# Black Five

## The fabulous Stanier Class 5MT 4-6-0 in 5 in. gauge

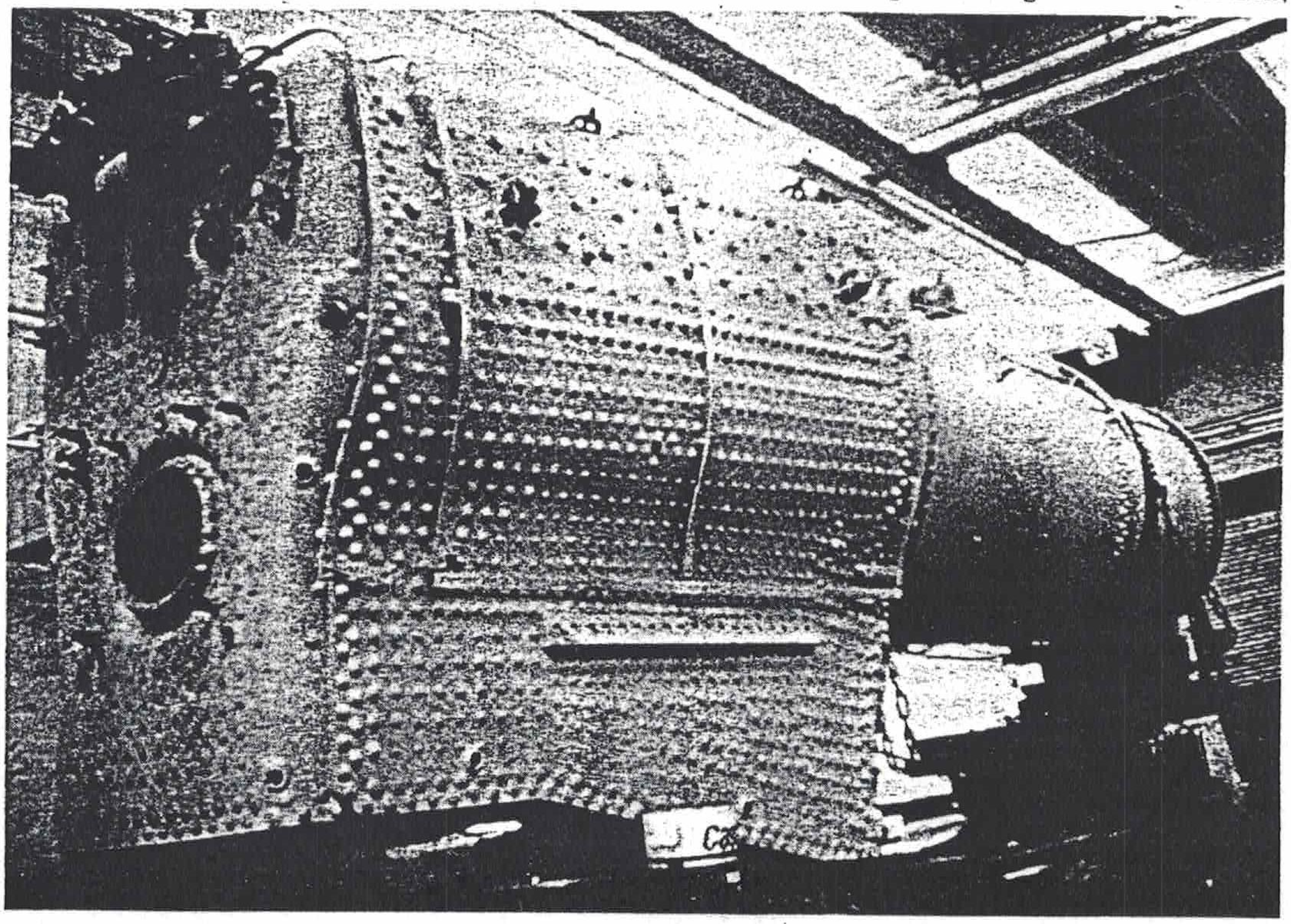
**Part 10 — The Boiler**

This is the part that I know a lot of you builders have been looking forward to, as being the biggest obstacle to completing your BLACK FIVE, or perhaps I should say greatest financial consideration. For me too it is a challenge to set down the construction procedure clearly and concisely, though this is something I relish, thus my advice to all builders is to read what follows carefully, and in conjunction with MINIATURE LOCOMOTIVE BOILERMAKING by Alec Farmer, before arriving at any decision as to whether to build this boiler or entrust it to one of our advertisers. For let me say straightaway that the BLACK FIVE boiler is by no means easy, the more so as the materials situation has deteriorated since the drawing was arrived at in early 1976.

The rest is all plus, for what sits on our BLACK FIVE chassis is what LBSC frequently referred to as a 'Swindon kettle', a magnificent steam producer that is as effective in miniature as full size. Whether the additional expense of all the tapers involved is justified I cannot say, indeed I doubt if detailed costings of maintenance between the various Works with their differing designs are available, plus in miniature I have been unable to detect any difference in steaming between a BLACK FIVE and E. S. COX, the latter having what I reckon to be a parallel version BLACK FIVE boiler as modified. However, in full size there is great merit in the taper boiler, not so much for its own sake, but because it provides a far better lookout ahead, the smokebox being so much smaller in diameter. That small smokebox could have presented a serious problem in provision of superheat, for this is an engine that crys out for really hot steam, but thanks to the 'invention' of the coaxial pattern by Alec Farmer, whose great advantage is in brushing through without the impediment of the spearhead ends, everything works out just fine.

Good fortune has been with me with BLACK FIVE right from her introduction, so let me take you through some of the story as it unfolded. Almost as soon as I added the last line to the original pencil tracing of Sheet No. 9, I had a visit from Geoff Tomlinson from Barnsley who was then a frequent caller, and he departed with a first print. It was barely a week later that I received photographs of the finished boiler, it was incredible!, Geoff telling me that he had encountered no problems with its construction; I will have to see if I can dig these photographs out of my vast collection. Initially, BLACK FIVE sales were somewhat disappointing, in fact only with this series some 15 years on have they approached and indeed now exceeded expectations, but one who showed an early interest was John Edwards from Cardiff, a lone LMS voice in a GWR stronghold! Sadly I no longer have easy access to the earliest issues of LLAS, they being kept permanently at the printers, but AYRSHIRE YEOMANRY featured pictorially a couple of times before making appearance at the inaugural DYD Rally at Bristol in June 1983, where I was privileged to sample her performance. Although I was unable to give him 100% marking, only 99% as I determined that the lead was less than I specified, just a month later this BLACK FIVE produced the most enduring memory of this design thus far, though likely it will be surpassed, judging by what is currently in the pipeline. For John entered AYRSHIRE YEOMANRY in the 1983 IMLEC at Guildford, speeding round the track with his fellow Whitchurch members as passengers, all of them clad in green overalls; the sight was unforgettable; only the proper sound at the chimney was missing! Anyhow, both construction and steaming qualities of the BLACK FIVE boiler were quickly proven, thus you can proceed with every confidence.

Taking the initial steps to establish DYD whilst employed in the marine industry, 'bore' sizes of copper pipe were the ones I was familiar with in everyday use, thus with the ugly head of metrication looming ever larger on the horizon,



Very rarely do I get the opportunity to correct a wrongly attributed photograph in the following issue of LLAS, that on Page 27 of LLAS No. 52 having been taken by Jim Proud. I am able to acknowledge the same source of the three shots of the boiler from BLACK FIVE No. 5305, when in the hands of the Hull Preservation Society for overhaul in 1986.

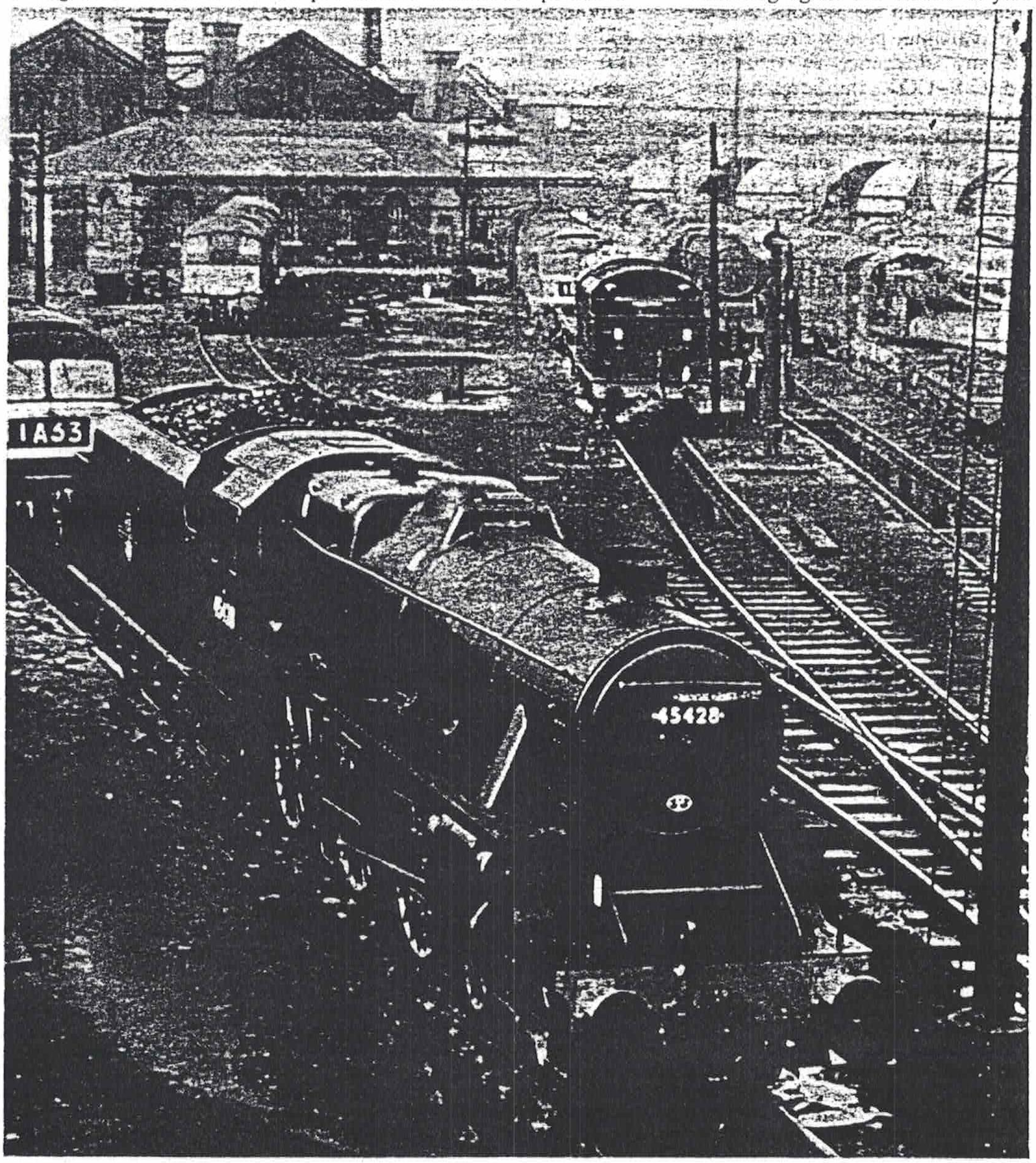
wrongly I thought that bore sizes would be retained at the expense of the o.d. ones with which model engineers are so familiar, trying to anticipate the inevitable. In the event, it has all gone horribly adrift, my crystal ball was duff, but at least all the early builders benefited from my specification. For although Alec Farmer as a professional boilermaker does not agree with me, I think there is the greatest merit when arriving at a taper barrel in having a parallel portion at the front end which is perfectly round within commercial tolerances. For not only is the feature as per prototype, but it provides the perfect platform for the tapered portion which follows, and also the ideal connection to the smokebox. However, unless someone can unearth a supply of 5 in. bore x 12 s.w.g. solid drawn seamless copper tube, we do not have such an advantageous start today.

**Boiler Barrel**

It is decision time, and for those builders who are going to tackle the boiler, the first requirement is a boiler kit, one complete with the flanged boiler plates. Because of the tube situation just mentioned, serious consideration should also be given to purchase of a rolled boiler barrel, one that is produced approximately to drawing and not as a continuous taper, for attractive as this is from a manufacturing point of view, it does raise the top feed bush to a degree where the fitting itself becomes far too prominent. The same problem arises if the earlier pattern boiler is chosen with top feed just ahead of the dome, when it requires a complete redesign of said top feed fitting to be able to screw it into the boiler, plus of course the feed is then in the wrong place, being far too close to the regulator, with the possibility of water carrying over with the steam, though of course such did not happen full size because of the internal feed arrangement.

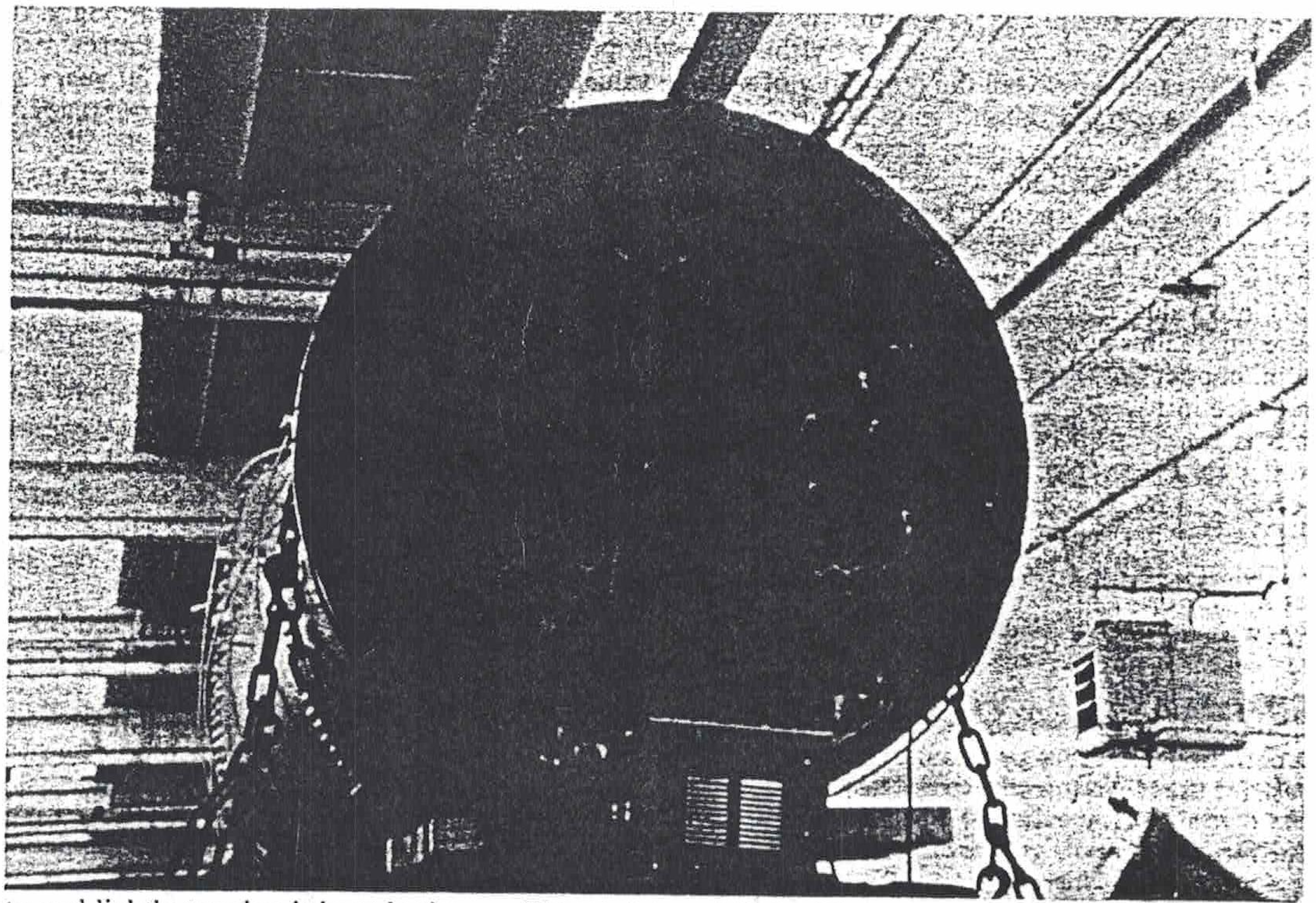
If you are going to produce your own boiler barrel, then the front section must be rolled and completed with a castellated joint, not a butt strap, as the latter would interfere with that specified for the tapered section. Braze up the joint with Silverflo 16 or equivalent, and you can deal with the top feed bush at the same heat. I have already made mention of the equipment required to tackle a boiler in LLAS No. 51 for NEWPORT, which is currently running alongside BLACK FIVE, thus can avoid repetition and concentrate on construction procedure, which will still give me plenty of explaining in this session!

Right, the front section is rolled and brazed up, though I doubt very much if it is truly circular at this juncture. If your rolls are open ended, then truing it up is a simple matter, but for the rest of us the smokebox tubeplate will provide the means. Chuck the formed plate in either the 3 or 4 jaw by the inside of the flange, turn to length and then begin turning down the outside to fit the barrel, a little at a time, checking again the barrel as you proceed by trying to push




Tom Greaves is very much a Stanier fan, the BLACK FIVE No. 45428 that in preservation came to bear the name of ERIC TREACY being very much a favourite when in his care. Here she has obviously been lovingly prepared for a special, such treatment meeting with Tom's approval, though it would be interesting to learn the vantage point from which he took this shot.

It is always interesting to make comparison between tube layouts in full size to miniature and I think readers will agree that I have captured the spirit of the successful BLACK FIVE boiler, if not the letter.



the latter over the tubeplate and lightly tapping it in at both ends when you reach the correct size.

For the tapered section, start with a 7¼ in. length of 6 in. diameter x 10 s.w.g. seamless copper tube. Wrap a tape measure around the parallel section just made, to establish its circumference, the same with the bore of the 6 in. tube, subtracting one from the other to arrive at the amount of 'V' to provide; mark off and saw this out. Thoroughly anneal the tube and gently tap over a large diameter mandrel to close the 'V', checking against the parallel portion to obtain the correct fit; this is very much make to place. Cramp the two pieces together and set up on the surface plate on the bottom centre line of the barrel when you will see that the ends of the tapered section are no longer vertical, hence the extra length. Wrap the tape around each end again and set to be vertical with an engineers square, then scribe round and also check for the 6½ in. dimension, sawing off the excess. This is not particularly easy, one of my understatements!, though the use of a bandsaw will help. Set up again on the surface plate, check that the bottom is a nice straight line, then drill in four positions to secure the two pieces together with 3/32 in. diameter snap head copper rivets, heads inside, hammering down into countersinks on the outside. Ahead of this though, cut the 1¼ in. wide butt strap from 3mm copper for the tapered length and secure this with about half a dozen copper rivets.

Dome bush next, so chuck the phosphor bronze casting in the 4 jaw, boring through to 1⅞ in. diameter and facing the end. Change to the 3 jaw, rechuck by the bore, face off and turn down over the full length of the casting to 2½ in. diameter, parting off a full 5/32 in. slice for the dome flange. Face the remaining bush off to ¾ in: overall length, then turn down over a 17/32 in. length to 2⅜ in. diameter. You already have the top centre line on the parallel section of boiler barrel, put there for the top feed bush, so extend this to the tapered length and establish the position of the dome, scribing a circle at same. Drill around the inside of this circle about No. 30 and gradually open out until the holes begin to break into each other, then cut out the surplus metal and file to the bush as your gauge. The dome bush has to be set level, which means back to the surface plate, wedging a sliver of copper to hold the bush firmly for brazing, dealing with the butt strap and joint between the two sections at the same heat; pickle, wash and thoroughly inspect.

**Throatplate and Outer Wrapper**

There are any number of ways of tackling the outer wrapper, but having been shown by Warren Shepherd at Boston Lodge when he was employed there how a skilled sheet metal worker would handle the job, I can do no better than copy his method. This involves making a wooden former of exact size around which to pull the copper, the same for the firebox wrapper, which then removes most of the possible problems. I doubt if many of us can come up with a block of pine around 12 in. x 9 in. x 6 in., so the first job is to glue some planks together, for which old floorboards are ideal, though have them lightly planed if at all possible.

Start at the front end of the block and remembering that the outer wrapper laps the barrel by ½ in., mark on the profile, including for the throatplate, cutting away at the 20 deg. angle for the latter. Now, mark off and saw away at the back end to arrive at the correct overall length, then offer up the flanged backhead and scribe around same to establish the profile. You will now be able to remove the larger amounts of wood with a bandsaw, after which a belt sander would come in very handy, though finally it comes down to chisels and sandpaper. Remember that what you produce in wood is going to reflect in the copper outer wrapper, so take your time and get it right, and Warren painted his finished blocks black to add a final touch of class. Use good quality paper or card to arrive at a dummy wrapper, laying over the block, then transfer to 3mm copper, scribe round and saw out to line. Usually I like to form wrappers from half hard copper sheet as purchased, but this is an exception where it needs to be properly annealed at the outset. Do as much of the forming as possible by hand and directly over the block, lifting it off and giving the copper an extra tweak to maintain good contact all the way round. Finally, remove from the back of the block, offer up the backhead, which has been cut to length at the bottom, and transfer the markings to the outer wrapper.

At the front end, bring the throatplate up to the barrel, bed to same and saw off at the bottom to length, then bring up the wrapper, scribe back from same and establish the bottom edge of the wrapper at each side, sawing away the excess. Use five 3/32 in. copper rivets to secure the throatplate to the bottom of the barrel, though it will still be extremely fragile until the wrapper is in place, so bring the latter up and arrive at the front profile as shown on the little inset on the drawing; again you can try this first with paper or card if you like to avoid the possibility of wasting valuable copper. Use a single, 1/8 in., snap head copper rivet on the top centre line between outer wrapper and barrel, then add a few more 3/32 in. ones at each throatplate flange, which leaves those top corners. I know some of our professional boilermakers much prefer a single piece throatplate, one that is double flanged to accept the boiler barrel, but this eats into valuable space at what is the heart of the boiler. I have no qualms at all in cutting the top corners out of 1 in. x 1/4 in. copper bar, it having become a standard practice with me since introduction on JERSEY LILY all of 20 years ago, thus is now well proven. Simply saw out and fit each top corner to place, after which you can add a couple of rivets between wrapper and barrel at the sides to hold them firmly in place for brazing. The secret of successful brazing is clean copper and sufficient heat, leave in the pickle until you have set up the brazing hearth and all your tools, then wash off, apply flux, heat up and apply the Silverflo 16 spelter, dealing first with the top corners, then going right around the barrel joint and completing with the throatplate legs; pickle, wash off and inspect, when you should see full penetration all the way around. Don't though forget the bush for the blow-down valve as I have!!

