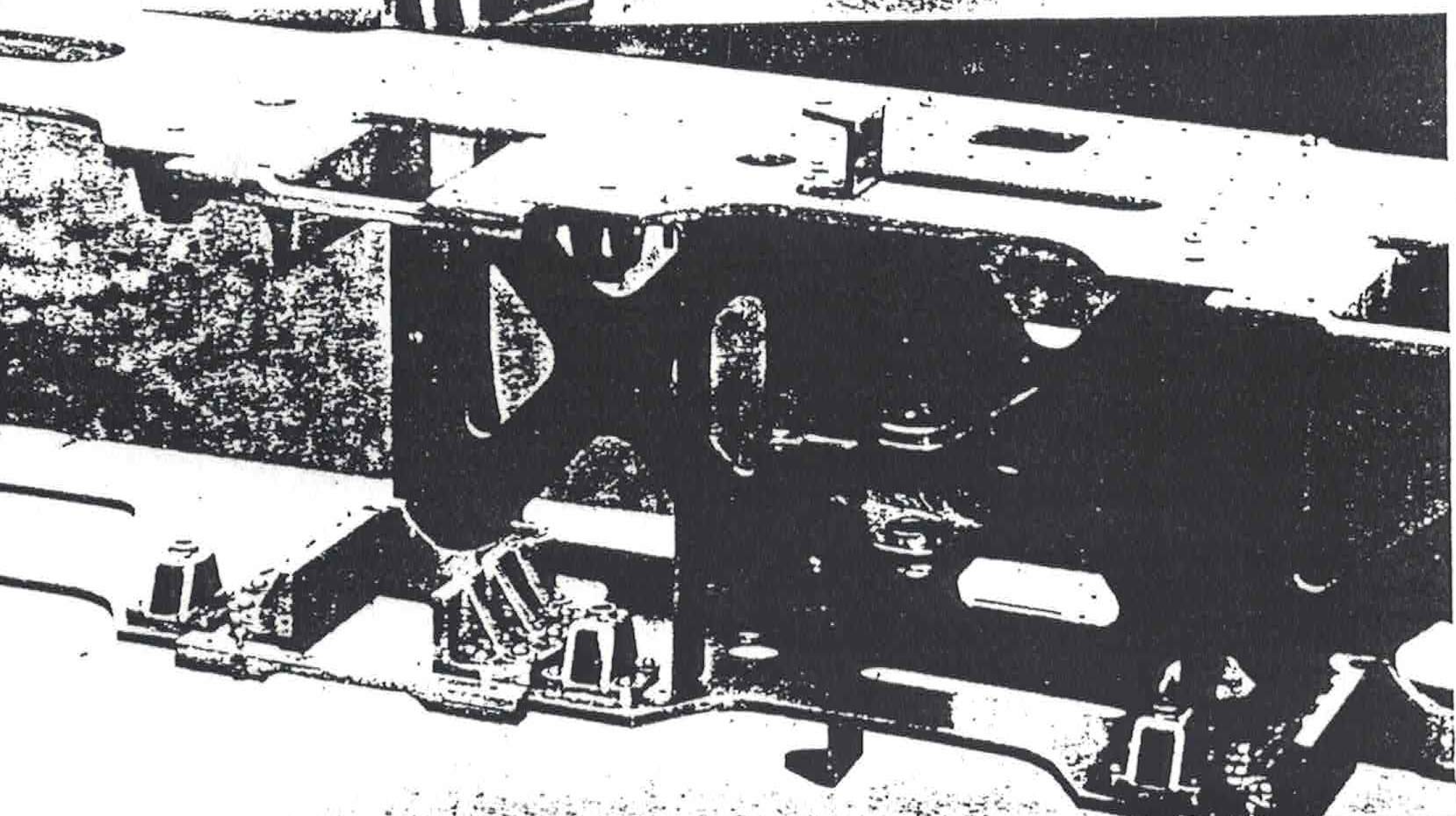
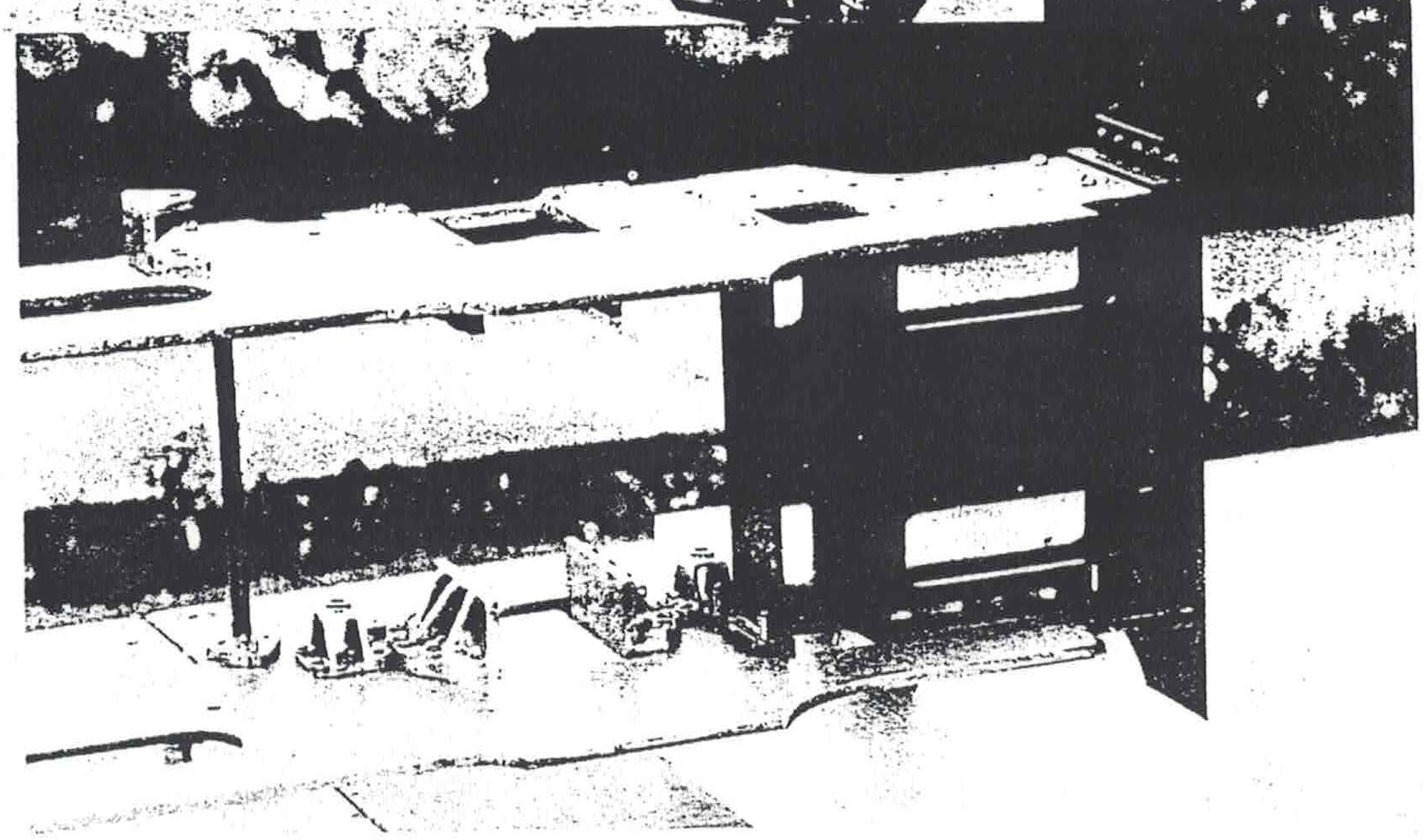
For the frames of my RAIL MOTOR No. 1, Reeves supplied me with normalised quality mild steel section, a little duller in appearance than bright flat, but more importantly when cut-outs such as at the horns were dealt with, the frames did not 'banana' but remained perfectly stable. I made very favourable comment to Reeves on this at the time, though from what was said in reply I don't think they realised they had normalised grade on the shelf, but it is so superior in quality that I have specified same again in hope. For those unable to obtain such aggreeable material, use a descaled black section in preference to bright finish, as other than using a heavy hammer, I cannot tell you how to remove any 'bananas'; I don't like the fruit either!
The length of frame at a finished 3 ft. - 0 17/32 in. means the plates are within the postal limit, and I guess the most likely section is 6 in. x 1/8 in. (or 3mm). Take one piece and file one of the long edges to be flat, using the lathe bed and marking blue to vertify same, then square off one of the ends as your second datum. If black steel is used, wire brush it first before coating with marking-off fluid, then carefully mark out to drawing.
We are now moving into the area where E. S. COX will begin to tax your skills, though this in turn will mean you derive extra pleasure from each operation, the profiling of the frames being a case in point. The mixture of angles and blending radii will require careful marking out to ensure smooth transitions, but the end result will really look the part. What makes the job a little simpler is that the horizontal centre line through the coupled axles strikes the bottom edge of the frames normal to the cylinder centre line and at a distance 1 9/16 in. from same, otherwise we would be in real difficulty in marking out this particular area. The cylinder flange is also important in arriving at the exhaust slots and fixings, so for the moment we only have to mark out for the 1/2 in. steam entry hole. Later on you will find that the top edge of the cylinder flange comes approximately 1/32 in. below the top edge of the frames; Roger Stagg had me worried for some days over this point as reams of calculations passed between us, until I finally discovered this 1/32 in. had been intentional on my part and was correct to prototype!
The only other feature requiring special comment is the rivet holes for attaching the horns, which in line with my standard practice are dimensioned on the frame detail. As there are individual raised bosses cast into the horns, it might well be thought preferable to drill the horns first to suit said bosses and then drill back through the frames; I can safely leave such decision to builders. We cannot make progress towards assembling the frames due to lack of horn/axlebox/smokebox saddle details on Sheet 6, but at least I can cover those details which do appear, starting at the front buffer beam.