**The Firebox**

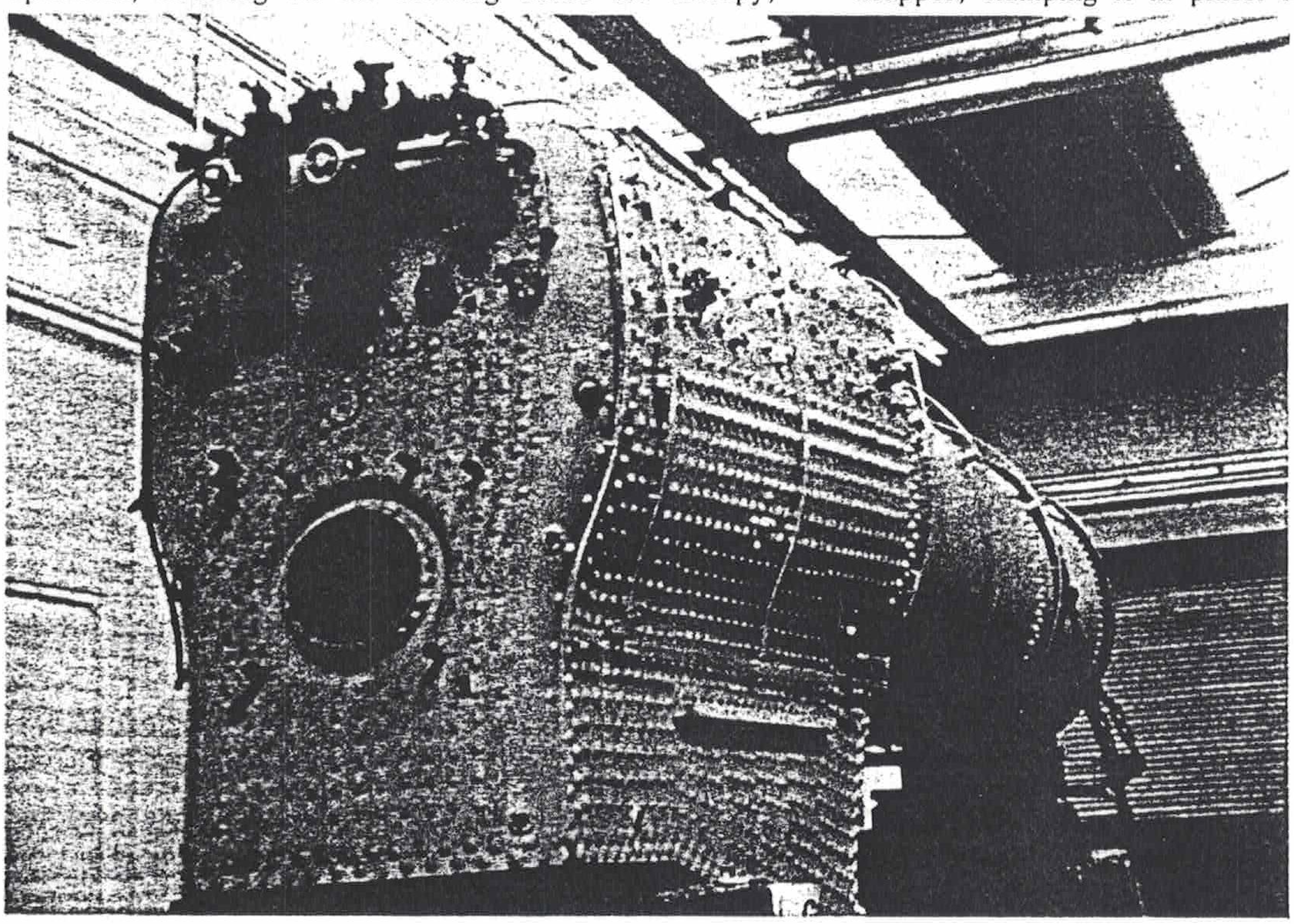
Just like the outer wrapper, the firebox tapers in at the sides along its full length, though this time we are better placed by having the tube and backplates already flanged for us, which renders the former detail redundant. Build up and shape the former block as before, wrapping 2.5mm copper around same, then saw off the end plates to correct height, offer up to the wrapper, mark off and saw away the excess. Before we assemble the firebox, there is some work to be done on the flanged plates, starting as always by applying a course file to the flanges to roughen them up a bit. The firebox tubeplate requires all the holes to accept the tubes, and it is best to deal with this as a pair with the smokebox tubeplate, marking one off and clamping back to back.

At this point in time, Merlin Biddlecombe who makes many of the fittings for me, is in process of recovery from a hernia operation, doodling on the drawing board for therapy, designing the boiler for a Standard Class 5 whose chassis he has inherited from Bill Perrett, which is an exact repeat of what I was doing some 30 years ago when recovering from tonsilitis. But whereas my Standard 5 had to be dropped as the boiler was beyond the capacity of my then five pint blowlamp, Merlin is much better placed today, though likely he will accept professsional help in 'stitching' the boiler together. Anyhow, in looking at my BLACK FIVE boiler as comparison, Merlin asked if he could use 1/2 in. diameter firetubes in lieu of the 7/16 in. ones which I have specified. No problem at all, it is just that the 7/16 in. ones fitted in better, and having done some experiments with both sizes, I doubt if anyone could tell the difference between them, certainly not of this length. So drill and ream the 21 holes to 7/16 in. diameter for the firetubes, and for the superheater flues, drill as large as possible and then complete with round files to the flues as your gauge.

For the firebox backplate, we need to make and fit the firehole ring, a piece of tube for the latter being provided in the boiler kit. Chuck by the bore, face and turn down to about 1 17/32 in. diameter over a 1/4 in. length, then reverse in the chuck, face again and turn down to leave 3/8 in. of original tube. Measuring down the slope of the backplate from the top flange, the centre of the firehole tube wants to be about 2 7/16 in. from same, so scribe the circle, cut out as for the dome bush and file to the tube as your gauge. Sit the latter on a block of lead and peen over the flange as shown on the drawing.

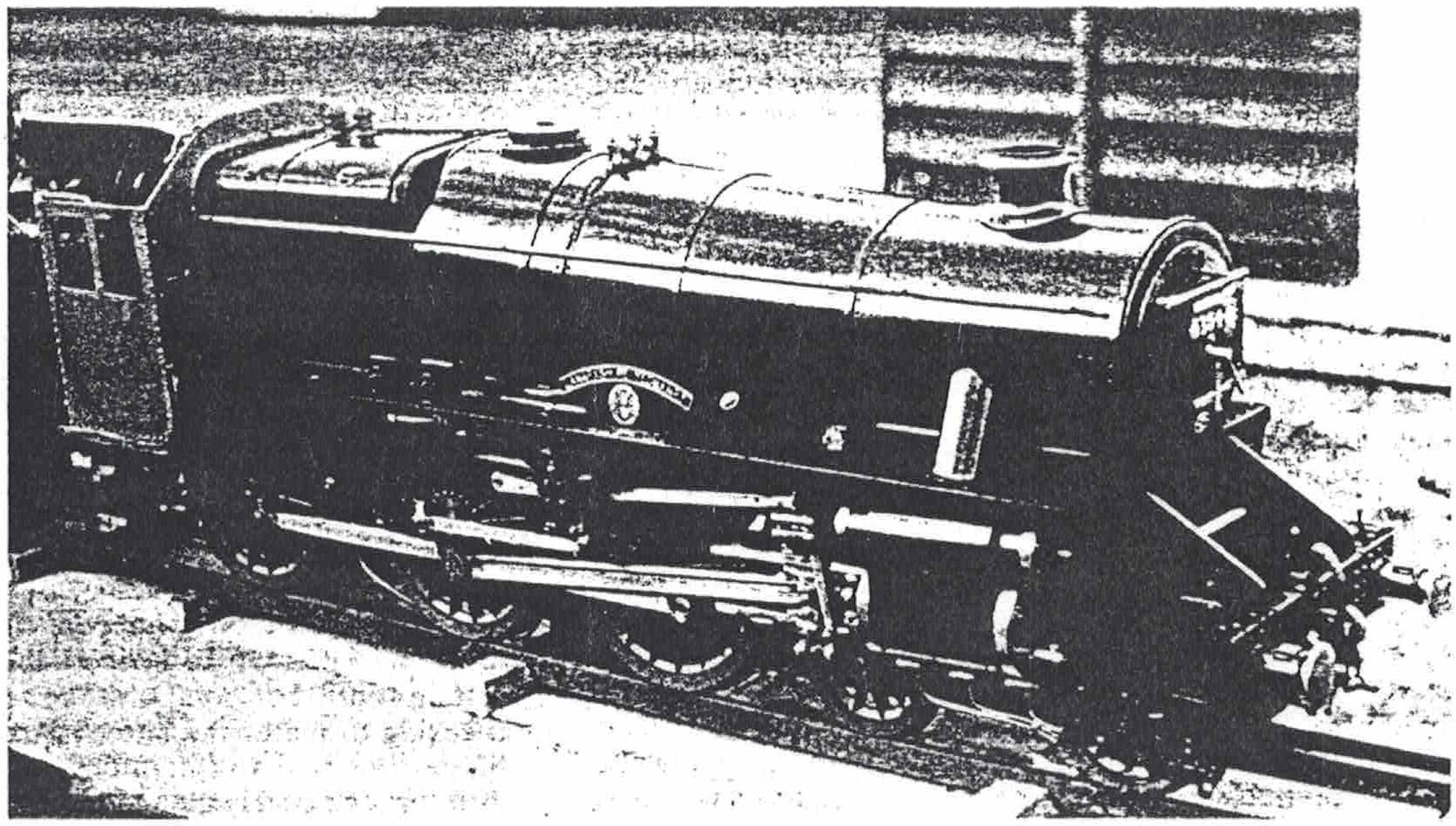
We can now assemble the firebox, using just a couple of rivets at each end in the first instance, before erecting inside the outer wrapper and cheeking as many dimensions and fits as possible, for once the firebox is brazed up it is extremely difficult to make modifications. Once satisfied, add just enough rivets to hold the pieces firmly together, any at the crown being clear of the girder stay area.

For the front section of foundation ring, we require a 3 5/8 in. length of 1/2 in. square copper bar, which has first to be fitted to the throatplate, then the firebox brought up and more metal removed to arrive at a 3/8 in. dimension between the two. The side sections of foundation ring are from 1/2 in. x 3/8 in. copper bar, but do not cut them as yet, merely use as spacers to correctly locate the firebox within the outer wrapper, clamping it in place. Again carry out as many



This picture is particularly useful in showing some of the backhead details, which readers are invited to check against those shown on my G.A. drawing published in LLAS No. 44.

All I can say with certainty is that this picture of a 5 in. gauge BLACK FIVE was sent in by Dennis Titley, neither builder or location having been revealed to me. LANARKSHIRE YEOMANRY is a superbly executed DYD, the top feed fitting being both modified and repositioned in line with the majority of the class, and I am sure that publishing this picture will lead to identification ere long.



dimensional checks as possible, using calipers between firebox sides and outer wrapper, also trying a superheater flue in place to see that it sits nice and level. I know other designers specify a rise in the tubestack between firebox and smokebox tubeplates, but how can you achieve this in practice? The only way I know of checking the tubestack is with an engineers square from the firebox tubeplate, and in the case of BLACK FIVE, a straightedge from the lower walls of the firebox wrapper; there is no way I know of allowing for any rise other than tweaking the tubes after brazing into the firebox tubeplate to align with that at the smokebox end. Being subject to external pressure, the fire and flue tubes are the most highly stressed in the whole boiler, and any forced bending adds a serious weakness, one that has been known to lead to said tubes being flattened under hydraulic test, thereby scrapping a brand new boiler.

There follows the most important operation of the whole boiler, that of correctly measuring the height of the crown girder stays between firebox top and outer wrapper, using inside calipers and checking along the full length for any variation. Leave the firebox in position, fold up each stay in turn and try in position before riveting back to back. Those holes you drill for the cross stays are rather 'hit and miss' as far as their position goes, so if you are in any doubt, then it is quite permissible to drill them at ½ in. diameter, the thing not to do is bend the stays to pass through same. Try the girder stays in place once more, scribe along the firebox crown from same, then remove and clamp firmly for brazing, resisting the temptation to use rivets to hold in position as this is a potential source of leaks. Pickle, flux and sit the firebox on the brazing hearth, to first deal with the girder stays, then the firebox tubeplate, keeping the flame clear of the thin section of metal between the tube holes, then turn over again and deal with the backplate, not forgetting the firehole tube. Allow to cool, pickle and inspect, as usual reheating if there is not full penetration of spelter.

Tubes next, so chuck each in turn in the 3 jaw, to face off to roughly identical length and polish the ends with emery cloth. The superheater flues should already be a good fit in the tubeplate, having used them as your gauge, but the firetubes will require a taper drift just to expand them lightly and hold in place for brazing. For this I use a large taper pin that is greased ahead of fitting each tube, given a couple of sharp blows and then another on the side to release it. Pickle again, but this time take great care in setting up on the brazing hearth for the reasons already given. Use pieces of firebrick to get the firebox sitting upright on its back end, fit the smokebox tubeplate over the outer end of the tubestack, though in this I am jumping ahead of myself. For first we have to flux around the tubes, then wrap Easyflo No. 2 spelter around rod or tube to arrive at rings which are then cut singly and dropped down over every tube and flue onto the firebox, then fit the smokebox tubeplate and carry out the aforementioned checks. With only the four rows of tubes, all can safely be dealt with at a single heat, so get the propane torch burning with a fairly diffuse flame and concentrate same on the firebox rather than the tubes. When the spelter begins to melt, transfer the flame inside the firebox and watch for a bright ring appearing around each tube on the inside, signifying full penetration, feeding in more Easyflo No. 2 if necessary to achieve this. If you are able, ease the smokebox tubeplate from the stack and anneal the outer tube ends before allowing to cool and then pickling; wash off and inspect.

**Erecting the Firebox**

We now have to erect the firebox inside the outer wrapper, when it is absolutely vital that the girder stays are in good contact with the latter. Going back to the early days of BLACK FIVE, a builder in Great Yarmouth found he had insufficient heat to complete his boiler, handing it over to Alec Farmer to braze up the foundation ring and backhead. On hydraulic test, Alec found that the firebox crown deflected downwards, and though he was able to tap it back up again and it withstood the test pressure, he was very concerned and contacted me about it. Now if you look at the drawing, there is no way when correctly brazed up, that the firebox crown can move without bringing the outer wrapper down with it, and such does not happen as there is upward pressure on the latter. Alec of course could not check the brazing of the girder stays to the outer wrapper as the backhead was already in place, but I was totally confident that this was the suspect area and likely due to the same insufficient heat that prevented successful completion of the boiler by the builder, so beware! Get those girder stays into intimate contact with the outer wrapper as the first step, before going on to fit the front and side sections of foundation ring, using a minimum number of snap head copper rivets, heads inside, to hold the foundation ring in place.

On the top of the outer wrapper, we have to turn up and fit the pair of safety valve bushes, in fact it is always a good plan to turn all the boiler bushes up as a separate exercise. Only enter the taper tap about four turns at this stage, just enough so that you can tap through the bush squarely later on. Cross stays next, so mark them off and drill 7/32 in. for the phosphor bronze rod, countersinking to build up a nice fillet. Flatten one end of the stays so that they do not drop right through the boiler, as will always happen at the most embarrassing moment!, when we must move forward and complete the smokebox tubeplate.

Turn up the steampipe bush, dealing with the tubeplate to accept same, and if you are at all unhappy about tapping directly through said tubeplate at 5/16 x 40T for the blower fitting, then turn up another bush for same, brazing them in as a separate operation. Mark off and drill four more 7/32 in. holes for the longitudinal stays, countersinking as before and flattening the ends of the rods. Make them 26 in. long as specified, and use copper wire to locate them at the firebox end; we are ready for the big braze. Pickle the boiler, then flux around the smokebox tubeplate, after fitting to the barrel and entering all the tubes!, then the foundation ring can be fluxed, followed by the cross stays, crown girder stays and safety valve bushes, and from now on we shall be using Easyflo No. 2, save for the backhead bushes. Lay the boiler on its back with the firebox protruding from the brazing hearth, which means the barrel must be weighted down with firebricks to prevent any disaster, then with the largest nozzle fitted to your propane torch, get a fierce flame going and concentrate it from underneath onto the top face of the outer wrapper. You can if you like cut strips of Easyflo No. 2 and lay against the crown girder stay flanges, though it is almost as easy to feed in spelter as you proceed. Watch though that heat flows from the outer wrapper into the girder stays, they should come up to a dull red together, the spelter running in like water. If this does not happen, stop right now and gently tap the flanges to get that contact before going any further, otherwise you will be in big trouble! If the safety valve bushes fall out, forget them at this braze, but try to tackle them if you are able as there is plenty of heat about at the moment!, then move to the cross stay ends, dealing with one side and then going on to the other. Foundation ring next, and if you did happen to forget the blow-down valve bush earlier on as I did, then fit and deal with it with the front section of foundation ring, going next to the sides. Likely by now you will have had enough for one evening, and I cannot stess too strongly that all brazing should be done outdoors and after dark, both on grounds of safety and being able to see when the copper reaches the correct temperature for the spelter to flow. Allow to cool, pickle, wash off and inspect, remembering this is the last time you will see a number of these joints and any 'misses' will likely end in failure.

Recently I have been asked several times why I universally specify 4BA screwed firebox stays these days, when a professional like Alec Farmer employs snap head coper rivets. The BLACK FIVE boiler drawing shows clearly that in 1976 I specified either, indeed just before this I went over completely to rivets. Actually, it was the same Alec Farmer who cautioned me on the use of rivets, correctly stating that for an amateur they were inferior as depending on the quality of brazing for their strength. Anyhow, if you are going to use rivets for firebox stays, a slight change in construction is required, leaving out the firebox backplate until the sides and throatplate stays have been fitted and brazed up, which of course gives easy access to the inside of the firebox. You have though to shield the tube ends, which would have been with asbestos in the old days, so you will have to find an alternative.

But I am ignoring the smokebox tubeplate, so stand the boiler upright, carefully packing it up from the brazing hearth so as not to disturb the longitudinal stays, flux around the joint and the tubes, then concentrate the flame on the outside of the barrel. Again the heat should run through into the tubeplate flange, though you can coax it a bit to make sure than the spelter fully penetrates, after which turn the flame down and play on the inside to deal with those tube ends. This is a most likely place for 'misses' and the most difficult to cure, so be generous with the spelter and don't worry about the looks of the job. This is the only place I have ever been caught out in my admittedly limited boilermaking experience and it was a real nightmare. Originally there was just a wee pin-hole weep at a superheater flue end, one I could easily have caulked or even left to seal itself. Pride though told me to reheat and such was disaster, for the differential expansions turned a pin-hole into a real leak, one I then chased all around the tubeplate with no success, indeed it took a professional coppersmith friend six attempts to arrive at the cure; I now know better!! Pickle again and we must break off to deal with the backhead.

**Fitting the Backhead**

Using plain rivets as stays, we now have to transform the firebox backplate into something resembling a porcupine, so fit the firehole tube to same, but don't braze it in as yet. Clamp to the firebox wrapper, clear of the backhead, and bring the latter up to scribe back from the firehole tube, cutting out the hole and completing with files whilst checking to place, the latter instruction applying equally to those of us who will be fitting screwed stays. Mark off and drill through backhead and backplate at No. 31 for the rivet stays, opening out those in the backhead to No. 30. Ease the No. 31 holes in the backplate with an 1/8 in. taper reamer until the rivets can be driven home, heads inside, and firmly retained for brazing, which carry out with Silverflo 16, including the firehole tube. Clamp again to the firebox wrapper, bring up the backhead and make sure it properly fits the outer wrapper, then remove to braze in the firebox backplate using Easyflo No. 2; cool, pickle and carefully inspect.

The backhead itself required a lot of pre-treatment before assembly to the boiler, so let me start at the top and work down. The first connection we come to is that for the manifold, that 25 deg. angle being fairly crucial, as it decides location of such things as the injector steam valves. Using the swivelling vertical slide on the 254V plus, this is a piece of cake, so clamp the backhead to the table, rotate through 25 deg., and on the vertical centre line, centre and drill through to 9/16 in. diameter. Turn up the bush to be a press fit in the 9/16 hole, drilling through at 11/32 in. diameter and entering a 3/8 x 32T taper tap so that you can complete tapping out the bush squarely later on. Next to be dealt with are the water gauge top fittings, so of course deal with all four of them together, when we come to the regulator flange, for which we require a 5/8 in. diameter hole in the backhead.

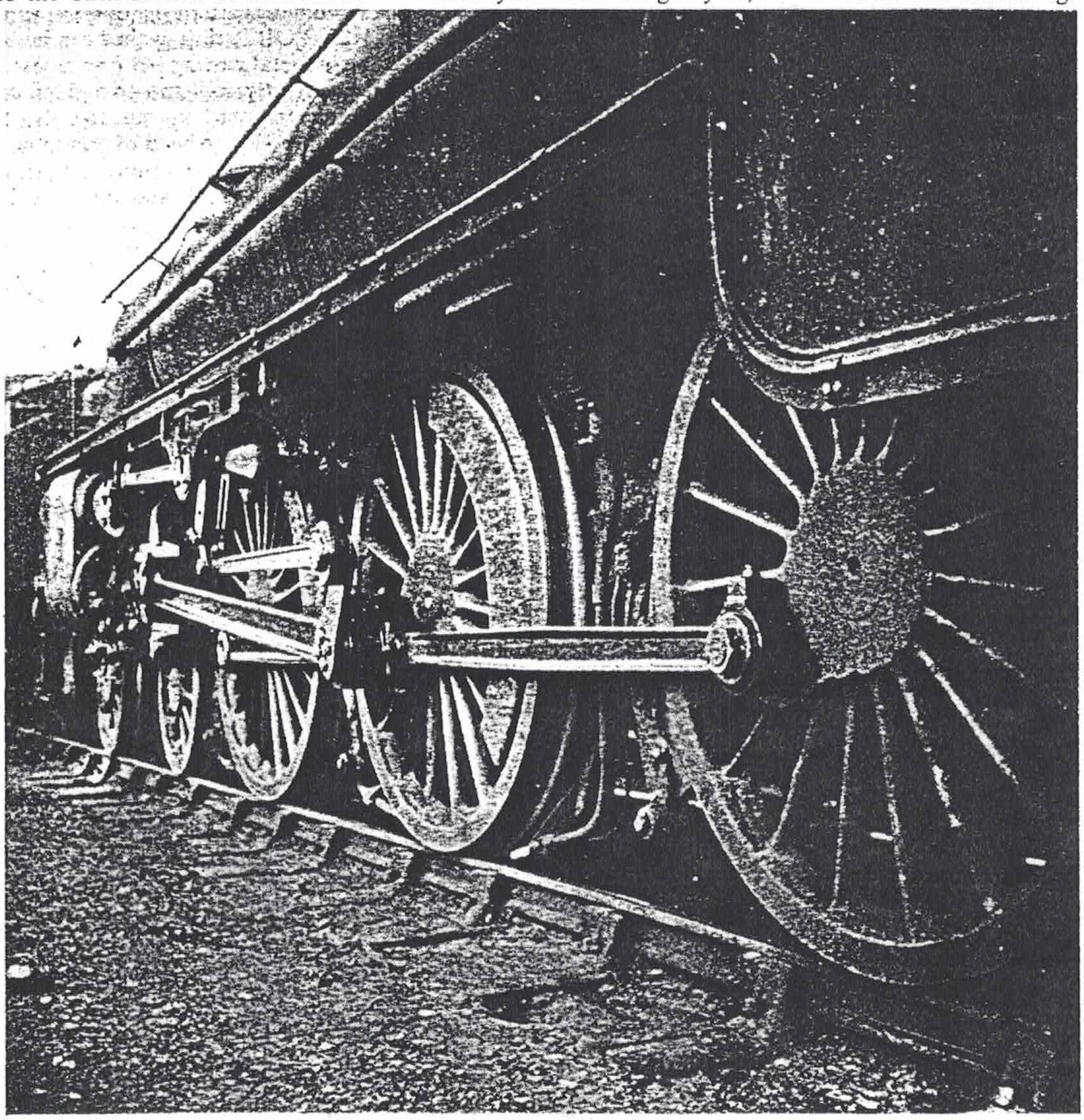
I now carry cast phosphor bronze stick, which is close grained and an ideal material for the larger boiler bushes, so chuck in the 4 jaw, face and turn down to 15/16 in. diameter over a 13/16 in. length. Further reduce to 5/8 in. diameter a close fit in the backhead, over a 7/16 in. length, then part off at a full 11/16 in. overall. Reverse and rechuck in the 3 jaw, to face off to length, centre and drill through at 1/4 in. diameter, following up with a 3/8 in. drill and 'D' bit to 1/2 in. depth; leave the gland tappings for the moment. The last provision we have to make is steam collection for the blower, starting with a 3/8 in. hole in the backhead, and this may be reamed with advantage, the hole being then very lightly spotfaced to 5/8 in. diameter. The collector itself is plain turning from 5/8 in. diameter bronze bar, which brings me to the internal pipe, on which I want to say a few words in general.

Internal pipes were a very common practice in full size, being put there to ensure best possible quality steam for the various ancillaries, in particular injectors which often took their supply from the inner dome. I had a case the other day where someone had used one of my DONCASTER boilers for another design, with its combined fitting for injector steam and feed check valves, but had not understood that internal piping was necessary for same to work effectively, hence he was trying to work with a hydraulic injector instead of a 'steam driven' one, which of course was a complete failure. Likewise for the blower, any water coming over with the steam causes nasty 'spits' at the chimney top, a potential source of scalding, so carefully locate the 1/8 in. o.d. thin wall copper tube both to come close to the top of the backhead flange as shown, and also to be clear of the regulator mechanism and manifold supply, for one unfortunate managed to puncture the supply pipe after the backhead had been fitted and had to revert to the traditional LBSC type externally fed blower valve, which ruined the looks of an otherwise neat backhead. So bend the internal pipe to be clear of all obstructions, then chuck a length of 7/16 in. A/F hexagon steel bar in the 3 jaw. Face and turn down to 3/8 in. diameter, a good fit in the backhead, over a 1/2 in. length, then further reduce the outer 1/4 in. to 5/16 in. diameter and screw 40T before parting off to leave an 1/8 in. thick head. Drop this bolt in the pickle, to get it well rusted, then assemble the steam collector and all the other bushes to braze them in as a separate operation with Silverflo 16.

Long before, you will have had to drill the four 7/32 in. holes for the longitudinal stays to pass through to be able to check alignment of the backhead in the outer wrapper, so now countersink those holes and we can fit the backhead for good, sitting the inside of the firehole tube on a large block of metal and peening over the outer lip. If there are any gaps between the backhead flange and outer wrapper, I much prefer to gently close them with my wooden mallet, rather than revert to gunmetal screws or the like to pull them together. That leaves the back section of foundation ring, which is very much make to place to fill the space that remains, so try to make it a close fit, when no other fixing will be required ahead of brazing.

Put the boiler in the pickle and give it a good soak, then carefully empty as it is almost a closed container and wash out thoroughly, then flux around the backhead joint, the firehole tube, and the rear section of foundation ring. Stand upright in the brazing hearth, which is where a hole in same becomes very useful to keep the backhead at working height and make the whole thing more stable, then get your blowlamp going with the largest nozzle, and have a mate standing by with supplementary heat, as you will surely need his services, as I expect you found with the penultimate braze! The backhead joint itself is fairly easy, especially if the boiler is well packed around with firebricks, the firehole tube much less so, then turn the boiler on its back for the foundation ring, which calls for maximum effort from your torches! With plain rivets as stays, these too will have to be dealt with at this heat, and as you are unable to check for full penetration of spelter, do build up a decent fillet around each of them and leave the shanks at least 1/16 in. proud after trimming them to length. It's time for a cuppa whilst the boiler cools right down, you too!, then into the pickle for a decent interval before washing off and polishing with steel wool to become a shining example of your workmanship.

With rivets as firebox stays, we can go straight on to hydraulic testing, but for those of us who will be using screwed stays comes the preliminary air test, though in both cases it is best to make and fit the inner dome first! We already have the flange by us, and if 1 7/8 in. o.d. x 16 s.w.g.



If I wrongly attributed the picture on Page 27 of LLAS No. 52 to Norman Lowe, this is one of his masterpieces, the pair of them giving lots of detail and covering both sides of BLACK FIVE's, even though I have no idea as to the identity of Norman's engine. The fish bellied rear coupling rod shows up to good advantage, as does the rear sandbox.

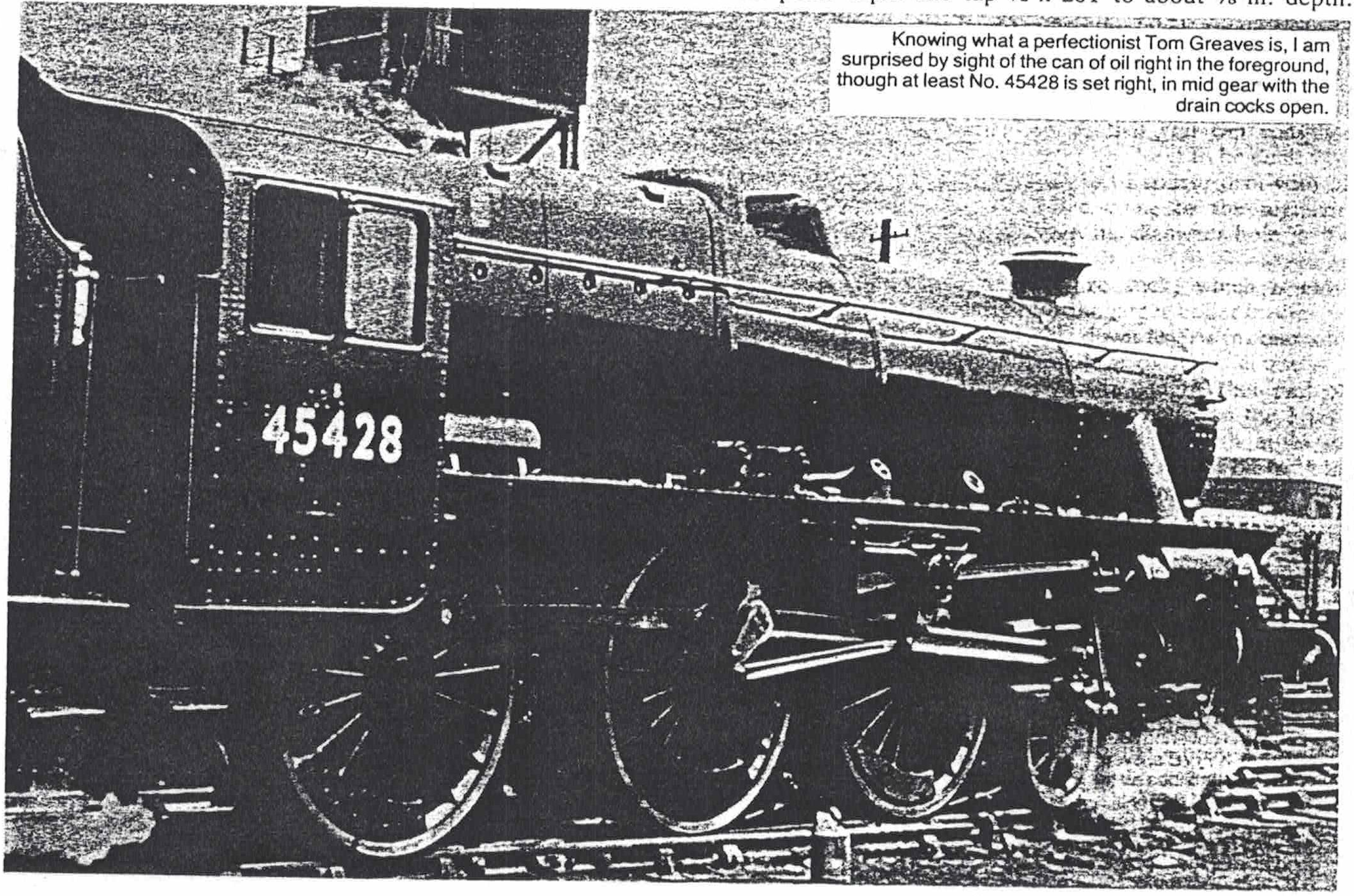
copper tube poses a problem, then use 1¾ in. bore firehole tube material that Reeves stock and turn down the outside to said 1⅞ in. diameter. That leaves the 3mm disc of copper to close off the top of the dome, plus the 3/16 x 40T bush, neither of which causes a problem, so assemble and braze up. Chuck by the tube to face off the flange to be flat, then scribe on the bolting circle at 2 3/16 in. diameter, dividing up into 16 equal pitches and drilling No. 30. Offer up to the bush, check first that it is flat and correct any distortion, then spot through, drill No. 40 and tap 5BA. Fixings must be from bronze and can be from either 7/32 or ¼ in. rod, the heads being of the cheese variety, plain saw cuts providing the slots for your screwdriver. I still prefer heavy brown paper gaskets soaked in linseed oil to proprietary material for all my gaskets, though I am certainly not going to influence your choice here; secure the inner dome and fit the 3/16 x 40T plug. Deal with the rest of the openings, tapping out and fitting plugs where appropriate, and a rubber bung will suffice at the regulator flange for this low pressure test.

I believe cycle inner tube valves have changed radically since my time in the saddle, but I still have my old style valve, the stem of which is soft soldered to one of the hexagon plugs. By now you will be well aware of just how big a BLACK FIVE boiler is and why it was beyond the capacity of my five pint blowlamp 30 years ago!, thus you really need use of the domestic bath to check for any leaks, purchase of a rubber mat for same being virtually mandatory! For this size of boiler, you can apply around 30 pumpfulls of air before submerged completely in water, moving the boiler around to release any trapped air, then look for the tell-tale bubbles. Hopefully there shouldn't be any, but rather than concentrate on any tales of woe here, I am going to deal with the matter separately in a future issue, otherwise this session will prove of infinate length!

Many years ago now, Martin Evans and I had a discussion about screwed firebox stays behind the scenes, when he said that any builder would be lucky to fit 10 of them in an evening. Not two years before, I had completely stayed a boiler containing 310 5BA monel ones in a week, sweated them over too, the most difficult part of the job being to actually screw the monel rod, thus I could not see the problem then, neither can I now. Also, in those days, I had to rely on my 6/10d (34p) Woolworths hand drill, whereas today even I drill electric!, though conversely, drilling by hand does very quickly teach the art of correct drill sharpening. Anyhow, mark off and use an automatic centre punch on a light setting to centre all the stays, drilling one row at time right through at No. 34. The most vital requirement is a brand new set of 4BA carbon steel taps, to reduce the risk of tearing the soft copper as you form the threads in same, plus a proprietary brand of tapping compound which makes life a lot easier. Never give the taps more than ¼ turn before easing back, as this will break up the swarf and help prevent jamming, removing the tap, cleaning it off and dipping in the tapping compound again before moving on to the inner firebox. Copper stays screwed 4BA are perfectly acceptable at the pitches shown, and given time I am able to supply same. Most you will be able to screw in with an ordinary tap wrench, the rest using the tailstock chuck or similar, after which fit 4BA commercial brass nuts to the protruding threads inside the firebox. For a more detailed description, please refer back to LLAS No. 51 and NEWPORT, when we can start fitting out the boiler ahead of the hydraulic test, they being a part of its integrity.

**Fitting out the Boiler**

Let us make a start with the regulator, which being the Stroudley pattern is only a variation of that shown for NEWPORT, thus again I can be brief. The regulator body is a gunmetal casting, so first assess the machining allowances, then lightly mill the two sides of the body to give useful datum for marking out and also for ease of gripping in the machine vice. Ahead of this though, chuck in the 4 jaw with the steampipe boss running true, to drill 15/32 in. diameter to 1 in. point depth and tap ½ x 26T to about ⅝ in. depth.




Knowing what a perfectionist Tom Greaves is, I am surprised by sight of the can of oil right in the foreground, though at least No. 45428 is set right, in mid gear with the drain cocks open.

Now to the machine vice, on the vertical slide, to mill across the top of the casting, then centre, drill and 'D' bit 3/8 in. diameter to break into the 15/32 in. diameter exit hole, taking care as you reach the latter, in fact I prefer to use a long series end mill as it is far less fierce at the critical point. Turn up an 1/8 in. thick plug from 7/16 in. rod to be a press fit in the 3/8 in. hole, brazing in for additional security, though ahead of this, turn up and also press in the support for the regulator rod, when this too can be brazed in place. At this stage, try the body inside the boiler, milling more from the cast recess if necessary to give clearance over the dome bush. Although the valve seat can be turned, I like to fly cut such faces as being inherently more accurate, so chuck a round nosed tool eccentrically in the 4 jaw, check that you can cover the whole seat at a single pass and do just that with a cut of no more than .005 in.; repeat until you arrive at drawing dimension. Mark off for the fulcrum bolt, centre and drill through at No. 40, countersinking to remove any burr before tapping out. The fulcrum bolt can be just that, or a combination of 1/8 in. stainless steel rod as the stud and a 5BA brass nut, the latter being peened to prevent its coming loose in service.

The valve is a 1¼ in. disc from the cast phosphor bronze bar, parted off at 3/16 in. thickness after drilling the No. 30 central hole, then marked off and drilled for the 9/32 in. ports and 6BA tapped holes. Again remove all the burrs produced, then lay on the sheet of crocus paper, or fine grade wet and dry, same being supported by the lathe bed, so that you can polish the working face both bright and flat. The special screws are plain turning from 7/32 in. bronze rod, and do get the threads really tight in the mating parts by opening out the die, as the last thing we want is a screw loose in the boiler!

The arm is from 3/8 in. x 1/8 in. flat, and both this and the links are OK from brass if my experience is anything to go on. Drill No. 44 for the special screws, No. 28 for the regulator rod end, tapping the pair of outer holes and punching through the central one before profiling to drawing. The links are from ¼ in. x 1/16 in. strip, the holes to suit the special screws being drilled at least No. 21 to give a bit of clearance and prevent the valve from tripping, which is the second most common cause of a regulator leaking; profile the links roughly to drawing, purely from an aesthetic point of view.

For the steampipe flange, chuck the cast bronze bar in the 4 jaw, face and turn down to 1 3/16 in. diameter over a 1 in. length. Further reduce to 5/8 in. diameter over a 5/8 in. length and screw 26T, then centre and drill 3/8 in. diameter to 1 in. depth. Follow up at ½ in. diameter to about ¼ in. depth, to provide a socket to accept the actual steampipe, then part off at a full 15/16 in. overall, reverse and face to length. The steampipe is a 10 3/8 in. length from ½ in. o.d. x 16 s.w.g. copper tube, so square off both ends and screw one of them 26T over at least ½ in. length, then braze to the steampipe flange; cool and pickle. Enter the complete steampipe into its bush, engage the regulator body, just to check for alignment, then ease the bolting spigot on the latter to a proper fit inside the boiler barrel. When satisfied, clamp the regulator in position, drill the barrel athwartships in two positions and countersink, drilling into the body at No. 43 and tapping 6BA; sweat over the heads of the screws to seal them. Now you can apply liquid jointing compound to both threaded lengths of the steampipe and screw hard into the bush, engaging the regulator body as you go. As things stand, the regulator valve is flapping about on the fulcrum bolt and needs restraining with a 20 s.w.g. stainless steel compression spring, when sadly we cannot complete the regulator due to lack of the rod detail, only turn up the neck ring and gland to drawing.

**Blower Valve and Union**

One builder, on receipt of his made up blower valve, commented how flimsy it looked and would it stand up to the job? But look at the design more closely, and whilst the portion external to the boiler is approximately to scale for appearance sake, it is not subject to boiler pressure, the portion that is being far more robust than a conventional blower valve. Also, the design is now almost 20 years old, being first used on LANKY back in 1974, and has stood the test of time, the only stipulation being that in common with all boiler fittings, the important bits are made from a good quality bronze. Thus for the body, we require a length of 5/8 in. diameter material, so chuck in the 3 jaw, face and turn down to 3/8 in. diameter over a 9/16 in. length, a good fit in the backhead. Further reduce to 5/16 in. diameter over a 15/32 in. length and screw the outer 5/16 in. or so at 40T, then centre and drill 1/16 in. diameter to about 5/8 in. depth. Follow up with a 5/32 in. drill and 'D' bit to ¼ in. depth and tap 3/16 x 40T, then part off at 15/16 in. overall. Reverse in the chuck, face off to length, and complete turning on the outer profile, not forgetting to reduce the flange to 9/16 in. diameter. Centre this end, drill and 'D' bit 5/32 in. diameter to a bare 5/8 in. depth and follow up with a 3/16 x 40T tap to 15/32 in. depth. To complete the body, cross drill No. 57 into the bore in the positions shown, keeping the three holes nice and equally spaced, to even out the stresses.

For the valve, chuck a length of 3/16 in. stainless steel rod in the 3 jaw and first turn down to 1/16 in. diameter over a 5/32 in. length, screwing 10BA. A little at a time, turn the next ¾ in. length of rod down to 5/64 in. diameter, then part off at 1 5/16 in. overall. Grip either by the 5/64 in. length of rod, when a collet comes in extremely handy, or grip the first 5/32 in. length of the 3/16 in. rod, this to turn on the actual valve, after which screw the remaining original rod at 40T to screw into the valve body. Both gland and gland nut are plain turning, being packed with PTFE for the lower friction this provides, leaving just the handle. Turn this from 5/32 in. stainless steel rod, first the actual handle with its slight taper and then the 'ball' portion, parting off to length. File on two flats, then centre pop, drill through at No. 55 and tap 10BA, securing to the valve with a 10BA nut to lock the handle.

The blower union body starts life as a length of 7/16 in. A/F hexagon bronze bar, so chuck in the 3 jaw, face and turn down to 5/16 in. diameter over a 5/16 in. length, screwing 40T. Centre and drill No. 41 to 11/16 in. depth, following up at No. 22 to about 3/8 in. depth and tapping 3/16 in. x 40T, then part off at 25/32 in. overall. Grip the first 1/8 in. or so of the hexagon bar in the machine vice, on the vertical slide, when with care you will be able to mill down to 9/32 in. square over a 5/16 in. length. Screw into the smokebox tubeplate to orientate the outlet union for ease of piping to the blower, then turn up said union and drill the body to accept same, silver soldering together. You will have to establish the length of blower tube to place, so start with a little extra length, facing off and screwing one end of what will probably have to be 3/16 in. o.d. x 18 s.w.g. copper tube 40T for ¼ in. length. Screw this into the blower valve, screwing the latter in turn into the backhead, this to arrive at the correct length of tube at the front end, sawing off to length, then facing and screwing 40T; assemble with liquid jointing compound on all the threads.

**Top Feed Fitting**

Whilst at the front end, we may as well tackle the top feed fitting next, the body being from cast gunmetal bar, which we can supply. Mill down to the required ¾ in. x ½ in. section, then square off to 1 7/8 in. overall. Next chuck truly in the 4 jaw, centre and drill through at 9/32 in. diameter, boring out to 5/8 in. diameter and 5/32 in. depth to accept the boiler connection, this being plain turning from the 5/8 in. diameter bronze bar that we have made such good use of recently. The next job is to drill the 5/32 in. diameter gallery to join from the clacks to the centre bore, which wants to be about 13/64 in. down from the top of the block, the outer end being plugged. Concentrate on the valve seatings next, so centre, drill and 'D' bit 5/32 in. diameter to a full 5/8 in. depth, following up with a 9/32 in. drill and 'D' bit to 13/32 in. depth and tapping the outer 5/32 in. or so at 5/16 x 40T, including the centre bore. The feed connections are from 5/16 in. rod and these can be brass at a pinch; screw the embryo fitting into its alloted bush and check that the pipes will lay neatly with the connections at the 30 deg. shown, modifying if necessary, then drill No. 22 below and keeping well clear of the valve seats. Lay on the brazing hearth, packing up the connections to align with the body, then silver solder together, not forgetting the plug and boiler connection; pickle and inspect. Seat a 3/16 in. ball in each valve chamber, then turn up plugs to give about 3/64 in. lift for the balls; erect to the boiler and we are winning!

**Safety Valves**

The correct design of a safety valve is not as easy as it looks, especially with 'pop' action, and having mastered the art with a combination of computerised springs and myriad jigs, obviously I am unwilling to reveal all our commercial secrets, though there is absolutely no reason why the builder should not experiment with same, always providing the end result does properly relieve the boiler. The 'pop' action is simple to explain, indeed Jim Ewins has divulged the method of obtaining same using a plain disc valve, it relying on transfering from a small to a larger diameter seat as soon as the valve starts to lift, the crunch being to have the correct spring to close the valve before pressure drops too far, and this can only be proven on the actual boiler to which the valves are to be fitted, for much depends on the rate of steam production. Anyhow, the body is turned from either 7/8 or 1 in. diameter bronze bar, with the hexagon portion milled on. For the cap, chuck a length of 1/2 in. bronze rod in the 3 jaw. Face and turn down to 7/16 in. diameter over a 5/16 in. length, screwing 26T, then further reduce to 3/16 in. diameter over a 1/16 in. length. Centre, drill No. 41 to 5/16 in. depth, then part off at 7/32 in. overall. 'Pop' valves really do remove excess steam from the boiler quickly, thus adequate provision has to be made at the escape slots, so grip carefully in the bench vice and file them to drawing. All this metal removal after screwing the outside will have raised any number of burrs, preventing the cap from entering the valve body, so use a triangular Swiss file


It was always a heartening sight to see an engine on which one had performed on Shed, move off on its next turn of duty. I approve of the driver, obviously a Yorkshireman by his flat cap as against the BR issue, a poignant reminder of my late uncle Frank Young who would wear nothing else, and having worn his BR one on occasion, I know why!

to tidy up the threads, until the cap can be screwed right home. For the valve stem, chuck a length of $\frac{7}{32}$ in. stainless steel rod and turn down to $\frac{3}{32}$ in. diameter over a $\frac{17}{32}$ in. length, to be a nice sliding fit in the cap. Part off at $\frac{21}{32}$ in. overall, reverse in the chuck, lightly face and centre, then use a $\frac{1}{4}$ in. drill to form the cup to accept the $\frac{5}{16}$ in. rustless steel ball: Wind up the spring from 18 s.w.g. piano wire, as stainless steel is far too soft unless properly heat treated and will very rapidly 'relax', destroying the initial setting. If this does happen, always accept the safety valve as reading correctly, never the miniature pressure gauge, and instead have the setting checked against the master pressure gauge to the Boiler Inspector's approval.