Front Buffer and Drag Beams

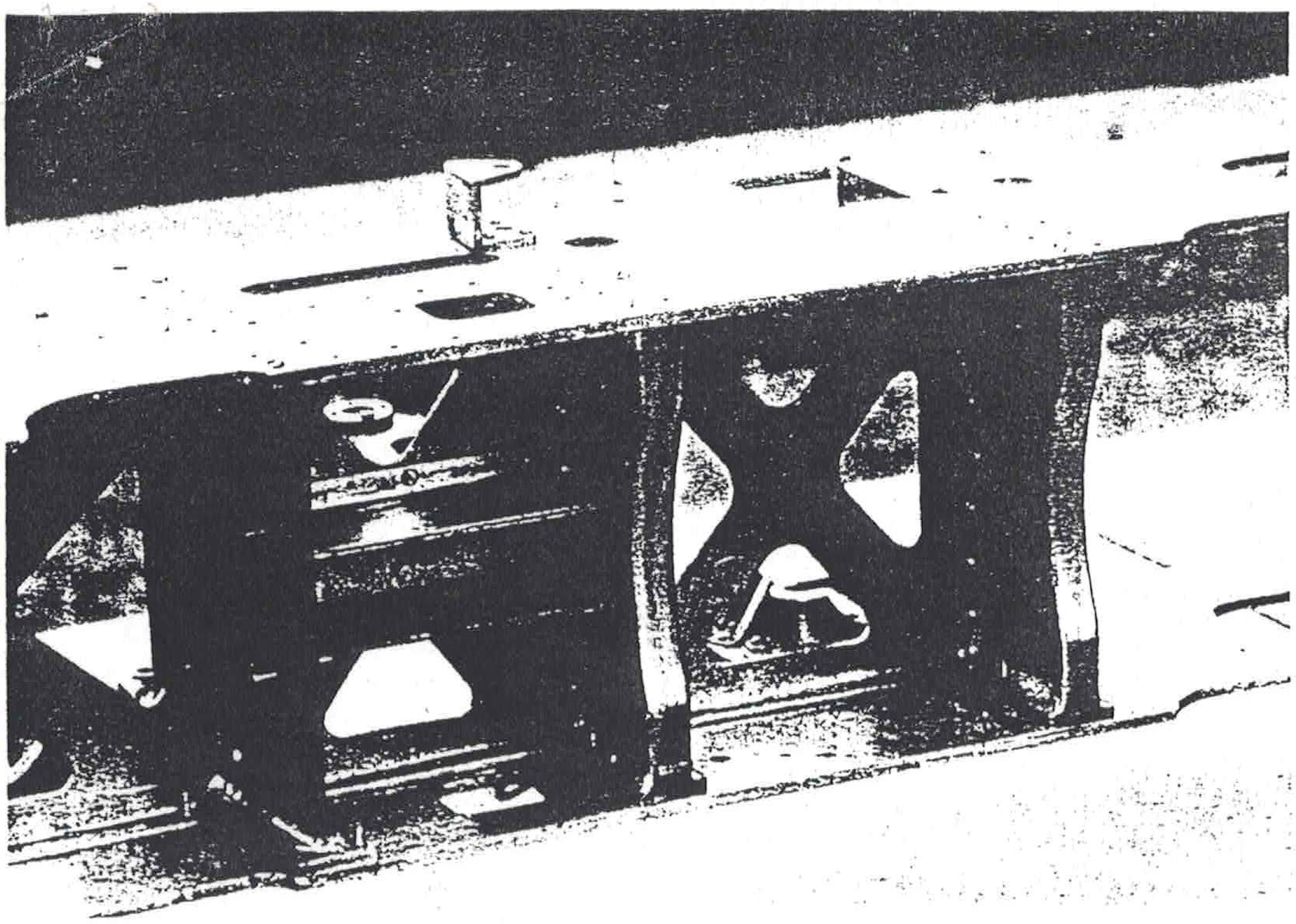
The front buffer beam is a composite of two squared 8 in. lengths of steel flat, 1 11/16 in. x 1/8 in. for the beam itself and a 2 1/8 in. x 1/16 in. section doubler. Clamp together, mark out, profile and drill all the holes specified. Back in 1979 when Sheet 6 was produced, 1/2 in. extruded brass channel was checked as being available, hence it was specified, though looking today it does seem to have become another casualty of metrication – ugh! As we need so little, 7 in. will suffice in total, the alternative is to mill down from 1/2 in. x 1/4 in. BMS bar. Drill back from the frames, secure with 1/16 in. snap head rivets, hammering down into countersinks to be flush with the front face of the beam, and we have a rigid assembly.
Cut four 2 1/8 in. full lengths from 3/8 in. x 3/8 in. x 1/16 in. angle and square off, then offer up one at a time to the frames to drill the No. 34 holes, making sure the front face is flush with the front edge of the frames; bolt in place. We must assume that the frames are at the correct 4 1/4 in. spacing, which the pony truck stay will ensure, when you can clamp the beam in place, drill through and rivet the angles to the beams; the buffers we have already from the second session, so with these fitted, this is as far as we can go on the front beam for the present.