**Superheater Flange**

It has been another marathon session, but at last we have reached the final piece part, one that is a bit of light relief. Chuck the cast phosphor bronze stick in the 4 jaw, it should be well faced by now!, to turn down to $1\frac{3}{16}$ in. diameter over an $\frac{11}{16}$ in. length. Centre, drill and 'D' bit $\frac{3}{8}$ in. diameter to $\frac{15}{32}$ in. depth before parting off a full $\frac{9}{16}$ in. slice; reverse in the chuck to face off to length and scribe on the bolting circle at $\frac{15}{16}$ in. diameter. Grip in the machine vice, on the vertical slide, to centre and cross drill $\frac{3}{8}$ in. diameter into the central bore, then turn through 90 deg. and use a $\frac{7}{16}$ in. end mill to produce the scallop for the wet header. Now you can mark off and drill the four No. 27 fixing holes to correctly orientate the flange, offering up to the steampipe, to spot through, drill No. 33 to $\frac{3}{16}$ in. depth and tap 4BA.

**Testing the Boiler**

Although I do not subscribe to steam testing a boiler to above maximum working pressure, as it serves no useful purpose, in my book the hydraulic test to twice working pressure should be carried out with all the fittings in place, being held for a minimum of 30 minutes. However, your Society Rules and Boiler Inspectors will be the final referee in this, in which they have my full support, save in one small matter.

For each of my designs, you will find a firm recommendation as to boiler working pressure, one arrived at by roughly calculating tractive effort against adhesive weight, there being no reason in my book to increase working pressure beyond the point where the engine will not hold its feet, and usually this works out between 80 and 90 p.s.i.g. However, it is realised that not all builders agree on this point, such is their perogative, and to avoid a mass of correspondence and further calculations, the drawing always states the design pressure at which all the relevant calculations have been made and scantlings provided. Such was common practice in industry in my time, for many installations would be uprated during their service life, without a whole heap of additional expense.

Despite the lack of some boiler fittings like the water gauges, no builder should be left in suspense as to the integrity of the boiler until the next session, plus there is every merit in carrying out a preliminary hydraulic test ahead of calling in the Boiler Inspector, so as not to waste his valuable time. So fill the boiler completely full, with no air present, connect up the tender hand pump, and pump the boiler up to test pressure in 40 p.s.i.g. increments, carefully checking round at each stage for weeps and plate deflections. If there are any 'warts', leave them for the Boiler Inspector to pronounce upon when he applies the official hydraulic test; **on no account try to hide them.**

Next session we will retire inside the smokebox, the most important feature of your BLACK FIVE.

# Calendar of Events

Already at this point in time, 1993 promises to be a spectacular year for major events, so as soon as you get your hands on a Diary, do make a note of some of the dates.

The New Year as has become traditional, kicks off with the Model Engineer Exhibition, this time at Olympia and a joint effort between the SMEE and Argus Specialist Exhibitions. Although many LLAS readers found the Alexandra Palace venue to be convenient, from the Isle of Wight it was a nightmare journey, though moving back into the heart of London will tip the balance in favour of public transport, which is of little help to exhibitors.

An event which has not had to change its venue, indeed it has grown with The Centre, is BRIGHTON MODELWORLD, which I now rate the premier indoor occasion in the UK calendar. For 1993 the all important dates are 19th/21st February and as ever the show is organised by the Sussex Association of Model Railway Clubs, with major contributions by Gerry Collins and Derek Lebbetts.

Moving into April, over the weekend 17th/18th April, Southampton Society of Model Engineers Ltd. are to host a SOUTHERN Miniature Locomotive Rally in Riverside Park, Bitterne. There is a largish selection of locomotives which qualify, those from the Southern Railway and its constituent Companies; BR (SR) too! I think back to my days at Eastleigh, with the ex-LSWR T9's and M7's, the many Maunsell designs including the 'King Arthurs' and 'Nelsons', plus the Bulleid 'Pacifics' and 'Spam Cans', thus there should be plenty of variety. The club track is elevated and for $3\frac{1}{2}/5$ in. gauges, and a $7\frac{1}{4}$ in. gauge track will be available for the Rally. It has been said that the SR is the least popular of the four Grouping Companies, but such is not my experience with FISHBOURNE and NEWPORT over more than a quarter of a century, thus I am looking forward to this inaugural Rally with the keenest interest. Further details are available from Mrs. Monica Batt, who is Hon. Secretary of the Southampton Society at 46 Vespasian Road, Bitterne Manor, Southampton SO2 4AZ, or from Gerry Tull at Haydonstone House, Silver Street, South Cerney, Glos GL7 5TS, he of TOTLAND and SIR LAMORAK fame!

Then on Sunday 6th June, the Sutton Coldfield & North Birmingham Model Engineering Society will be staging and hosting the 11th DYD Rally at their Balleny Green site, only I should now say 'complex'. For since our last visit in 1987 for the 5th Rally, like yours truly's waistline, they have expanded!, there now being an outer loop to the $5/7\frac{1}{4}$ in. gauge ground level track, adding greatly to the excitement. Already in 1987, this was a premier site, with its excellent Clubhouse and covered steaming bays, and being ideally placed geographically, I am hopeful of a record attendance, indeed with almost a year to go when these notes were typed, already the response is more than encouraging.

To the now established events which are marked on the calendar, like the Isle of Wight Locomotive Rally will be held towards the end of April, IMLEC and Guildford during July, with the National Locomotive Rally at Illshaw Heath in September, a host of others are added each year, as proof that ours is still a growing hobby. Invariably dates are chosen well in advance, the necessary preparations made, but so often thought is only given to the vital matter of publicity at the last moment, frequently with insufficient notice to appear in this section, with predictable result. Don't miss out, there are thousands of LLAS readers starting to plan their expeditions for 1993, indeed my own calendar is just about full already! So let me have details of **your** event before Friday 27th November and it will be published in the February 1993 issue of LLAS; **do it now!!**

# Black Five

## The fabulous Stanier Class 5MT 4-6-0 in 5 in. gauge

**Part 11 — The most important bits!**

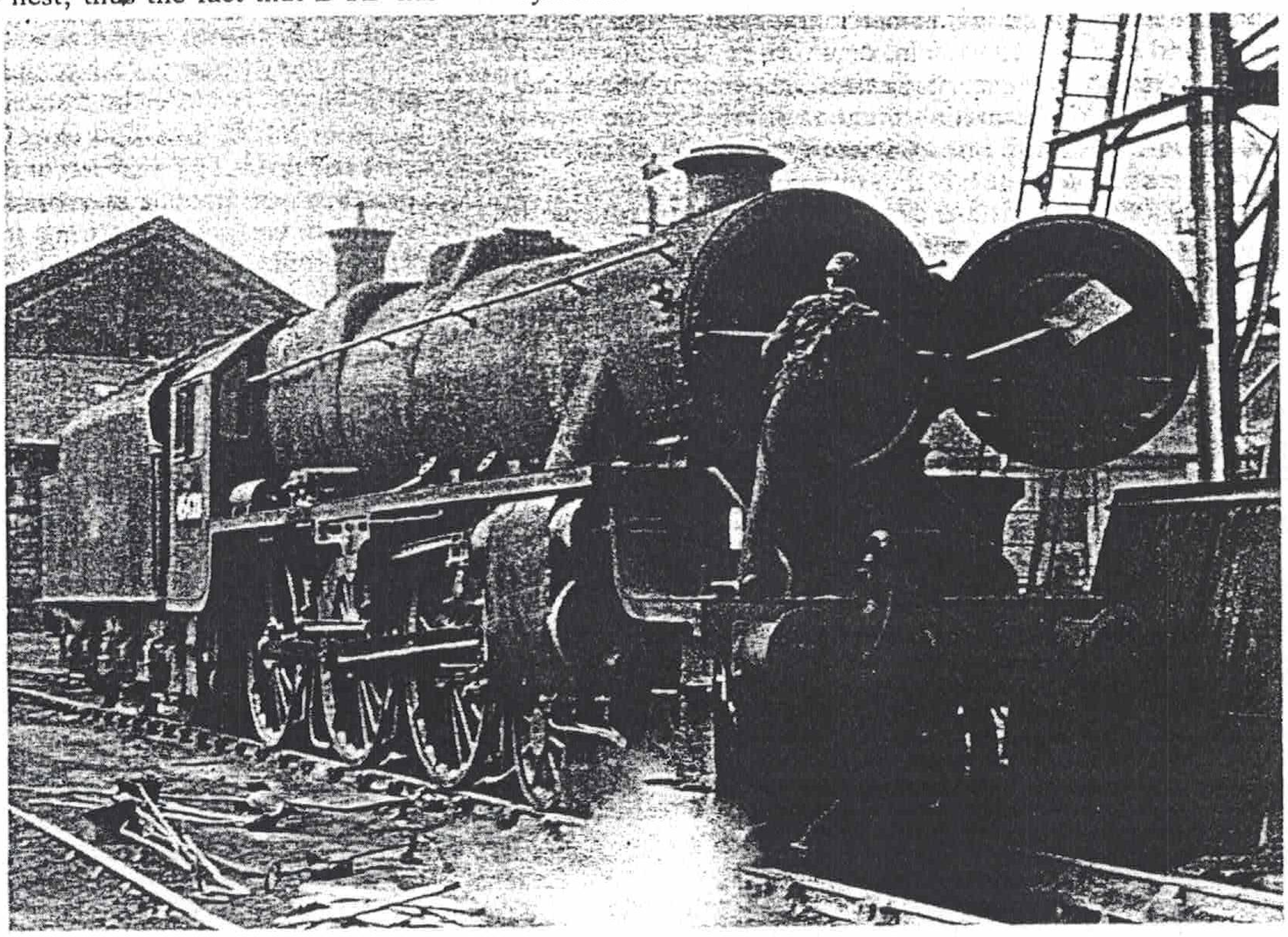
How do I justify the opening title against what seems a mundane collection of parts, the beginning of the tidying up process which will conclude the Walschaerts version BLACK FIVE in the next instalment? First and foremost is the ability to stop your engine when the need arises, far more important even than starting it, in which the steam brake forms a vital part, even though ultimately it is the train which stops the engine rather than the reverse. Moving on, whilst the boiler design is fundamental to its free steaming, such cannot be realised without the aid of the ashpan and draughting; they together are the determining factors in the performance of your BLACK FIVE on the track.

It is a year or two ago now that I had discussion with my solicitor as to how our two professions regard the truth. The process of the Law takes evidence from those involved and arrives at a considered judgement, truth being insubordinate to same. An engineer cannot do that, for my life has been a constant search for the truth, which applies even more so today to my Christian faith. All of us make mistakes, such are excusable, but what it is important is that an engineer recognises them when they occur, and learns from them, for to avoid the truth is to court disaster. I quoted as example to my solicitor an aircraft designer, where failure to recognise the truth can be fatal, as was demonstrated by that Boeing 747 crashing into the block of flats in Amsterdam, which should not have happened, as this was the second such incident. Likewise, although I can **tell** you in these notes the various design features arrived at to guarantee performance, only you the builder can **prove** them in service, for mere words mean nothing against actual experience. I do though have tangible proof that my design features are along the right lines, for uniquely in the hobby my livelihood is utterly dependent on my designs, for there is no LBSC or Martin Evans to help feather my nest, thus the fact that DYD has completed 26 years of trading must mean something, otherwise I would be but a distant memory! With that thought in mind, let me advance construction of BLACK FIVE.

### STEAM BRAKE

For the brake shaft, start by chucking a length of 3/4 in. diameter steel bar in the 3 jaw; face and turn down to 11/16 in. diameter over a 1 9/16 in. length. Further reduce the end 11/32 in. to 9/32 in. diameter, then use a round nose tool to form the shoulder before parting off at a full 1 3/8 in. Reverse in the chuck, face off to length and repeat as for the other end.

The fork end connects to the brake cylinder, so take a length of 3/4 in. x 5/16 in. BMS bar, drill the No. 22 pin hole, then turn the bar over and drill another No. 22 hole to indicate the end of the slot. Clamp to a length of angle, which in turn is bolted to the vertical slide, to mill down to 3/16 in. thickness as shown, then mark on and roughly saw out the profile. Radius the end over a mandrel with an end mill, then deal with the slot before completing said profile to line. Offer up to the shaft, scallop to suit, and we must deal with the pairs of return spring and brake arms. Clamp two, say, 6 in. lengths of 1/2 in. x 1/8 in. BMS flat firmly together, to drill the ends No. 11 and No. 30 respectively, radiussing them to drawing over a mandrel with an end mill. Bolt together, remove the clamps, then complete fashioning together. Erect all five pieces to the shaft, stand in the brazing hearth and silver solder the joints, clean and paint save for the journals which should be lightly greased. Turn up the bearings from 3/4 in. diameter bronze bar; we know how to deal with such things as return spring spindle, push rod, and brake gear pins, which brings me to the brake cylinder.



Once more I have been able to delve into Tom Greaves box of BLACK FIVE photographs for a few more gems. This engine is obviously due off shed again shortly, the tender already having been coaled in readiness. Note particularly the correct mid gear valve position and open drain cocks, otherwise the driver would have received a rocket from Tom!

This and the bottom cover we can supply as gunmetal castings, in fact they date back as far as JERSEY LILY and No. 78000, both of which have been described in 'Model Engineer' and LLAS respectively. Rub a file over the top face of the brake cylinder casting to get it nice and flat, then grip by the upper flange in the 4 jaw chuck and get it running true. Face across the bottom flange, turn it down to 1¼ in. diameter, then bore through to 13⁄16 in. diameter. Reverse in the chuck, which can be the 3 jaw, to face across the top flange to the required ⅞ in. overall dimension, turning same down to 1⅜ in. diameter.

The bottom cover casting has a nice chucking spigot provided, so chuck by the periphery in the 4 jaw for same to run true and clean it up, rechucking by same in the 3 jaw. The bottom profile only requires cleaning up with a round nose tool, in fact this could be done when dealing with the chucking spigot, so face off to length and turn on the spigot to a good fit in the cylinder bore, leaving the 7⁄64 in. thick flange which is now turned down to 1¼ in. diameter. With a knife edge tool, scribe on the bolting circle at 1 1⁄16 in. diameter, marking off and drilling the six No. 44 holes, together with the No. 41 vent, though in this I am jumping ahead of myself! For before we can release the cover from the 3 jaw chuck, we have to centre, drill and ream 5⁄16 in. diameter to at least ½ in. depth, then part off the chucking spigot. Offer up to the cylinder, spot through, then drill and tap the latter 8BA for hexagon head bolts.

Top cover next, for which first chuck a length of 7⁄32 in. brass rod in the 3 jaw. Face and screw 40T over a ¼ in. length, then centre deeply to form the seat for a 5⁄32 in. pipe nipple, drilling No. 34 to ⅝ in. depth. Start parting off a 7⁄16 in. slice, but only reduce to around 11⁄64 in. diameter before moving on ⅛ in. and parting right off. Take an odd piece of 3mm brass sheet and scribe a 1⅜ in. circle on same, then mike the spigot on the steam connection and drill to be a press fit, one reinforced with a drop of silver solder. Cut out the circle, then chuck carefully by the connection to turn the cover to size and face across to be steamtight. Scribe on the bolting circle with a knife edge tool, mark off and drill the holes, offering up to the brake cylinder in turn and drilling through, finally to the drag box and we can move on to the piston.

Chuck a length of ⅞ in. diameter brass bar in the 3 jaw, centre and drill No. 10 to ¼ in. depth. Next turn down over a 21⁄32 in. length to 5⁄16 in. diameter, an easy sliding fit in the bottom cover. Use a parting off tool to produce the ⅛ in. wide groove down to 9⁄16 in. diameter, then start parting off, say to the same diameter, before turning the piston to a tight sliding fit in the brake cylinder. Part right off, then reverse in the chuck, to centre and drill No. 41 to ⅝ in. depth. Follow up with a 3⁄16 in. drill and 'D' bit to 5⁄16 in. depth, tapping the outer ⅛ in. at 7⁄32 x 40T. Drill the No. 41 drain hole into the central bore as shown, then drill the top face No. 53 and press in the 1⁄16 in. pin, this to ensure the full piston area is always exposed to steam.

For the ball retainer, chuck the 7⁄32 in. brass rod in the 3 jaw, face and screw 40T over a ¼ in. length. Centre and drill No. 48 to ¼ in. depth and part off an ⅛ in. slice, then cut the slot with a hacksaw, this for a screwdriver, use same to run through the die again, and assemble with an ⅛ in. rustless ball inside the piston.

Whilst you can use ⅛ in. square PTFE packing in the piston groove, in more than 20 years of use, I have never found the need for same, as I guess condensate fills the groove and acts as the sealant.

**SANDBOXES**

Reference to the annonymous photograph on Page 29 of LLAS No. 52, which can now be attributed to Jim Proud and location Hull Dairycoates, shows how prominent are the sandbox fillers on No. 5305. Curiously, they do not show the means of fixing of the filler tubes to the frames as per my drawing detail, and we at Doncaster always regarded such feature as shields to protect vital areas from sand ingress, but then there was plenty of scope for variation between the 842 members of the class! Unlike E. S. COX, my Horwich 'Crab', thus far there has been no request for cast sandboxes, which is just as well, knowing the confusion the former have caused at the foundry!, plus in any case they are best fabricated.

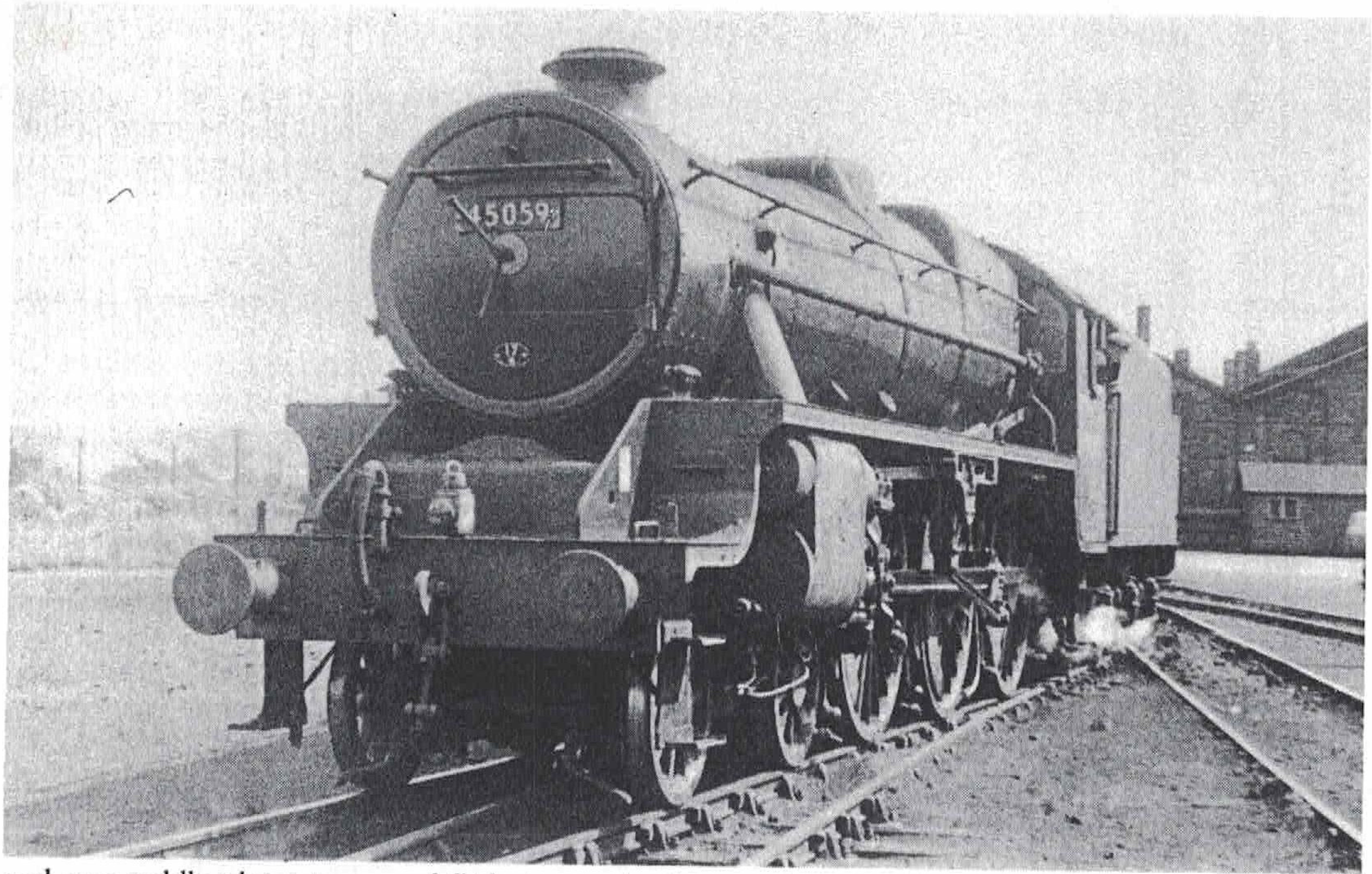
The end view is common between the leading and driving sandboxes and this provides the clue to the 'missing' dimensions, for the driving sandbox is 1 5⁄16 in. square at its top and ⅝ in. square at the base. This gives a common shape between front and rear faces of the leading sandboxes, plus the rear face of the driving pair, so make one as a template and use for the other five. Walls can be either 1.2 or 1.6mm thick, so cut pieces 1 7⁄16 in. x 11⁄16 in. for the front face of the leading sandbox and 1¾ in. x 11⁄16 in. for the rear face, bending the latter to place. That leaves just the top and bottom closure pieces, which also serve as attachment to the frames, so bend these up from 1.6mm brass, clamp all the pieces together and braze up; whoops! For I have forgotten the filler, which besides requiring an explanatory note, also prevents the sandbox from becoming completely air-tight during brazing, only that would never happen!

The problem with sandbox filler tubes that come up from inside the frames is that they come very close to the boiler barrel, even in full size, and scaling down merely magnifies the lack of clearance. It would be easier to omit them, were they not so prominent, thus all I could really do was reduce the difficulty. Whereas the photograph refered to in my opening sentence shows the filler tubes secured by medium of a square flange to the sandboxes, instead I have chosen to merely slide them over a projecting spigot on the sandbox, and the best way to make that spigot is from 7⁄16 in. brass rod, the next decision being whether to make the filler tubes from 7⁄16 or ½ in. o.d. copper tube. In either case, erect the sandbox and bend up the tube to place, to arrive at approximately what I have shown, and do note that it requires a wee scallop in the top edge of the frames to increase clearance at the boiler barrel. Next cut the shield 2⅛ in. x 1 1⁄32 in. from 1.6mm brass sheet and drill a hole to accept the filler tube, one that will have to be made eliptical to accommodate same. Silver solder together, pickle and clean, then offer up to the frames to gauge the positions of the No. 44 holes specified, drilling them through to place.

For the filler lid, or cap as the drawing detail calls up, chuck a length of ⅝ in. diameter brass bar in the 3 jaw. Face across and use a small boring tool to arrive both at the interior profile and push fit over the filler tube, then part off at a full ¼ in. Reverse in the chuck, face across and use a ball ended end mill or 'D' bit to arrive at the depression for the hand hold. The latter is a short length of ⅛ in. x 1⁄16 in. brass, shaped to suit said depression and silver soldered in place.

At the bottom end of each sandbox, at least for the leading and driving pairs, mark off and drill a No. 22 hole in the centre of same. Chuck a length of ½ in. brass rod in the 3 jaw, face, centre and drill No. 22 to ¼ in. depth, parting off a 3⁄32 in. slice, though first scribe on the bolting circle at 11⁄32 in. diameter with a knife edge tool. Mark off and drill the four No. 44 fixing holes, then braze to a length of 5⁄32 in. o.d. thin wall copper tube, with about ⅛ in. projecting, this giving positive location in the sandbox base. You will have to go back to LLAS No. 44 and the G.A. of BLACK FIVE to check how the sandpipes are bent to arrive above the rail head, which leaves the trailing pair.

The building base for the trailing sandboxes wants to be the top plate, which includes the lugs to attach to the underside of the running boards, so bend these up and fashion to



For members of the RCA (Rivet Counters Association), there is plenty of detail on the smokebox as No. 45059 rolls off Shed.

and rear saddle plates to a good fit between the frames, the 7/16 in. dimension being the critical one, then deal with the side plates, bending them in at the top and bedding to the top plate. There is nothing to prevent the use of short lengths of 1/2 in. x 1/2 in. x 1/8 in. steel angle to join the end and side plates together, using a few iron rivets as fixing, though leave them clear of the diaphragm plate which completes the basic structure. If you decide on a riveted pre-assembly, then offer up each side plate in turn to the frames, clamp firmly in place, and drill the 3/4 in. diameter hole for the exhaust. Also, when locating the pieces of angle, space the side plates about 4 5/32 in. apart, just so you can take a facing cut across them to ensure that the joint with the frames is, exhaust, steam tight.

Copper bends for domestic plumbing are now off the shelf at builders' merchants and remarkably inexpensive, which solves the problem of bending up large diameter copper tube for our exhausts, so acquire a pair, which will now be in metric size. They won't be quite the shape I have drawn, but this matters not one iota, so saw them off to the length we require and melt out the soft solder if that part was not sawn away. Open out the holes in the side plates to a tight push fit for the bends, then scarf the upper ends and turn up the blast pipe flange to suit. That leaves the top plate, for which drill a 3/4 in. hole on the centre line and then open out with a course round file to gain clearance. Whereas with involved exhaust 'spiders', it is necessary to braze up same as a separate operation, with this simple one the whole can be dealt with in a single operation.

Bolt a large angle plate to the vertical slide and clamp the saddle to same, checking that you can either mill or preferably fly cut the whole of one of the side plates, then reverse and deal with the other side to arrive at the 4 1/8 in. overall dimension. Turn the saddle over again, this time to bring the blast pipe flange towards the chuck, and very carefully true it up, indeed you can mark off and drill four No. 34 fixing holes on a 1 1/32 in. p.c.d. at this setting.

Sadly, we now have to remove the cylinders to erect the saddle, when the fixing holes will be exposed. Those which are common to the cylinder flange at the top will have to be tapped 6BA, though you may prefer to drill through from the row of countersunk ones that have been provided specifically for the saddle at No. 34 and nut them on the inside of the saddle; it all depends which is the easier solution for you, the builder.

**Boiler Joint Ring**

The length of boiler joint ring was arrived at to allow the saddle rear fixing bolts to penetrate same, giving a very rigid assembly, though conversely, machining a slender casting over such a length does pose problems in distortion. The solution, and one I have applied to those builders who have asked me to supply a suitable casting, is in fact to provide two of them, ex-JERSEY LILY, when the problem no longer arises. Deal with each in turn, obtaining both a tight fit over boiler barrel and smokebox shell, to be sure this joint is completely air-tight.

**Smokebox Front Plate, Door and Fixings**

The smokebox front plate I envisaged as being flame cut from 3/8 in. steel plate, although I have over the years supplied a fair number of gunmetal castings. Machining is easy and only the mitred seating for the door deserves mention, being a practical solution to the problem of air ingress at the bottom of the door that lasted until the end of the Steam Era and into preservation, indeed there should be further evidence of same in this very issue; if I can find room for the photograph!

Despite the drawing detail indicating otherwise, the smokebox door has always been an iron casting, a practice I tried to extend to many of my other designs, only to come unstuck. There is a substantial chucking spigot, one that also doubles as the central boss, so be careful not to part it off completely in your haste when the moment arrives. Grip first by the periphery in the 4 jaw chuck and set to run true just to tidy up said spigot, then rechuck by the latter in the 3 jaw. Turn down to 4 25/32 in. diameter and face across the back of the door, then chuck again by the periphery, turn on the boss, centre and drill through at No. 27 for the dart.

Crossbar next, and I would machine this from 1/2 in. square steel bar, so first square off to 5 1/2 in. overall length. Grip in the machine vice on the vertical slide to remove 1/8 in. of metal and leave the centre portion 1 in. long of the original section. Next reduce the thickness along the full length of bar to 7/16 in., in fact you can go further in reducing the end 3/8 in. to 1/4 in. thickness and blend in the rest. That leaves the centre slot, for which drill a row of No. 3 holes, opening out into said slot with a 7/32 in. end mill and filing the ends to be square.

For the dart, we require a length of 7/16 in. steel rod, so chuck in the 3 jaw, face and turn down to .110 in. diameter drawing. This time there is no problem with the filler tube, so square off an 11/16 in. length from 1/2 in. o.d. copper tube, the actual gauge being of no consequence, making the top plate a push fit for same, which will then hold it in place for brazing. Ahead of this though we have to complete the sandbox, so deal with the rear face next, which because of its shallow inclination, can safely be made to drawing dimensions. Front face next, for which make the 1/4 in. fold at the top, then complete to match the rear face. That leaves the side faces, which are simply a matter of filling in, followed by the bottom closing piece which is a variation on those for the other pairs, again being secured to the frames; braze up.

**Running Boards and Valance**

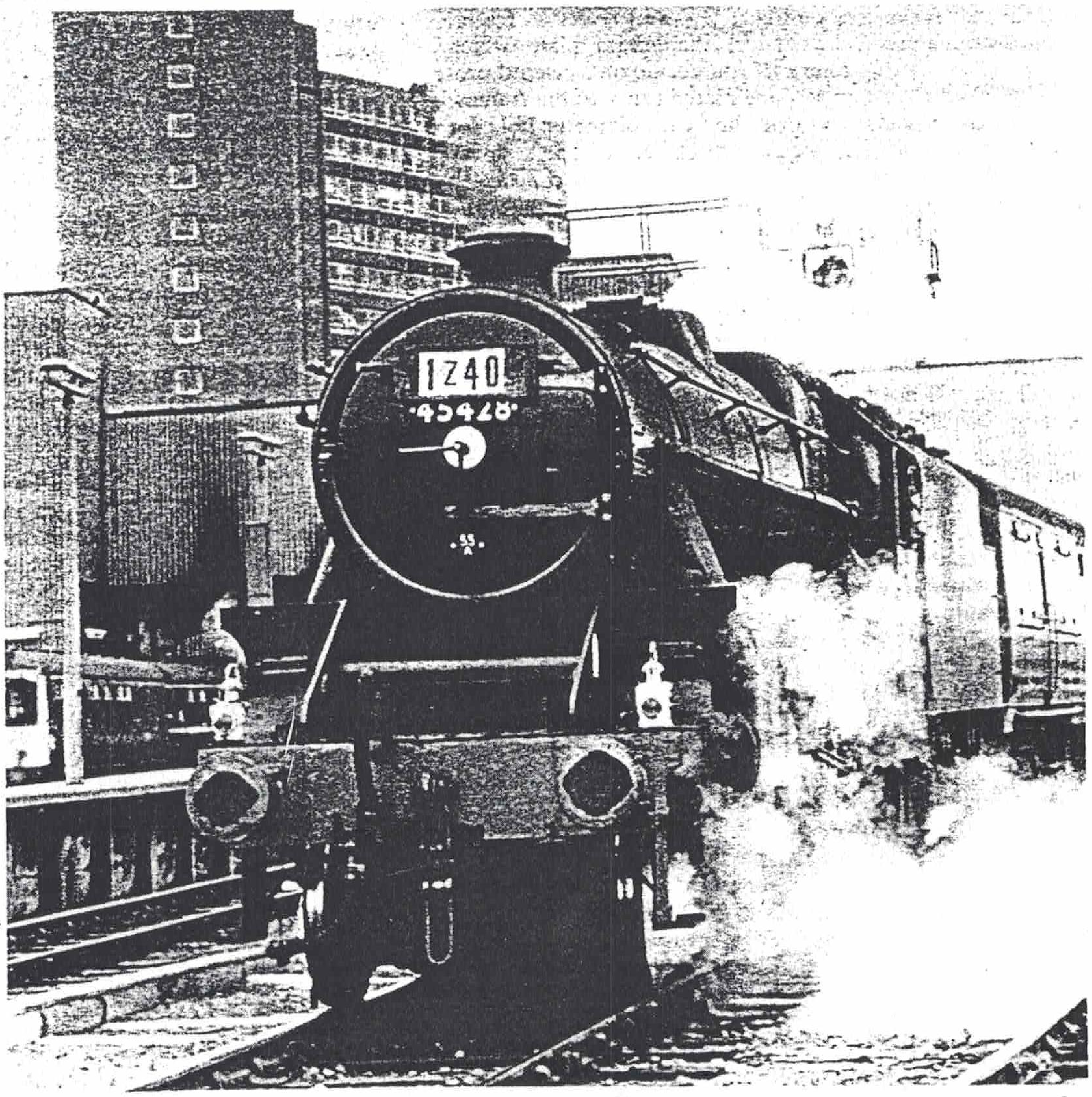
The platework really wants to be dealt with in a single session, but as the side running board and valance sizes are specified hereabouts on the drawing, I had better make some mention of same. Already you will be aware of a number of supports for the running boards, like the motion plate and its girders, plus the brackets each side of the rear sandboxes, to which we have just added the sandboxes themselves. It has to be checked that these are nice and level, and what better way to do so than from the actual running boards, thus I recommend that the material be allocated for same at the appropriate time. They can be finally trimmed to length when the front section running boards and cab are ready for erection, though there is no reason why such things as mechanical lubricators cannot be mounted on same, or the cut-out made for the reach rod, plus fixing of the reach rod support; it all makes for less work at the end when you are itching to get to the track!

With regard to the valances, for years I have been worrying needlessly that the correct 5/16 in. vertical dimension could not be arrived at without recourse to filing down the nearest commercial size, for I now notice in Reeves 23rd edition Catalogue that 5/16 in. x 5/16 x 1/16 in. brass angle is a stock size, so use it! You may have to reduce the top face to clear obstructions at various points, but such should be of a local nature rather than extend the full length of the valance.

In my hurry to get to the smokebox, I see I have omitted to describe the sandpipe flange for the pair of rear sandboxes, but as these are plain turning I trust I will be excused in my headlong dash for the murky depths!

**THE SMOKEBOX**

I really must learn to curb my enthusiasm, which has now returned in full measure after Trevor's bombshell, for as yet there is a yawning gap between the frames in way of the cylinders, to be filled with the smokebox saddle. Maybe this is just as well, for it will be much easier to first use Reeves rolled smokebox service for the shell, when the top plate on the saddle can be made to match, indeed why not invite Reeves to perform this task for you, when the rest will be easy. First trim the top plate to drawing dimensions, then mark off and drill the 38 holes at No. 34. Square off the smokebox shell to length, clamp the top plate in position and drill through, when you can mark out and cut the opening in the shell, to allow the latter to bed perfectly to the saddle. Mark out on 3mm steel sheet and cut the front




For some reason, this picture makes me feel depressed, so let me try and analyse such thoughts, especially as I have not a clue as to location. The building is anonymous and could be anything from high rise flats to an office block; completely characterless. The bridge is also 'modern' and featureless, just a maze of vertical lines and already smoke blackened. The station platform too shouts 'pre-cast concrete', as do the lamp posts. Even No. 45428 seems to be having an off day, looking unkept and uncared for, wheezing steam, but at least the smokebox detail is clear, thus the picture serves its purpose.

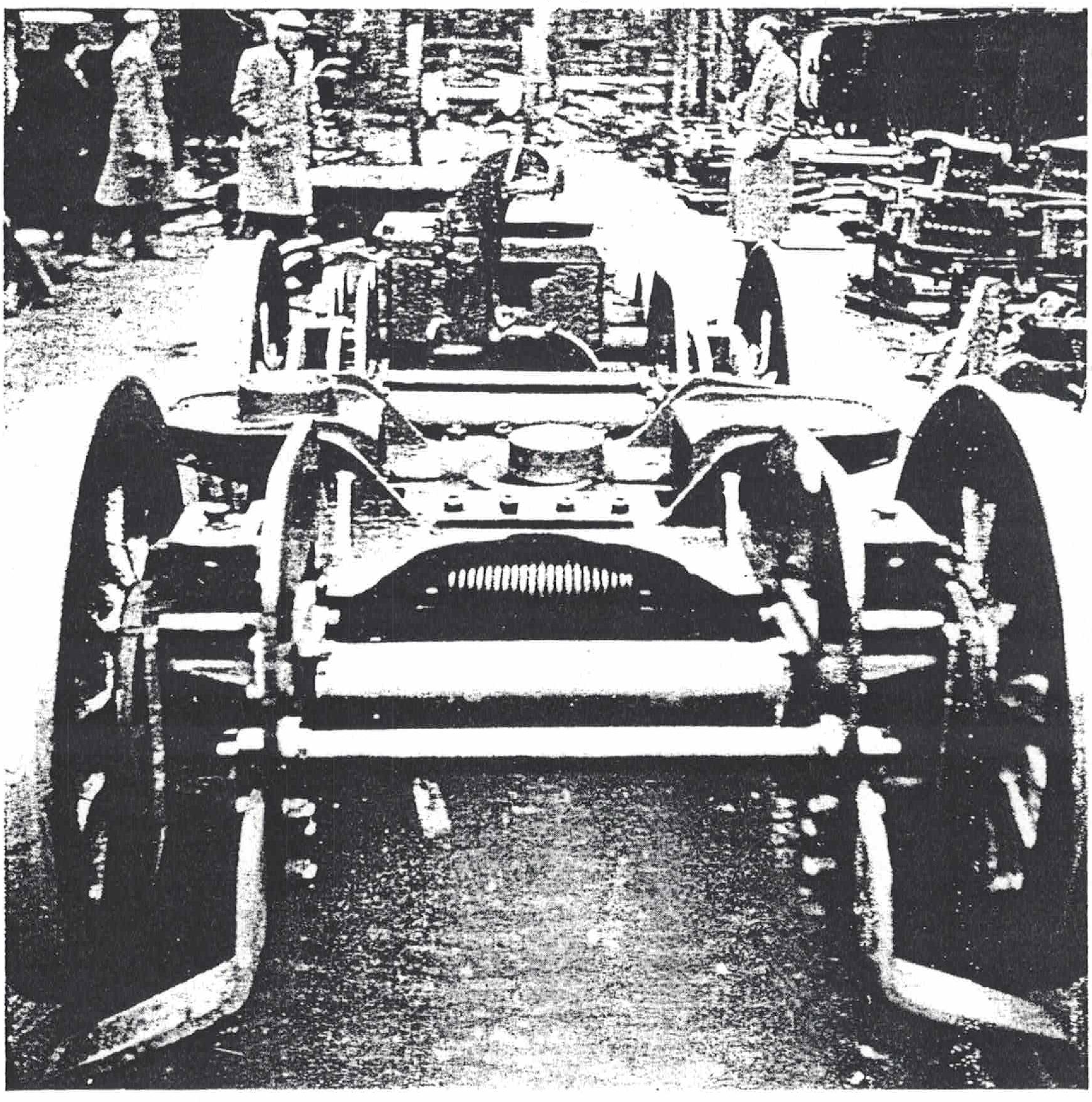
over a $^{11}/_{32}$ in. length, screwing 6BA. Reduce the next $1^{19}/_{32}$ in. length down to $^{9}/_{64}$ in. diameter, this in about $^{1}/_{2}$ in. increments, checking against door and crossbar until $^{7}/_{32}$ in. of turned rod protrudes through the door, then part off to leave a $^{5}/_{32}$ in. thick head. File the flanks down to match the turned portion; then complete the profile, which leaves just the square portion, to be dealt with in conjuction with the handle.

These door handles are extremely distinctive and worth spending a lot of time over to get them right, the bosses at least being straightforward, the squared one being broached and the dart filed to suit. For that handle, chuck a length of $^{5}/_{32}$ in. steel rod in the 3 jaw with $1^{1}/_{16}$ in. protruding and file on the taper, the smaller diameter being towards the chuck. Pull the rod out another $^{3}/_{16}$ in. and start parting off, but only reduce to around $^{5}/_{64}$ in. diameter before moving on $^{1}/_{16}$ in. and parting right off. Mike the spigot, drill the boss to be a press fit, then add a drop of silver solder as additional security. The smaller, front, handle is similar and from the same $^{5}/_{32}$ in. rod, the problem being that 12 deg. set. Without an elaborate jig, one that is far too time consuming for such a mundane piece part, I cannot tell builders how to drill the boss at such an angle, and yet even a degree or two in error shows up. Even worse is that if the attempt is made to correct any error after brazing in, either the handle bends or the boss distorts, thus you may have to make more than one of them before you are satisfied with the result. Bend up the crossbar supports from $^{1}/_{4}$ in. x $^{1}/_{8}$ in. steel flat and fix each to the smokebox front plate with a single rivet, head inside and hammering down into a countersink in the front face. Now we can assemble the pieces made so far to tackle the door hinges.

We already have the bottom centre line on the smokebox shell from the saddle, so from this we can arrive at the top and horizontal centre lines; mark them on. This will allow us to determine the positions of the hinge blocks, so mark off and drill the two No. 34 holes for same. For said hinge blocks, mill down a length of $^{7}/_{32}$ in. square steel bar to $^{7}/_{32}$ in. x $^{5}/_{32}$ in. section and chuck truly in the 4 jaw. Turn down to .110 in. diameter over a $^{7}/_{16}$ in. length and screw the outer $^{3}/_{16}$ in. at 6BA, then mark off and drill the No. 47 hole. Saw from the parent bar and you will have to use a filing button to radius the end; erect to the smokebox front plate.

For the hinges, chuck a length of $^{7}/_{32}$ in. steel rod in the 3 jaw, face, centre and drill No. 47 to $1^{1}/_{8}$ in. depth, parting off two $^{13}/_{32}$ in. slices. The hinge straps are $2^{3}/_{4}$ in. lengths from $^{3}/_{8}$ in. x $^{1}/_{8}$ in. steel strip, silver soldered to the bosses and then fashioned to drawing. Before thinning down the straps though, it is best to grip them in the machine vice on the vertical slide, with the boss hard against the jaws, to mill the $^{5}/_{32}$ in. slot, checking to place against the hinge block.

The hinge pin is a $2^{25}/_{32}$ in. length of 2mm steel rod, to which is pressed on and brazed the wee head; clean up the latter including removal of excess spelter. Erect the door and secure with its dart, thanks to the mitre it will be self-centering, then use the hinge pin to locate the hinges. The hinge straps will require both bending and twisting to get them a proper fit to the door, after which clamp firmly in



This picture should have appeared much earlier in the BLACK FIVE series, for which apologies, being full of splendid detail at the bogie building stage. It was filed with the Norman Lowe collection, which makes the location Horwich I am guessing, though who are the non-workers in the background? A de Glehn type bogie is particularly sturdy, the frame bearing brackets being cast integral with the massive bogie centre.

place, before drilling each in three or four positions for 1/16 in. snap head copper rivets, heads inside and hammering down into countersinks; file flush.
The handrail on the door seems to be at a constant height for all engines, so mark off and drill the two No. 34 holes, fitting commercial handrail stanchions. The handrail is a 3½ in. length of ⅛ in. steel rod, with those little 'buttons' pressed onto the ends, which brings me on to the lamp irons. Rather like DONCASTER, although at least the type seems to be the same throughout, there are a variety of positions, so really you have to choose your prototype and fit accordingly. Just as example, on No. 5231 the iron is positioned as per my detail, but on 5428 it has wandered off to around the centre line of the door and right of centre, the reason for which perhaps Tom Greaves can elaborate.
Within the last group of details is the snifter, a simple fitting I do not propose to describe, though if any builder is in doubt, I have dozens of the little things on shelf, not having the gumption to list them for years now!

**Completing the Steam Circuit**

We left the steam circuit stranded at the superheater flange, or rather the superheater elements divorced from same, so the next job is to make up the wet and dry headers. These are plain lengths of 7/16 in. o.d. x 20 s.w.g. copper tube, with ⅛ in. ends brazed into same, the length of headers being quite critical in order that the whole assembly can be withdrawn through the smokebox front plate opening. Before brazing up though, drill for and fit the element ends, and also the lengths of 5/16 in. o.d. thin wall copper tube down to the steampipe unions.
The positioning of the latter is a bit naughty, to come within the spat, introducing a nasty bend in the short length of pipe down to the cylinder flange. It would be very tempting to move the steampipe union downwards to straighten up the final pipe, but to do so would make it impossible to assemble with the cylinder in place, so resist. There is also very little room for the steampipe flange, which means it can only be 3/32 in. thick, and dictates the use of bronze rather than brass for the extra stiffness this provides, being best turned up from 1¼ in. diameter bar, which we can supply as a cast stick. The three fixing holes are roughly on a ¾ in. p.c.d. and can be scribed thus with a knife edge tool before parting off, then drilled and the profile fashioned around them. I would complete this end of the steam circuit and then deal with the internal pipe from the dry header to suit, when we can move on to the exhaust side of things.