The drag beam is somewhat less complex, the two rubbing plates being to accept the buffers at the front of the tender. The 4 23/64 in. dimension assumes frames 3mm thick and in any case are positioned to place, drilled through and rivetted. Whilst in this area we may as well tackle the substantial drag box.

Drag Box

The shaping of the drag box is entirely authentic, including the deep cut-out in the side flanges to match the frame lightening hole, though someone is bound to remark that the intermediate webs should show in that particular view; they were omitted for clarity, whoever he or she is!
Start with the main horizontal plates, from 1/8 in. or 3mm plate, squaring them off at lengths of 4 1/16 in. and 2 15/16 in. respectively, and of width so that when the side flanges are added the total becomes 4 5/32 – 4 3/16 in., sufficient for machining to size. Drill, saw and file, or mill the lightening holes, clamp together and drill through at 1/4 in. diameter for the drawbar pin. Turn up the bosses and if you turn another piece 3/4 in. thick as a temporary spacer, you will be able to bolt the lot together and arrive at the correct 3/4 in. spacing. Now it is simply a question of making the other parts to fit, drilling and tapping 8BA as required to hold the plates together with round head screws for brazing. Coat liberally with flux that has been mixed to a stiff paste, so it will adhere and prevent oxidation of the steel at the joints, heat quickly and silver solder all the joints; allow to cool and wash off under running water using an old toothbrush to scrub off all excess flux.