**Blast Nozzle/Blower**

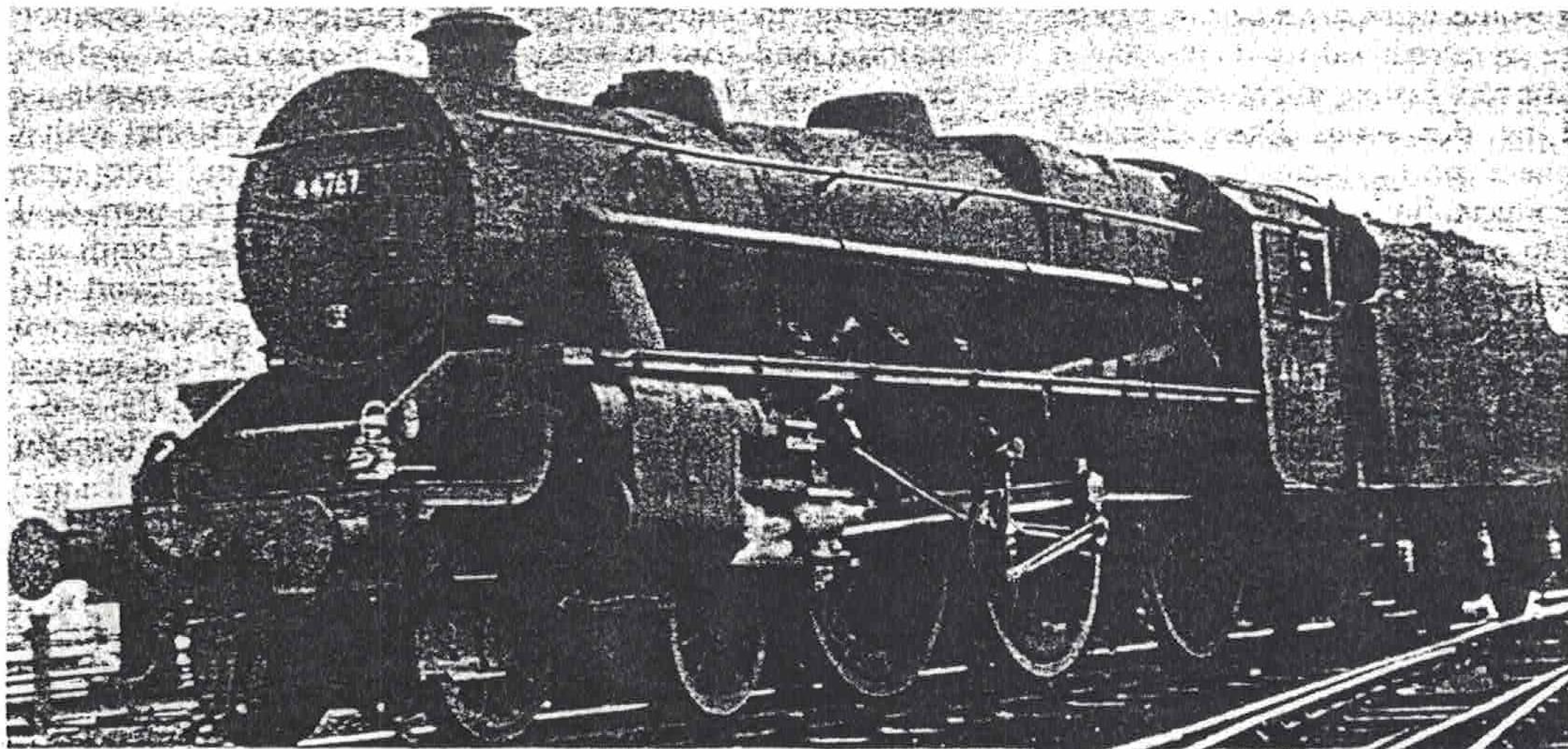
Having made the steampipe flanges from cast bronze bar, we may as well continue with this material for the blast nozzle body, so chuck in the 4 jaw, face and turn down to 1¼ in. diameter over a 1¼ in. length. Next centre and drill 13/32 in. diameter to 1½ in. depth, boring out approximately to drawing, the .42 in. dimension at the top being the critical one. The next bit is purely profiling to drawing, and if the short length of copper tube eludes you, then turn this up from the bronze bar to fit the 1⅛ in. diameter on the body. Part the body off to length and I see that having specified four No. 34 holes in the blast pipe flange, I have now mated it with six No. 41 holes on the blast nozzle body, for which red face! Whichever fixings you decide upon, drill flange and body as a pair before attaching the former to the blast pipes, which will make life a lot easier.
Turn up the blower belt steam connection from 7/32 in. brass rod to a press fit in the sleeve, then silver solder the complete assembly together. That leaves the four No. 70 holes, which I still find best to drill by hand with my trusty 6/10d (34p) Woolworths 'machine'. Erect to the blast pipe flange, make up the blower pipe in two sections from ⅛ in. o.d. thin wall copper tube, and we can move on to the most interesting parts.

**Petticoat Pipe and Chimney**

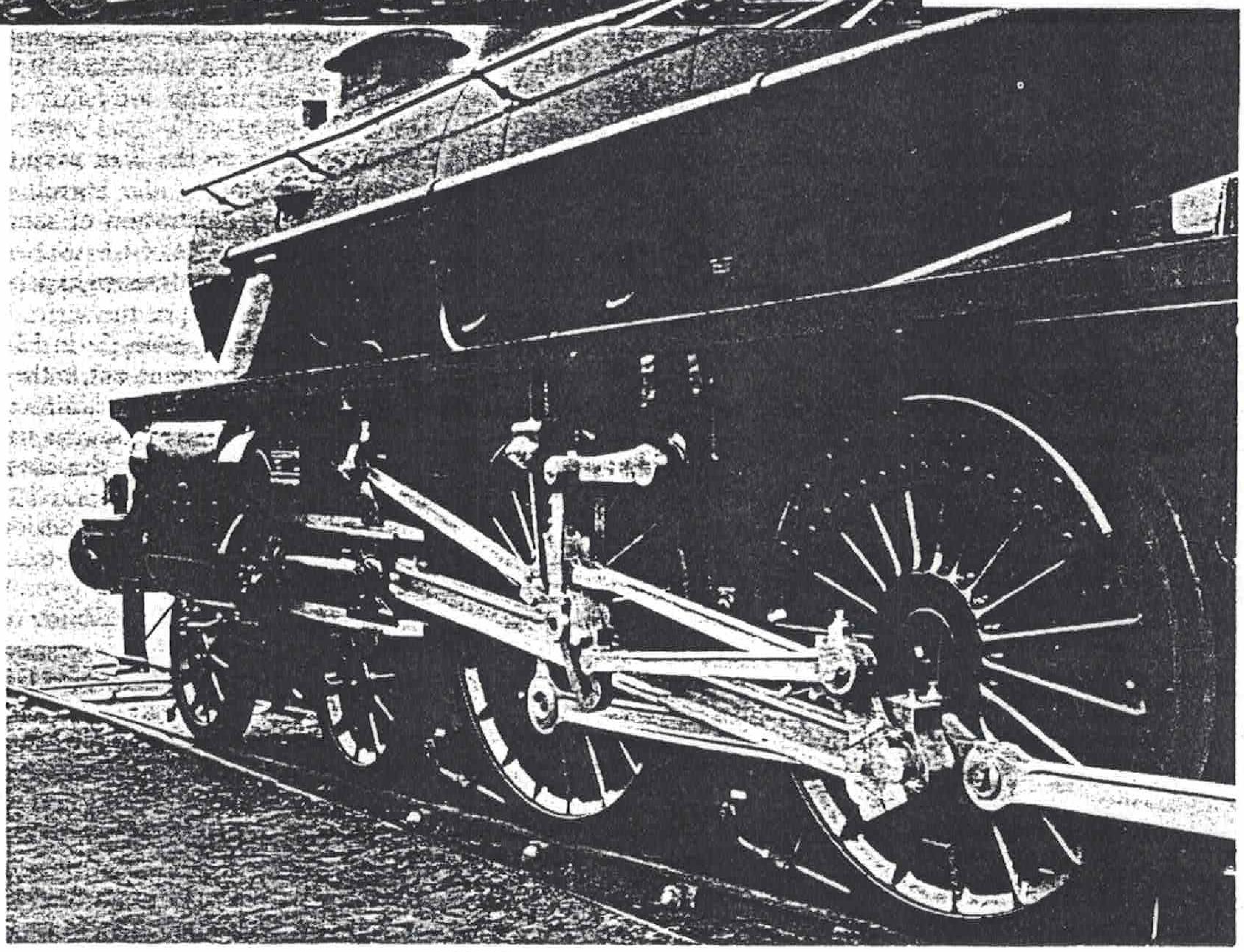
Before I forget it, we require a simple alignment jig for petticoat pipe and chimney from the blast nozzle, so chuck a 5½ in. length of ⅝ in. diameter steel bar in the 3 jaw and turn down to .42 in. diameter over a ½ in. length, a tight fit in said nozzle.
The petticoat pipe is a pert gunmetal casting which I now see does duty on no less than nine DYD's, though it started life for BLACK FIVE. First chuck by the parallel portion in the 4 jaw, face across the bottom and turn down to 2¼ in. diameter, rechucking by same in the 3 jaw. Carefully turn down the parallel portion to 1½ in. diameter and face off to 1 31/32 in. overall; rechuck again by the parallel portion. Bore out to 1 3/16 in. diameter, then set the tool over two deg. and deal with the upper, tapered, portion, until its length becomes 1 1/16 in. as per drawing. Although it is possible to turn the flare to template, I find it both quicker and easier to deal with this with file and emery cloth, running the lathe at around 900 r.p.m.; never use a file without a handle that has been firmly fitted. The flange is a 1¾ in. square from 1.6mm brass, which with extreme care can be bored out to 1½ in. diameter to fit over the petticoaat pipe. Bend to suit the inside of the smokebox shell, when you will have to ease the fit over the petticoat pipe again, only this time make the fit a tight one, which will then hold the flange in place during brazing.
On the top centre line of the smokebox shell and 3¾ in. from its front extremity, scribe on a 1⅝ in. diameter circle, drill No. 30 holes around the inside of same and break out the redundant central portion, filing to line. Before attaching the petticoat pipe to the shell by medium of four 7BA countersunk screws, we must tackle the chimney in order to establish proper alignment with the blast nozzle.
The chimney is a lovely iron casting, and having machined a few of these Stanier pattern myself when at Doncaster, I rate them alongside those used on the LNER B1's for attractiveness; I wonder who was responsible for such a lovely form. We know it wasn't E. S. Cox, for he reverted to the Horwich pattern on the BR Standard classes, and likely we shall never know, unless a LLAS reader has the answer.
On the full size engines, only the bore of the chimney was touched, this to accept the petticoat pipe, but in 5 in. gauge leaving the finest sand casting unmachined externally is not good enough, thus we must grip the chucking spigot in the 4 jaw and clean up the outside as far as we are able. At which point to deal with the bottom flange to snugly fit the smokebox shell is open to question, but what is important is that in conclusion the recess to accept the projecting spigot on the petticoat pipe must be 3/16 in. deep. Now set the boring tool over 2 deg. and bore out until there is no mis-match between petticoat and chimney bore, parting off the chucking spigot being the final operation.
Bring petticoat pipe and chimney together on the smokebox, fit the alignment tool, and use inside calipers to get the pair centrally disposed. When an engine does not steam as it should, then this is the first point to be checked, so take your time and get it right first time. Only when satisfied, remove the chimney, drill through shell and petticoat pipe No. 41 in the four corners of the latter, countersink the shell and fit those 7BA countersunk screws, with nuts inside.

**Ejector Exhaust Elbow and Steampipe Spat**

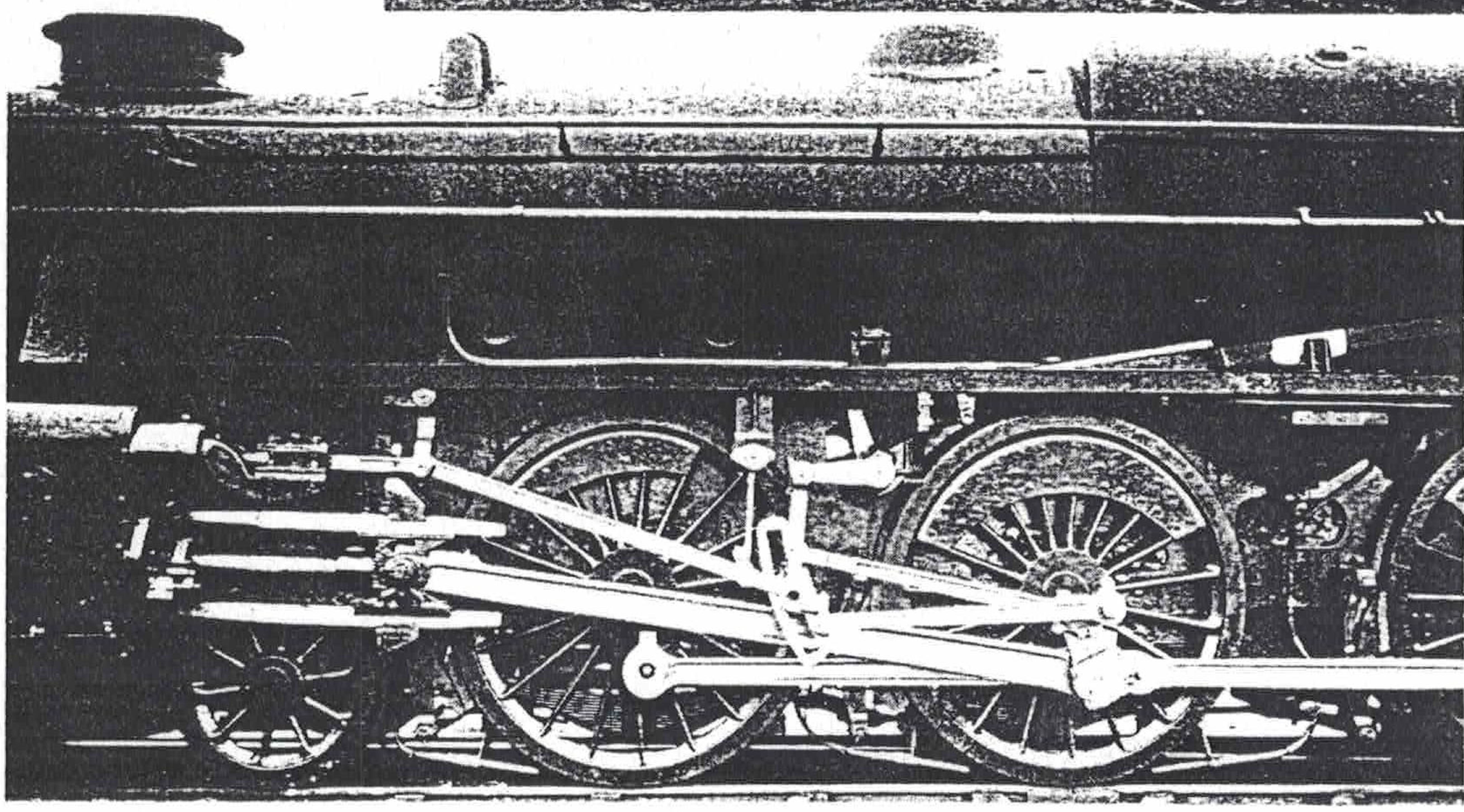
Before we move away from the smokebox, we have to tidy up a few odds and ends, starting with the ejector exhaust elbow. For E. S. COX the Horwich 'Crab', I described how to make a similar elbow by 'lobster backing', which is cutting tapered chunks and brazing them together, then blending the shape externally to arrive at the finished item. I




Some stages in the, BR, life of BLACK FIVE No. 44767, the unique Stephenson link gear engine. Here she is in single chimney form and looking to be in need of a good clean.



In contrast to the above, this and the following picture was taken with No. 4767 as she then was newly outshopped from Crewe, with all motion highly polished. This single engine is proving almost as popular with BLACK FIVE builders as all the rest of the class put together, quite possibly due to her prowess in preservation, indeed I was watching a video of her in action only last evening, just to keep my eye in!



There is a particular reason for publishing this picture now, rather than holding it for the final session in which we shall be tackling the Stephenson link valve gear. For sitting on top of the smokebox is a double chimney. Norman Lowe both sent in this picture and made all the patterns for BLACK FIVE, having been employed in the latter role at Horwich, yet despite years of searching, he is unable to unearth the patternmaking drawing for the double chimney, thus it does not appear in my lists. Obviously they were not very successful in service, though for what reason I have been unable to discover, though no doubt a LLAS reader will be able to throw light on this.

am not so sure this solution would work for BLACK FIVE, certainly not unless the bore were reduced to 3/16 in., and it is tempting to think that a lost wax casting might provide the answer. I was enthralled by the series Doug Hewson contributed to 'Model Engineer' on the subject of lost wax castings, and know his products find favour with LLAS members, so is it possible to produce the elbow, Doug? I have a feeling much will depend on how widely used is this particular pattern of bend, with likely Doug's own Class 4 2-6-4 Standard Tank holding the key, which makes a lovely engine in 5 in. gauge.

When I was working at The Plant, probably because they were tucked away largely out of sight, the two trades which for me had the greatest mystique were the blacksmiths and sheet metal workers. Most of you are now familiar with my dummy and adjustable eccentric rods, particularly for Walschaerts valve gear, to arrive at the correct setting before making the actual rods. Well, the same thing was required full size, both for new and also engines under repair, the difference being that the rods already existed. So you took the rods along to the blacksmith, with a chalked instruction on same, like 'shorten 1/8 in.', or 'lengthen 1/16 in.', collecting same half an hour later exactly to requirement. The sheet metal workers had their own little shop, alongside the patternmakers by the river bank. They used to emerge with tape measure and chalk, lift a few dimensions off the engine, scurry back to their warm shop, then days later arrive back at the engine with a complete spat, or another such part that I will come on to in a moment, which invariably seemed to fit perfectly, leaving us to erect it; I could do with such service now!

As a very average sheet metal worker, I place great reliance on wooden formers, thus would make up the spat section in wood and fit it to both smokebox shell and running board. It is then a simple matter to fold annealed copper sheet around the front and sides of the block and trim off the excess. The back section is best flanged up with the copper in the as supplied condition, which is likely to be half hard, with 2.5mm thick tapping strips silver soldered to same. If you now cut away the wooden former in the back corners to accept the tapping strip, you will have a firm base from which to drill and tap for the 12BA fixing screws. That leaves the two end flanges, which can only be fashioned to place, with cut-outs to clear the steam pipe, and if you are able to silver solder the pieces together, so much the better, otherwise use 'Comsol'. If 12BA fixings to smokebox and running board is too nerve-wracking, then use 10BA screws with smaller heads for the same effect.

**Lagging and Cleading**

In the bad old days, a mixture of asbestos string and cloth would soon produce an even taper over the length of the boiler barrel over which to fit the cleading, but thankfully the dangers of asbestos are now universally known, so I won't repeat that particular instruction. I must admit though that I only have very limited experience post-asbestos, thus can only make suggestions as against precise instruction. I do though enjoy cooking and am greatly taken with the properties of aluminium foil and the ease of working with same, thus I would use crushed foil to build up the even taper, holding it in place with fuse wire, topped off with a sheet of glass cloth, being one of the lucky ones who are not allergic to same!

The cleading is easy, for I 'discovered' the superb properties of brass shimstock for same with FISHBOURNE more than 30 years ago now, and this has become a standard supply from Reeves for the purpose, thus I feel that I have achieved something. To arrive at the required shape for the barrel, take a sheet of good quality paper, make cut-outs for both top feed and dome, then roll around the lagging, trimming the edges to place. Transfer to the cleading material and trim to suit, with a 1 in. lap on the bottom centre line. Hold the cleading in place with a couple of Spanish windlasses, which are merely loops of string, with a length of rod poked through so that you can wind them tight around the brass shim, then with a large soldering iron, deal with the lap joint to make it nice and tidy. Boiler bands are from 3/16 in. x .018 in. brass strip, so fold around the cleading in the positions shown and bend the ends over at 90 deg., drilling No. 44 for a long 8BA bolt. In the normal folded position, if you allow a 1/2 in. gap between the ends, when the bolt pulls them together this will close down to between 1/8/1/4 in., which is ideal.

I mentioned sheet metal workers earlier, and we need their services again for the top corners of the Belpaire firebox, though first lag and clead the rest of the firebox, to give us a guide. My solution then is to go back to the good old wooden former, making it to place and then hammering 1mm thick copper sheet over same. The boiler bands adjacent should be sufficient to hold the corners in place; if not then use the big soldering iron just to tidy things up.

**Top Feed Casing and Dome Cover**

Having decided on the Ivatt version boiler with the top feed on the front ring of the barrel, thus far I have failed to provide proper illustration of same, the only example thus far being on Page 19 of LLAS No. 46, courtesy of Norman Lowe. I hope to put this right when I come to feature No. 4767 in the final part of the series, but for the moment can I refer readers to Page No. 28 in LLAS No. 52. The feature I particular want to point out is the trough like cover for the top feed pipe. This is a most difficult feature to reproduce in miniature and a part of me says to bury the actual feed pipe under the cleading, when the cover becomes a dummy and can be represented by Isopon P38. On reflection though, this does not seem such a good idea, so the next thought is to put the feed pipe on the outside of the cleading, but still represent the cover with Isopon. Yet another idea is to slit and splay out a length of 1/4 in. o.d. thin wall copper tube and sweat or screw it to the cleading sheet, but once splayed out, it is not going to be easy to bend the cover to match the cleading. However, the so far anonymous builder of LANARKSHIRE YEOMANRY as illustrated on Page 33 of LLAS No. 53 has made a superb job of same, so perhaps when he reveals his identity, he will also tell how he made his feed pipe cover, thereby resolving my predicament!

The top feed cover at least is easy, namely requiring to be tidied up with file and emery cloth externally. Grip by the central portion in the machine vice, on the vertical slide, just to clean up the inside to a close fit over the top feed fitting, then bed to the cleading to complete.

The dome cover requires even less attention, being bedded to the cleading as a first step, after which file the lip to a feather edge all the way round and blend into the rest of the profile, then mark off and drill the No. 44 fixing hole to complete.

**Boiler Erection, Grate and Ashpan**

At least one professional boilermaker to my knowledge now incorporates the expansion brackets as part of the structure, which in this instance will consist of brazing 3½ in. lengths of 3/16 in. square copper bar to the outer wrapper sides, and avoids piercing same. At first I viewed this feature with horror, for it removes the possibility of adjustment to get the boiler nice and level in the frames, but having been forced to do something similar with TOM ROLT, I could begin to see the idea has some merit, though I doubt I could make the more complex BLACK FIVE boiler exactly to drawing dimensions, in fact I know I couldn't!! Because the boiler is already beginning to grow outwards as it comes to the area in which the expansion brackets are to be fitted, they are going to be difficult to fold up in the usual way from 3mm copper sheet. The alternative is 5/8 in. x 1/4 in. copper bar as available from Reeves, which is a lovely metal to mill if you use paraffin as cutting fluid. Thoroughly anneal same after machining, which will remove the residual paraffin, then bed to the outer wrapper. Ahead of this though we have to set the boiler level in the frames.

Already we can secure the boiler at the smokebox end, there being a convenient point under the throatplate flange for packing, above the boiler stay, as shown on the drawing. It is the bottom of the boiler barrel that is parallel with the frames, not the best of datum to work from, but you can put a straight edge across the bottom edge of said frames and measure up to the barrel to check this out. When satisfied, bed the brackets to the outer wrapper, taking care not to distort the latter, then mark off and drill the four 1/4 in. diameter holes specified to clear the firebox stay heads. From this you can determine the positions of the fixing screws, so mark off and drill the brackets No. 30. Offer up to the outer wrapper, spot through and drill No. 40, using new 5BA carbon steel taps so as not to tear the threads in the soft copper. The screws are cheesehead from 3/16 in. or 5mm bronze rod, screwed 5BA with the die opened out to give a tight fit, then fitted with a drop of liquid jointing compound.

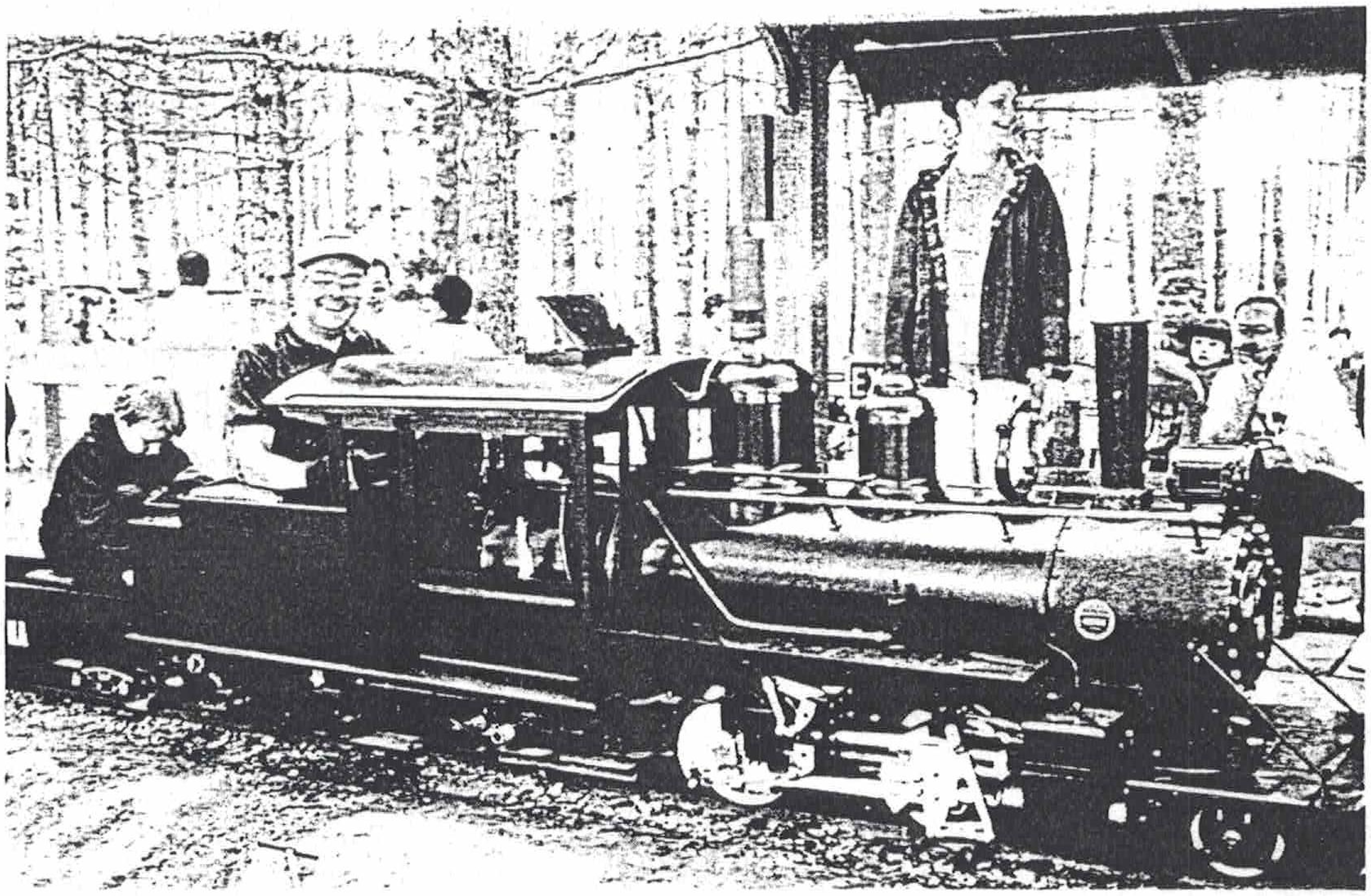
Sadly we cannot complete the grate and ashpan assembly, this for want of the grate supports and damper door which appear on Sheet No. 11, though we can get most of the way. Over the years, I have come to appreciate just how vital is ashpan design to the success of any engine, far more so that spacing of the fire bars, and fortunately in BLACK FIVE we have a near perfect example, which above all else explains why they were known as the enginemen's friend. To get a proper idea of the shape, I would take some stiff card and cut it out to place, scoring it lightly to represent the bend lines, and sticking the bits together with clear tape to check it out. Transfer from the card to 1.6mm steel sheet, including the bend lines, then saw out and fold up the various pieces. Join them together with short pieces of 1/4 in. x 1/4 in. x 1/16 in. brass angle, using soft iron or copper rivets, try in place over the extension to the firebox and braze all the joints. Ahead of this though we have to provide a hinge for the damper door, so square off a 2 in. length of 3/16 in. steel rod, chuck in the 3 jaw and drill No. 41 from each end; position as shown. A coat of heat resistant paint will make the ashpan look that much better, though how long it will remain there in service is debatable! Offer up to the firebox extension and mark along each side for four or five 8BA round head fixing screws, making sure you can drill and tap them in the firebox legs, so do this to place.

The damper lever is from 5/16 in. x 1/8 in. BMS flat, so first chuck truly in the 4 jaw and turn on the handle over a 1/2 in. length. From this mark on the fulcrum pin position, which is 7/8 in. below the handle, followed by the damper rod pin which is a further 3/4 in. on. Drill No. 22 and 31 respectively, profile to drawing, then press a length of 1/8 in. steel rod into the No. 31 hole. The actual position of the damper lever is best checked to place, for you will find it very useful at times in service as well as when dumping the fire. Although you can make up a fancy little bracket for mounting same, a 5/32 in. rivet will suffice. The damper rod is a plain length of 1/4 in. x 1/8 in. BMS strip, the ends drilled No. 30 to place, but as we cannot determine its length in this session, it will have to be set aside until next time.

I know there are still some builders who will go to any lengths to retain the LBSC traditional feature of being able to pull out a dumping pin to decant the fire all over the place. In this instance, not only would this destroy the most important feature of the whole ashpan behind the trailing coupled axle, but decanting the fire would get ash into the trailing axleboxes, something to be avoided at all costs. My feature of being able to pull the centre section of grate out through the door is now well proven and just as quick in dropping the fire, and takes it clear of the bearings.

The bars are from 3/8 in. x 1/8 in. stainless steel flat, bent to drawing and left long for the moment for fitting once the grate supports are in place. Just as a guide, the top of the bars should come no lower than level with the top of the foundation ring, just in case I forget to mention this in the next session. The spacers are best made from 1/4 in. stainless steel rod, though the 1/8 in. rod for the rivets is from mild steel. I would desist from hammering the rivets over at this stage, just peening the ends over, so that we can check against the grate supports and the firebox, which is as far as we can go this time.

## PHOTOGRAPH OF THE YEAR!



This one would have graced the cover but for being in black and white. Taken by Art Jones, it shows a happy builder with his engine, Jim Small and MAXI-LUCKY 7. I know both the feeling of building a successful engine and never having the opportunity to drive her!, though far from being a disappointment, it is nice to sit back and watch!!

# Black Five

## The fabulous Stanier Class 5MT 4-6-0 in 5 in. gauge

art 12 — Walschaert engines roll!

or a majority of BLACK FIVE builders, this is the final art of the story, leaving only the unique Stephenson link notion to be described in the next issue. Yes, I do realise here is a further alternative in the Caprotti engines, but aving been frightened by sight of Denis Evans' version of ame, I will leave this one for the watchmakers amongst our raternity!

**Completing the Grate and Ashpan**

Ve left the grate and ashpan in a most unsatisfactory state, he latter in need of the damper door. Chuck a length of 3/16 n. steel rod in the 3 jaw, square off to 2 in. overall length, entre and drill No. 41 to a full 1 in. depth, then reverse and epeat. The door itself is a piece 2 in. x 1 1/32 in. from 3mm teel sheet, so next chuck a length of 1/8 in. steel rod in the 3 aw, face and turn down to about 1/16 in. diameter over an 1/8 n. length, parting off to leave 1/4 in. of original material. Like the spigot, drill the door to accept same and press ome, then braze the bits together. Grip in the machine vice n the vertical slide, to mill away the hinges to match those n the ashpan, then assemble with a length of 3/32 in. tainless steel rod, peening over the ends.
Like the damper door, the grate bearers are from 3mm steel heet, the side fixing lugs either being bent up to place or razed on separately. Mark out and saw to profile, ompleting with files, then deal with the slots for the firebars o a 'rattling' fit: too tight a fit and you will be in all kinds of rouble. The front bearer is easy to locate, being immediately head of the grate spacers, to hold the bars clear of the hroatplate. The rear bearer needs a mite of care, for it must e sufficiently clear of the spacers to allow a loop of wire to e inserted through the firehole door to attach under said pacer to lift and draw the centre section of grate out hrough the door. I know this sounds fraught with difficulty, ut once the wire is bent up to the right shape, it is a piece f cake, the fire decanting into the ashpan, part of it out hrough the air entry, the rest being easily removed through he open damper door. Rarely if ever will the side sections eed to be removed, though they too will come through the oor, and if the centre section is replaced first, then they asily slide back into place. There is but one problem in that ome Boiler Inspectors require the ashpan to be removed or their annual inspection. Generally I support all Boiler nspectors, for their's is the ultimate responsibility, but what emoval of the ashpan exposes I am at a loss to explain: it as certainly not a requirement in full size.

**Injector Steam and Whistle Valves**

One thing I have tried to promote, ever since spending a ascinating evening with Roy Amsbury in his workshop, is ealism inside the cab. Whilst I have not quite managed it 00% with the injector steam valves, which should be bolted o the manifold, the overall effect is considered quite good, lus the design is inherently safe, so let me progress the air.
For the main body, chuck a length of 1/2 in. bronze rod in he 3 jaw, face and turn down to 11/32 in. diameter over a 5/32 n. length, using a round nose tool. Centre and drill No. 30 o 1/2 in. depth, following up with a 3/16 in. drill and 'D' bit to 1/32 in. depth, then tap the outer 5/32 in. or so at 7/32 x 40T. Turn on the 1/2 in. spheric radius, which parts off the body rom the parent bar, then lay aside for the moment.
The upper portion is from the same 1/2 in. rod, so face and turn down to 5/16 in. diameter over a 37/64 in. length, changing to a round nose tool and further reducing over a 1/4 in. length to 1/4 in. diameter, leaving the 1/8 in. shoulder as shown. Screw 5/16 x 40T over a 5/32 in. length at the outer end, then centre and drill 1/8 in. diameter to 7/8 in. depth, tapping 5/32 x 40T to 5/32 in. depth. Part off at 7/8 in. overall, then drill the No. 34 steam entry holes, before reversing in the chuck to deal with the bottom profile, including the recess to accept the main body, clamping lightly to same. Spot down through the bore, then drill 1/8 in. diameter into the main body to come clear of the valve seat. The bottom union is from 1/4 in. rod, which can be from brass at a pinch, though bronze is perferable, this piece being straightforward. Clamp the three pieces together, to be in line, then spot through from the union and drill the main body, again coming clear of the valve seat; braze up, pickle and clean.
For the valve stem, chuck a length of 5/16 in. A/F hexagon bronze rod in the 3 jaw, face and turn down to 7/32 in. diameter over a 5/32 in. length, screwing 40T. Centre and drill No. 41 to 1/2 in. depth, tapping 5BA to 9/32 in. depth before parting off at a full 3/8 in. overall. Reverse in the chuck, using a screwed adaptor, to face off to length, turn down to 7/32 in. diameter over a 5/32 in. length, and screw 40T to complete. The gland nuts are simple turning from the same material, the packing PTFE, which brings us to the valve spindle. Having access to monel at that time and applying same successfully to valve spindles and the like, this was my specification, though most builders these days will find stainless steel rod more readily available, the requirement being 5/32 in. diameter. Chuck in the 3 jaw, face and turn down in about 3/16 in. increments to 3/32 in. diameter, a sliding fit in the valve stem and over a 21/32 in. length. Reduce over the next 1/4 in. length to 1/8 in. diameter and screw 5BA, then deal with the valve itself, parting from the parent rod.
At long last I am able to dispense with description of the handwheel, for Doug Hewson has a most excellent lost wax casting for same, one which we now employ on our commercial fittings, which I trust is sufficient recommendation. I suggest that the end of the valve spindle is screwed 7BA and the handwheel tapped to suit, the former being lightly peened over on assembly, though a 7BA locknut is equally practical, in which case the spindle must be lengthened to suit, otherwise there will not be enough room to pack the gland with ease.
If the whistle valve body is made from 1/2 in. square bronze bar, then it can be chucked truly in the 4 jaw chuck to be turned down to 5/16 in. diameter over a 25/32 in. length and the outer end screw 40T over an 1/8 in. length. You could get away with 7/16 in. square bar, but this has to be chucked eccentrically to provide the necessary land for the lever fulcrum pin. Centre and drill No. 51 to 1 in. depth, following up with an 1/8 in. drill and 'D' bit to 21/32 in. depth, then a 3/16 in. drill and 'D' bit to 3/8 in. depth to form the valve seat. The lever is from 3/32 in. thick brass, which probably means 2.5mm these days, shaped to drawing. Mark off and drill for the 1/16 in. fulcrum pin in both body and lever, the offset dimension being 5/32 in., then mill or file the slot in the body to accept the lever, dealing with this end of the body to match the rest at the same time; assemble with a 1/16 in. brass rivet, though first we must deal with the outlet union to the whistle. All through this session, it will pay dividends to keep looking back at the G.A. as in LLAS No.

44, like now it will show the correct orientation of the outlet union relative to the whistle lever. In the LBSC era, tradition was that you pushed the whistle lever, whereas I prefer a cord hung from the cab roof where this was used full size, thus this lever is pulled to blow the whistle. Turn up the union, silver solder it in place, then seat the 5/32 in. ball. Most of us have experienced the embarrassment of a sticking whistle valve at some time, and it helps avoid same by making the 1/16 in. plunger rod about .010 in. shorter than the distance between lever and ball, which you can do to place. The spring wants to be from either phosphor bronze or stainless steel wire and can be made captive if you like by turning a disc to a press fit in the end, say 3/64 in. thick and drilled centrally at No. 30, then there is no chance of spring and ball falling out on assembly to the manifold.

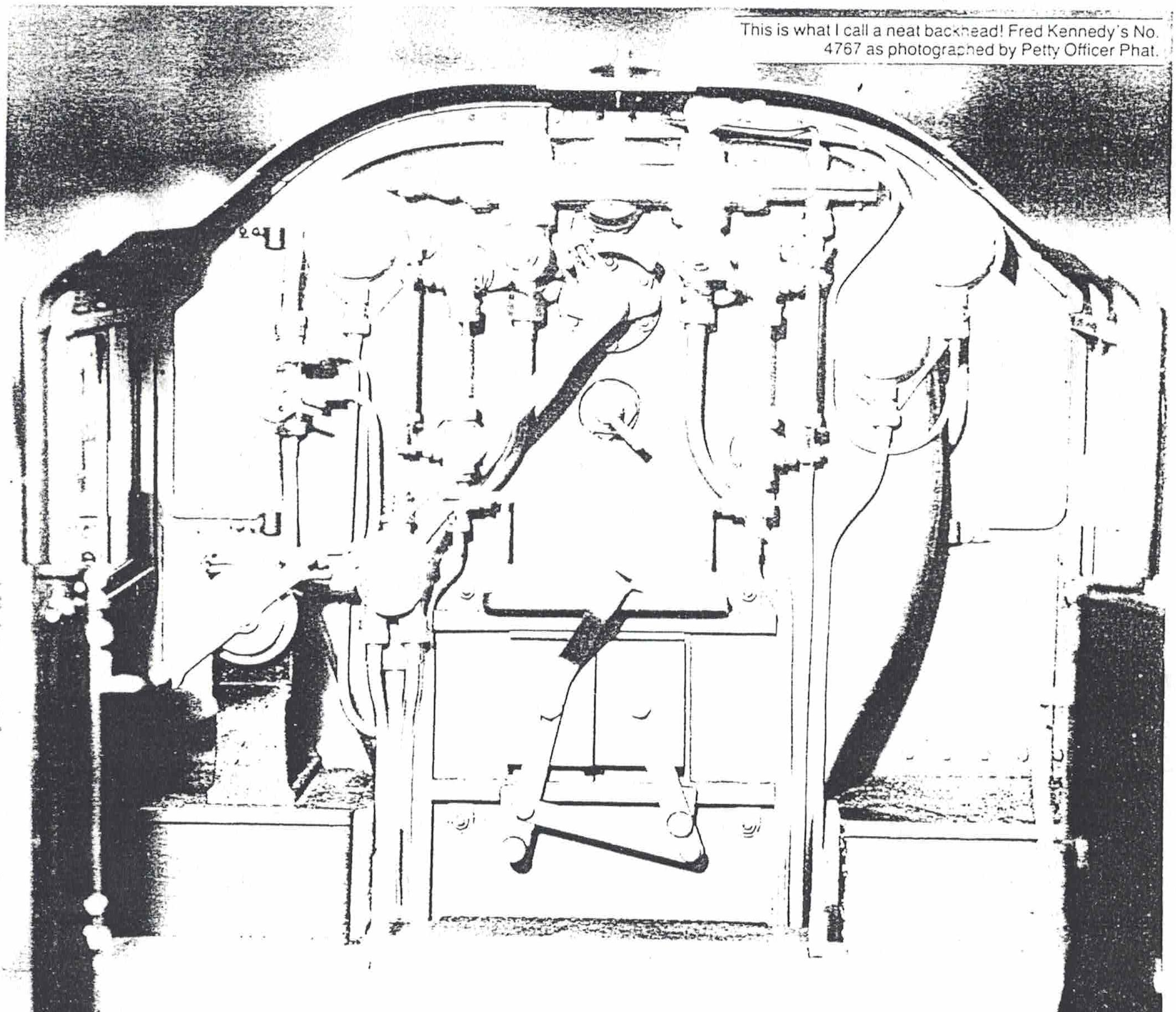
Mention of manifold, and we shall come to this in a moment, reminds me that we have to deal with the flanges for attachment of the injector steam and whistle valves to same, all being from the 1/2 in. bronze rod. Chuck in the 3 jaw, face, centre and drill 9/32 in. diameter to about 1 in. depth, tapping 5/16 x 40T. For the whistle flange, use a knife edge tool to form the small groove as shown before parting off a 7/32 in. length, then part off two more flanges at 7/64 in. thickness to secure the injector steam valves to the manifold. That leaves the ejector steam pipe flange, so face, centre and drill No. 30 to 3/16 in. depth, then scribe on the bolting circle at 11/32 in. diameter with a knife edge tool before parting off another 7/64 in. slice; drill the four No. 51 holes.

One of the injector steam valves is blanked off with a hexagon headed plug at the top, the other has a connection for the pressure gauge, though it can be an ordinary male union in place of the elbow specified, the latter being straightforward from 7/32 in. bronze rod.

### Manifold

The main central portion of the manifold is turned up from 5/8 in. diameter bronze bar and I suggest you start with a 1 3/8 in. squared length. First rough it out, turning the ends down to 5/16 in. diameter, then chuck by each end in turn to drill right through at No. 17. Finish off the central, spherical, section next, then grip in the machine vice on the vertical slide to mill a flat for the steam connection, drilling No. 6 as shown. It is best if you have already turned up said steam connection, for you can then mike the spigot and drill the central portion to suit, silver soldering together; screw into the boiler.

In times past, we were often asked if we could supply the complete manifold, which is not feasible, for to ask builders to sit the manifold bush at exactly 25 deg. in the backhead is asking too much, yet if the injector steam valves do not hang vertically they look plain awful, so this is a job that simply has to be done to place. So turn up the sleeves from the 1/2



This is what I call a neat backhead! Fred Kennedy's No. 4767 as photographed by Petty Officer Phat.

n. bronze rod. assemble them to the injector steam valves. and bring the whole up to the embryo manifold on the boiler. setting vertically and scalloping the central portion to accept same and at the 25/32 in. dimension specified. When satisfied. turn up the ends. scallop to suit the sleeves. and silver solder the complete manifold: now you have something to be really proud of!

### Water Gauge and Whistle

I do not propose to describe manufacture of these items for BLACK FIVE. having done so on numerous occasions over the years. plus both are commercially obtainable. thus will make but brief comment on same.

I know there is a school of thought in favour of one large water gauge. rather than the two I have specified. but in the early 1970's when I was running on a different track most weekends. with varying water quality. I quickly came to the conclusion that two water gauges as per full size practice was infinitely preferable. At that time. I was also using Schellbach glass as supplied by Whistons. which was great for viewing. but far too prone to breakage from being so brittle. One day I was replacing a gauge glass. wetting the end in water to aid sliding on the rubber rings. when I noticed that surface tension was leading to a completely false reading. so I tried a whole range of Schellbach and Pyrex glass. with frightening result. I know this was only against atmospheric pressure. but with Schellbach glass I could get a false result of anything up to 3/8 in.. even when the glass was thoroughly wetted. whereas the maximum discrepancy with Pyrex glass was 1/8 in.. which I have employed ever since. Now I don't want to be alarmist. for there is much that can be said in favour of Schellbach glass. especially as one's sight does not improve with age. but the effect of surface tension must be taken into account in arriving at correct boiler water level: it is so easy to be misled.

I suppose nearly all of us have experience of a water gauge playing up. when no amount of blowing down will rectify it. and the only safe recourse is to add feed water until there is evidence either at the safety valves or chimney. My experience when running with a boiler fitted with two water gauges is so much better. such incidence being much reduced and invariably confined to only one of the pair. the most minor point being that the backhead is neater and more realistic: safety though comes first!

Turning to the whistle. and again this must be regarded as a safety device. thus has to be reliable. It also has to make the 'right' sound. and in this I mean as a warning rather than absolutely authentic. indeed latterly I have become as critical of the puny note made by LNER 'Pacifics' such as FLYING SCOTSMAN and BLUE PETER as by the 3/8 in. tube ones made by Arthur Grimmett long years ago now and which I refused to stock. My feeling is that our 5/8 in. tube ones are just about perfect. though of course they are as unauthentic for LNER 'Pacifics' as they are for the BLACK FIVE. A whistle of the length as specified on the drawing will take some hiding. the alternative being as described by LBSC in his THE LIVE STEAM BOOK.

Where to move next? I think it will be best if we complete the regulator and go on to the firehole door before coming back to the remaining cab fittings.

### Completing the Regulator

For the regulator rod. start with a 15 in. length of 3/16 in. stainless steel rod. Chuck in the 3 jaw. face and turn down to 1/8 in. diameter. this to fit the boss in the regulator body. Mill or file a square over the next 1/8 in. length to suit the lever. then insert through the backhead and engage at the dome. Next chuck a length of 5/16 in. bronze or stainless steel rod. face. centre and drill No. 13 to 3/16 in. depth. parting off an 1/8 in. slice. With a 5/32 in. taper reamer. ease the fit to a push one over the protruding regulator rod. then fit the neck ring in the stuffing box to locate the collar. moving it forward about 1/64 in. so that it does not bind as the rod expands: braze in place. Chuck again in the 3 jaw. to remove all excess spelter in way of the neck ring. and we must deal with the regulator stop and handle before completing the outer end of the rod.

The stick of cast bronze bar that I supply for boiler bushes and the like is the ideal material for the regulator stop. so chuck in the 4 jaw and turn down to 1¼ in. diameter over a 7/8 in. length. after facing across. Further reduce the outer 5/8 in. length to 1 1/16 in. diameter. then centre. drill to around ¾ in. diameter and 7/8 in. depth. then bore out to 15/16 in. diameter to a neat fit over the stuffing box. Saw out the required segment. mark off and drill the pair of No. 44 holes. spot through. drill and tap the stuffing box 8BA to 1/8 in. depth.

If I were making the regulator handle today. and chance would be a fine thing!. then I would mark it out on a 6 in. length of 1 in. x 3/16 in. BMS bar in preference to fabrication. Drill a No. 28 hole and file out to 9/64 in. square. then drill another couple of ¼ in. holes clear of the profile. so that you can bolt same to the length of angle used when making the coupling and connecting rods. bolting the latter to the vertical slide table. Now you can reduce the thickness to 5/32 in. at the boss and 3/32 in. along the rest of the bar. or at least the length that will be used in forming the handle. Mark out the profile. saw it roughly to line. then bend up to drawing before tidying up the edges. all to the specified dimensions. File or mill a square on the very end of the regulator rod. fit the handle and prove operation of the regulator. checking that it will both fully open and close within the limits of the stop. Likely you will not get it right first time. so saw off the surplus rod and try again. Once satisfied. transfer from the handle to the stop and file metal away to drawing. then extend the square so that the handle comes within the confines of the stop. but is not hard up against same. Chuck the regulator rod in the 3 jaw. part off to length. turn on the outer spigot to 3/32 in. diameter and screw 7BA to complete.