This is a case of a picture, or rather three of them, being of more help to builders than a thousand words from my pen — much prettier too! Front, centre and rear of E. S. COX frame assembly by that wishing to remain anonymous, Horwich, builder and photographed by Norman Gregory.



This shot by Norman Gregory vividly illustrates the massive strength of the E. S. COX chassis around the driving axle, all of it authentic detail.

Dry, wirebrush, then spray with zincplate from an aerosol to prevent rusting. Turn or mill the side flanges to 4⅛ in. overall, offer up to the frames, spot through, drill and tap 6BA, then offer up the drag beam in turn and attach this with 8BA countersunk and 7BA hexagon screws as indicated.

Rod Stay

I doubt if this stay contributed much to the overall strength of the frames full size, though as a spacer it would have been useful, the same applies in 5 in. gauge. Cut the end plates from 1 in. or 3mm plate, clamp to the frames, drill through and bolt. Take a full 4⅛ in. length of $\frac{3}{16}$ in. steel rod and turn down for ⅛ in. at one end to around 5/32 in. diameter; reverse and repeat until the shoulders are a close fit between the two end plates. Mike the spigots and drill the end plates to be a press fit, assemble and check for alignment to the frames before brazing, then tidy up and zinc coat.

Inside Motion Stay, Boiler and Expansion Link Bracket Stays

We will next deal with the remaining 'vertical stays', the most substantial being that which ties in with the motion plates. Cut the centre web from 3 in. x ⅛ in. flat, cut the end flanges 3¼ in. long from $\frac{11}{16}$ in. wide material, screw together and braze up, then clean, zinc plate and machine to width. Offer up to the frames, tilting to be normal to the cylinder centre line, spot through, drill and tap. The rear top corner of the side flanges should come flush with the top edge of the frames, when all you have to do is trim off the excess ahead of this; leave the holes in the cross member for the moment.
Boiler/expansion bracket stays are from a common casting, which involves tidying up the bottom flange, cutting half of it away as shown for the boiler stay, then milling the side flanges to 4⅛ in. overall. Offer up to the frames, with top flush with said frames, spot through, drill and tap 7BA for hexagon head bolts.

Gusset and Horizontal Stays

Back to the front end, where the buffer beam will receive some additional support. For the gussets, cut out the plates to drawing and either rivet or silver solder on the two pieces of ¼ in. brass angle. Clamp in place, drill back from the frames at 3/32 in. diameter and bolt in place, then drill the other two holes from the buffer fixings to complete.
Horizontal stay No. 1. I have made reasonable easy by not physically fixing it to the pony truck stay, it provides ample strength without such an additional complication. The requirement is $\frac{1}{16}$ in. (1.6mm) flanging quality steel and the recommendation that you make up a squared flanging block, size 8 in. x 4 in. and at least ⅜ in. thick; file on a wee bending radius so that the plate being flanged is not cut during this operation. Although the 4 in. width mentioned above is nominal, it is critical to the whole successful outcome of the finished flanged plates and care should be taken in arriving at such a dimension that after the flanges are produced, simply filing away a few thous on each face will result in the correct 4⅛ in. overall width, so take time in making up the flanging block as it will pay rich dividends.
Where the corners are shown relieved, make simple cuts initially and trim to drawing after flanging; the lightening holes are best dealt with after flanging, to minimise distortion. Although it would be nice to be able to rivet all the horizontal stays in place, practically this is not possible in 5 in. gauge unless left until final assembly, so bolting has to be resorted to in most instances. Horizontal stay No. 1 can be fitted, but Nos. 2 and 3 require the presence of the smokebox saddle for completion. Stays Nos. 4 and 5 are relatively straightforward, particularly the latter; those braces which complete the structure between the motion plate and expansion bracket stays are a legacy from when a separate steam brake cylinder was fitted for the leading coupled and pony truck wheels; they add considerable rigidity and are therefore worthy of retention as happened in full size.
Once again we have covered a fair amount of ground in a short space, but from here on in the reverse will apply.