### Firedoor Assembly

I was reading an account of the then newly outshopped Stanier 'Pacific' PRINCESS MARGARET ROSE only last evening. this in a 1935 issue of 'The Locomotive'. in which it was stated that the firedoors were mounted on rollers for ease of opening. I have never seen such a feature. certainly it does not appear on the Works drawings for BLACK FIVE. plus being fairly well balanced anyhow. I was wondering if they would shake open on the run?

Let us make a start with the surround. the base of which is a piece 3⅛ in. x 2⅛ in. from 1.6mm steel sheet. Mark off to include the back of the tray. then drill the four No. 34 holes and profile to drawing. You can either bend up the rest of the tray from 1.2mm thick material. or mill from 4mm plate. there being very little to choose between the two methods. The slides are from 7/32 in. square bar. such section only being available in brass according to Reeves latest Catalogue. which will be perfectly OK. Fit an angle plate to the vertical slide. clamp a 4 in. length of bar to the angle plate. then use a slitting saw to produce the slot for the door. sawing away the excess at each end. You really want to try the doors in situ before brazing up the surround. plus we still need the brackets as fulcrum for the lever and handle ahead of this operation. the brackets themselves being from 1.6mm steel strip. the fulcrum pins turned from 7/32 in. steel rod. Positioning of the brackets is critical to ensure both doors open together. thus you can further delay brazing until all the bits have been made and tried in place.

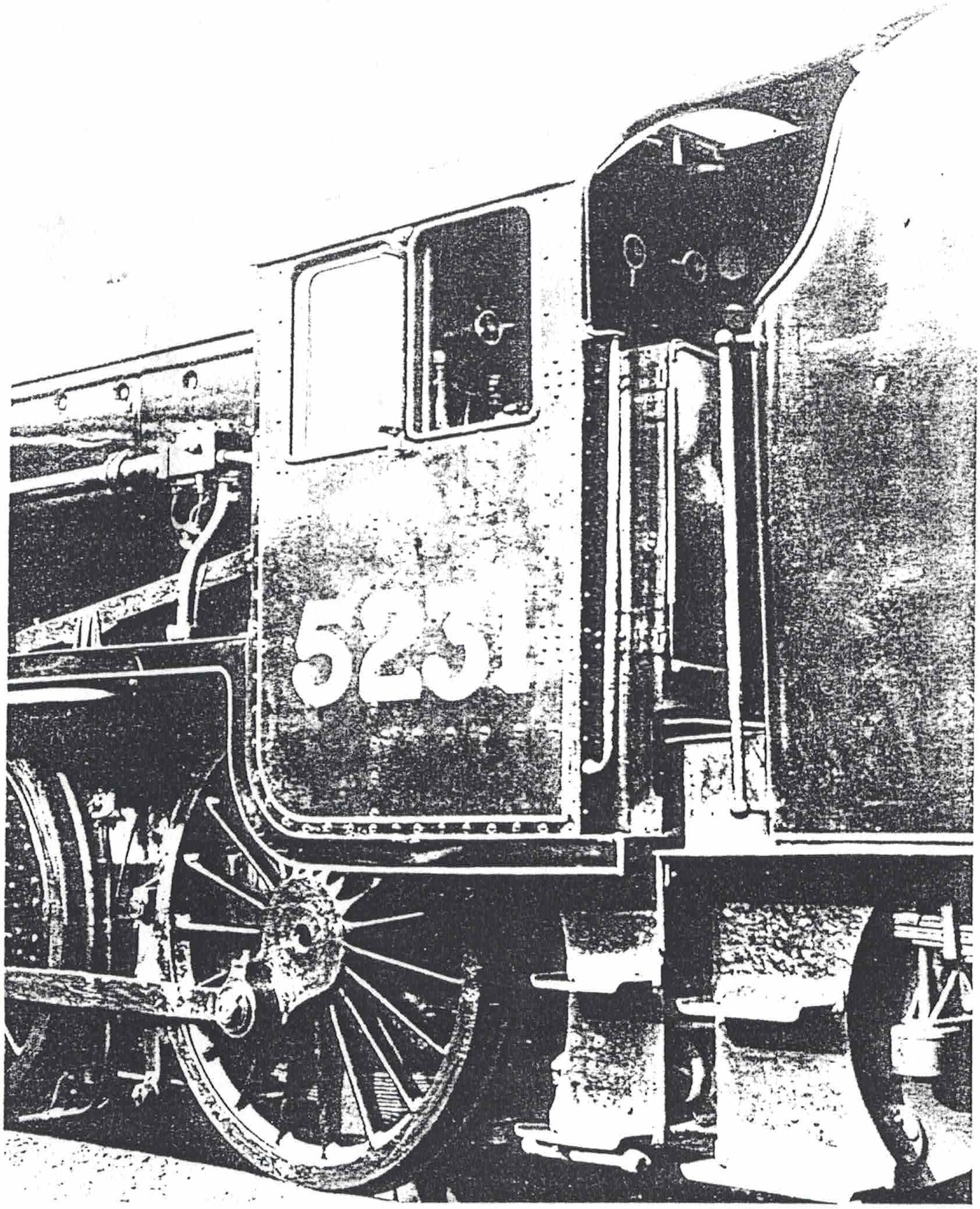
The doors are quite clever. being castings full size. and include an air entry slot at the bottom. We shall have to fabricate them. so start again with the base. which is a piece

$1\frac{9}{16}$ in. x $\frac{25}{32}$ in. from 1.6mm steel sheet. Drill centrally at No. 31 and press in an $\frac{1}{8}$ in. pin, which wants to be $\frac{13}{32}$ in. long, then mark off and drill the four No. 45 air holes. The outer piece is bent up from the same width and thickness material, drilled to slip over the projecting pin, side pieces being added to complete the box structure, when the whole can be brazed together; try the doors in the surround.

Bend up the handle from $\frac{7}{32}$ in. x $\frac{1}{16}$ in. steel strip to approximately the dimensions as shown, and please refer back to the G.A. again, when you will see it is positioned so that the driver can assist by opening and closing the door as each shovelful is fed into the firebox. Such was common practice on the smaller tank engines, like the 02's on the Isle of Wight, but the little experience I have of sliding firehole doors on larger locomotives was that the driver was far too pre-occupied in keeping a proper lookout to worry about such mundane matters, thus the firedoors remained open for each round of firing. Turn up the boss from $\frac{7}{32}$ in. steel rod and scallop the handle to suit, then mark off and drill No. 43 for the $\frac{3}{32}$ in. pin, two holes at $\frac{1}{8}$ in. diameter to start forming the slot, completing the latter with files; braze up.

The lever is from the same section material as the handle, so first mark off and drill all the holes, opening out the pair of $\frac{1}{8}$ in. ones into the slot as shown. Turn up the wee boss from $\frac{7}{32}$ in. steel rod, press in the $\frac{3}{32}$ in. pin and braze up, completing the profile with files. That leaves only the link, perfectly straightforward from $\frac{3}{16}$ in. x $\frac{1}{16}$ in. steel flat, when all the pieces can be assembled. Chuck a length of $\frac{3}{16}$ in. steel rod, face, centre and drill No. 31 to about $\frac{3}{8}$ in. depth, parting off two $\frac{1}{16}$ in. slices and pressing them over the ends of the fulcrum pins, then centre again, this time drill No. 43 to $\frac{3}{8}$ in. depth and part off a further two $\frac{1}{16}$ in. slices to hold the link firmly in place.

I know there are a lot of you nowadays who do not like




I have been saving this Tom Goulding masterpiece for some time, it being full of useful detail for this latter stage in the proceedings. For such a simple cab side, there sure is a lot of detail to include, especially if one is a member of the R.C.A. (Rivet Counters Association). Then ahead of the cab is the ejector, and of course it is open to builders to tart up Brian Hughes functional design to be more realistic in appearance. Taken in conjunction with the previous photograph on Page 30, this provides a fine record of a typical Stanier cab.

apping into the boiler plates after the boiler has been ydraulically tested, or indeed at all, thus a 3mm thick apping strip will be required above and below the firehole o cater for same. It is not quite as simple at that though, for uch would leave a large gap at the back of the surround for nregulated air entry over the top of the fire, which has to e avoided, thus you must flange up a backhead surround, or which can I refer builders to the NEWPORT series unning parallel with BLACK FIVE, the space between backhead surround and the backhead itself being filled with ibreglass matting or the like.

## VACUUM BRAKE EQUIPMENT

Let me briefly describe the vacuum brake circuit as it applies to the engine, taking in the steam brake as we reach same, as a prelude to dealing with the piece parts on this sheet, as they are not the total required.

Centrepiece is the vacuum ejector, located on the LH side of the firebox just ahead of the cab, again as shown on the G.A. The one depicted is the standard Hughes type, which is detailed with the, vacuum braked, bogies on Reeves RV7 drawings. This is a 'single jet' ejector, meaning there is no separate 'pilot jet', and whilst we have produced kits which include a 'double jet' ejector in the past, same has only been in very limited quantity. The ejector is of course supplied from its ejector steam valve, which is detailed on Sheet No. 11, there being two valves in the fitting. For an ejector with both pilot and main jets, obviously the small jet valve has an individual purpose, plus in any case must remain open at all times when running. In my variation of the design, feeding a single jet, steam from the small jet valve by-passes the main valve, going directly to the ejector, where it helps maintain train pipe vacuum against any air leaks into same. Please adopt full size practice and open the main jet valve ahead of braking, so that you have full control of the train at all times. Many a full size driver has forgotten this to his cost, in fact I wonder why such an antiquated system was retained into BR days, when the combined injector/brake valve as example described for DONCASTER, was so much safer.

When running, vacuum in the train pipe is retained at a constant level by means of a limit valve, which we have been able to supply, though such is not to detract from the Hughes pattern as on the Reeves drawings. To apply the vacuum brake, air is allowed to enter the train pipe at the brake valve, and in full size this is allied to a graduable steam brake valve for the engine, which can also be applied independently when the engine is running light with no vacuum in the train pipe. I have omitted that facility, the steam brake being applied slightly after air enters the train pipe, to provide a measure of control so that it is the train which brakes the engine, rather than the reverse. I will describe this feature more fully when we come to making the actual brake valve.

The final and most important point I want to make in this opening gambit is that with an engine of the power of BLACK FIVE, some form of continuous braking is essential, and as the Hughes system is the one that has been around for nigh on 30 years now and is well proven, such is the one to adopt universally; such is my strong recommendation.

### Ejector Steam Valve

Most of us have an odd gunmetal casting lying around somewhere, and such will be ideal for the valve body; we need a piece roughly ¾ in. x ⅝ in. x ⅜ in. Mark off for the main valve and get this running true in the 4 jaw, to turn on a 3/64 in. raised spigot to 5/16 in. diameter, facing right across. Centre, drill 3/32 in. diameter and 'D' bit to 15/32 in. depth, following up with a 3/16 in. drill and 'D' bit to 11/32 in. depth to form the valve seat and tapping the outer 5/32 in. or so at 7/32 x 40T. Although the valve stem, spindle and gland nut are not quite identical to those items for the injector steam valve, they are sufficiently similar for me to dispense with their description, plus the same Hewson handwheel can be used to add a final touch of class.

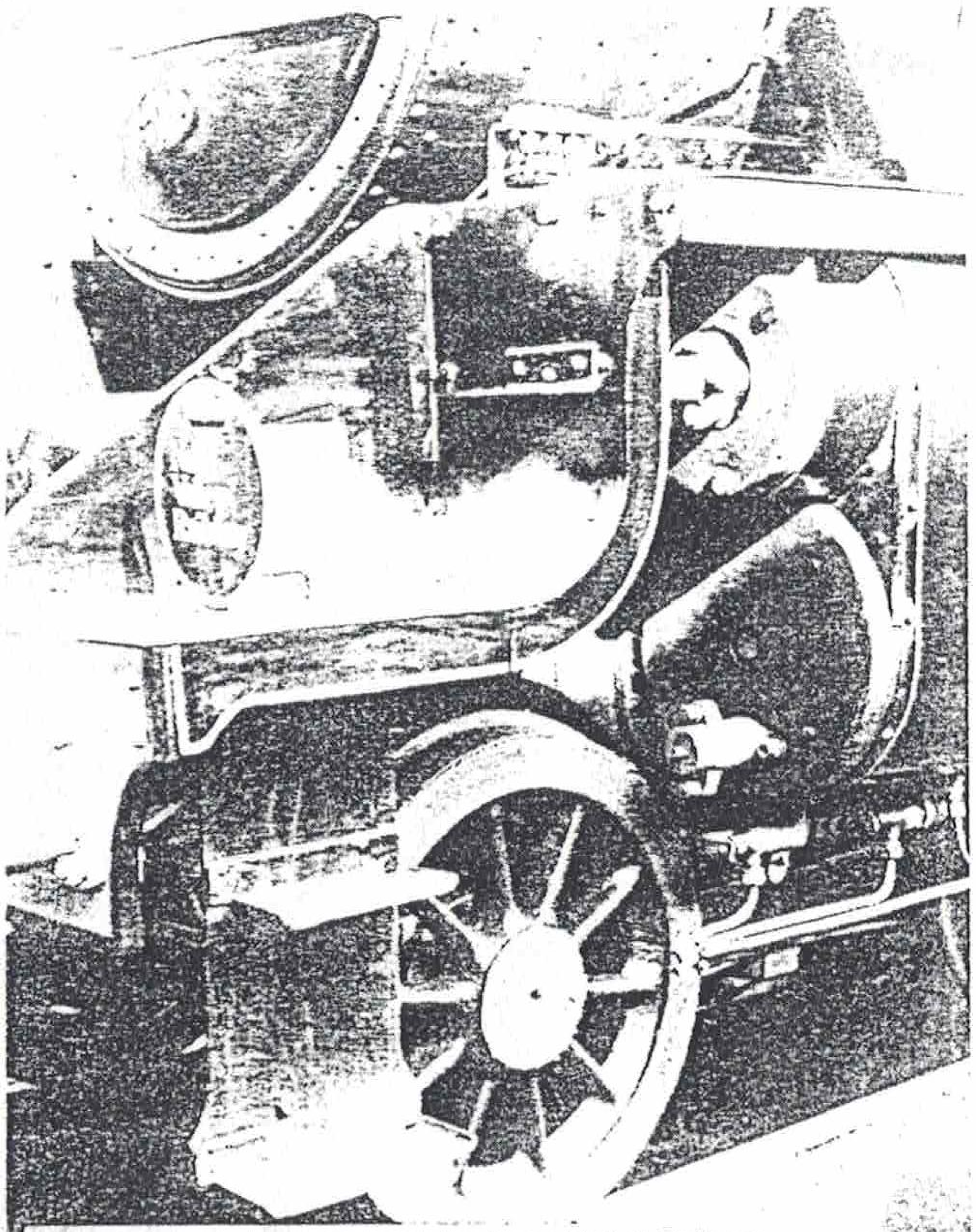
Remove to the machine vice and vertical slide to deal with the pilot valve, for which centre and drill 1/16 in. diameter to 15/32 in. depth, followed up with a 5/32 in. drill and 'D' bit to ¼ in. depth and tapping the outer 5/32 at 3/16 x 40T. Because a plain 8BA thread exposed to steam at boiler pressure is bound to leak if no gland is provided, which will be very uncomfortable for the driver, I have instead specified a double seated valve, one which seats onto the valve stem when opened. This of course means that the handle will only traverse about 270 deg. from fully closed to fully open, which requires careful machining to achieve. Chuck a length of 3/32 in. stainless steel rod in the 3 jaw, face and turn down to .086 in. diameter in increments over a ⅜ in. length, setting the tool over 30 deg. to achieve the back seat; screw 8BA. Form the other portion of the valve as you part off, leaving about 5/64 in. length of the original material, then chuck a length of 7/32 in. A/F hexagon bronze bar for the valve stem. Face, turn down to 3/16 in. diameter over an ⅛ in. length and screw 40T, then centre, drill No. 51 to ⅜ in. depth and tap 8BA. Countersink the mouth of the tapped hole to accept the valve, then part off to leave a 1/16 in. head: assemble and adjust as necessary. We have made handles such as that depicted before, for NEWPORT if not for BLACK FIVE, thus the description exists, this one being tapped 8BA to suit the spindle and retained by a 1/32 in. pin.

To complete the body, we have to make and fit the pair of 7/32 x 40T union connections, drilling the internal passages from same as specified. Complete shaping the body to drawing, then braze in the connections, pickle and clean up.

### Combined Vacuum/Steam Brake Valve

An odd end of cast gunmetal bar is best suited for the brake valve body, so chuck in the 3 jaw, face and turn down to ¾ in. diameter over a ¾ in. length, parting off a full ⅝ in. slice. Rechuck in the 3 jaw, face off to length, then centre, drill through and ream to ⅛ in. diameter. Next mark off and drill the specified ports from each end of the body and we must tackle the union connections. The ¼ x 40T at the front from the train pipe is easy, the body being drilled to accept same and continuing at No. 34 to meet the air entry port, at which point you can file the wee nick as indicated. This is so that you can make a minor brake application, say just to steady the train into a curve, the brakes releasing almost immediately once the port is closed off through the ejector getting on with its job.

Towards the back of the body, there are two 7/32 x 40T union connections, one going to the steam brake cylinder and the other exhausting to atmosphere, the latter pipe being taken down below footplate level. Turn them up as before, though with a spigot a full ⅛ in. long to enter the body as shown. Take the body to the machine vice on the vertical slide, centre a hole, drill No. 41 to pick up the relevant port, then open out to a press fit for the union connection: repeat. Full size, on top of the body is the vacuum limit valve, which feature I have utilised for steam entry to that brake valve, the vertical portion of which may also be spigotted if you prefer, with 1/16 in. hole drilled right down to the central bore, picking up the steam port on its way down. The steam pipe connection though will have to be scalloped to suit the vertical portion, when we just need the support for the brake handle guide to complete the assembly. The best way to tackle these is as a pair, so chuck a length of 1 in. diameter brass bar in the 3 jaw, face, centre, drill and bore out to ¾ in. diameter, a nice fit over the valve body, parting off a 1/16 in. thick slice. Mark a segment off as the guide, drill the pair of No. 51 holes, then saw out and file the end radii. Offer up to the remaining portion of ring, spot


This shot reminds me to thank the Nene Valley Railway for their assistance in illustrating the BLACK FIVE series.

through, drill and tap the 10BA holes, then saw away the surplus and fashion the ends to drawing, lightly clamping to the body. Now you can silver solder all the joints, taking care to keep spelter away from the end faces, typewriter correcting fluid being an excellent way of achieving this.

For the dummy limit valve, chuck a length of 5/16 in. brass rod in the 3 jaw, face and turn down to 5/32 in. diameter over an ⅛ in. length, screwing 40T; centre and drill No. 50 to about ¼ in. depth. Leave 1/16 in of original rod, then turn the next ⅜ in. down to ¼ in. diameter, rounding off the raised collar with a file, then drill the No. 57 blind holes as an optional extra, before parting off. Screw into the body, then drill No. 50 from the steam entry connection into the central bore of the limit valve. Looking at the assembly of the combined brake valve, you will see a wee spring extending down from inside the limit valve to the top of a short length of stainless steel rod, which I have labelled the steam valve. The idea of this is that when a small application is made to the main vacuum brake, there is no point in making a similar application to the steam brake, for all it will achieve is a condensate build-up in the latter, thus it is likely to be waterlogged on the occasions that we desperately need it. The idea is to have a slot in the brake valve spindle, so that the steam valve drops away clear of the port when the steam brake is applied, and the shaping of said slot does require some care to make sure the steam valve does not become jammed, thus wants to be cam shaped rather than the hole I have shown, so try it on an odd end of ⅛ in. rod before making the actual spindle. Staying at the steam brake end for the moment, next turn the valve cap from the ¾ in. diameter bar, which can be brass if you wish. Scribe on the bolting circle with a knife edge tool, mark off and drill the five No. 51 holes, offering up to the body in the orientation as shown, to spot through, drill and tap 10BA to about ⅛ in. depth. I see that I have specified 'plastic gasket' as the sealing medium, since when I have learnt better!

For although it provides the perfect seal, it will also run up the threads of the 10BA fixing bolts, after which you will have to drill them out, for you will never unscrew them unless the threads have been greased.

Steam brake valve next, for which chuck a length of ½ in. brass rod in the 3 jaw. Face across and turn down to 15/32 in. diameter over a ¼ in. length, then centre, drill No. 41 to ¼ in. depth and tap 5BA, lightly easing the mouth of the tapped hole with a countersink bit. In a recent letter to me, Norman Lowe reported that he had suspended construction of his LNWR 4-4-0 'Precursor' TITAN to make a rotary table. The object of the exercise was to then machine the smokebox front plate, after which it has been laid aside with no immediate further use. I can think of another good use right now, for gripping the ½ in. brass rod in the 3 jaw chuck attached to same, we could quickly deal with the blind steam and clear exhaust ports in the valve face, whereas the other way is to drill a series of holes, blending them into a blind port, plus rotating through 90 deg. and then 65 deg. is easier said than done! Once the ports are completed, return to the 3 jaw chuck to clean any burrs from the valve face, then part off a 3/32 in. slice.

The brake valve spindle is plain turning, save for the 3/32 in. square to accept the vacuum brake valve, though leave this for the moment, as it has to be properly orientated. Screw the steam brake valve to same, indeed this could best be done by gripping the spindle in the tailstock chuck and screwing into the valve before parting the latter off. Apply a drop of fine grinding paste and bed the valve to the body, cleaning off every vestige of said paste and applying a drop of molybdenum disulphide grease on conclusion. Ahead of this though, you will find that the brake valve disc partially obscures the steam entry port, so relieve the valve as shown to clear said restriction.

For the vacuum brake valve, chuck the ¾ in. diameter brass bar in the 3 jaw, face, centre and drill No. 43 to ¼ in. depth, parting off an ⅛ in. slice, with a slight radius at the edge. File or broach the central square, then mark off and drill the No. 30 air entry hole, in fact you can make the whole face a 'pepper pot' of blind holes if you like, to represent full size. Next read Note No. 2 on the drawing, position the valves as thus specified, then file or mill the valve spindle to achieve same. The brake handle is best turned from ⅛ in. brass rod, the lower portion filed to the section shown, after which it is silver soldered in place. Now you can bed the vacuum brake valve to the body in the same way as for the steam valve. Assemble with a double coil spring washer, and luckily I have one or two of these by me, remnants from a washer selection provided by Whistons long years ago, as was the 8BA nut with its fibre insert by way of locking to complete the assembly. That is all but for fixing the brake handle guide, which requires turning up the wee spacers from ⅛ in. brass rod.

**Firehole Screen**

In my dash for completion, I see I have omitted to provide for the driver's personal comfort in the shape of the firehole screen, probably because I reckon it was of dubious value. On the LNER engines with which I was most familiar, such screen was attached to the firehole door hinge, swinging independently from same as I described for DONCASTER. Its main purpose as explained to me was in reducing glare from the fire, which was never the best feature in driving a steam locomotive after dark, which is why so many drivers kept their heads out of the cab, even in the most inclement weather.

When men were demobbed after WW1, vast numbers of them were taken on by the railways, their seniority being measured in days rather than years, thus many of them employed on the footplate never reached the top links as drivers; many who did were nearly 60 years old and past their peak; to me it seemed a crazy situation. Much was made of the way Dick Hardy dealt with the situation at

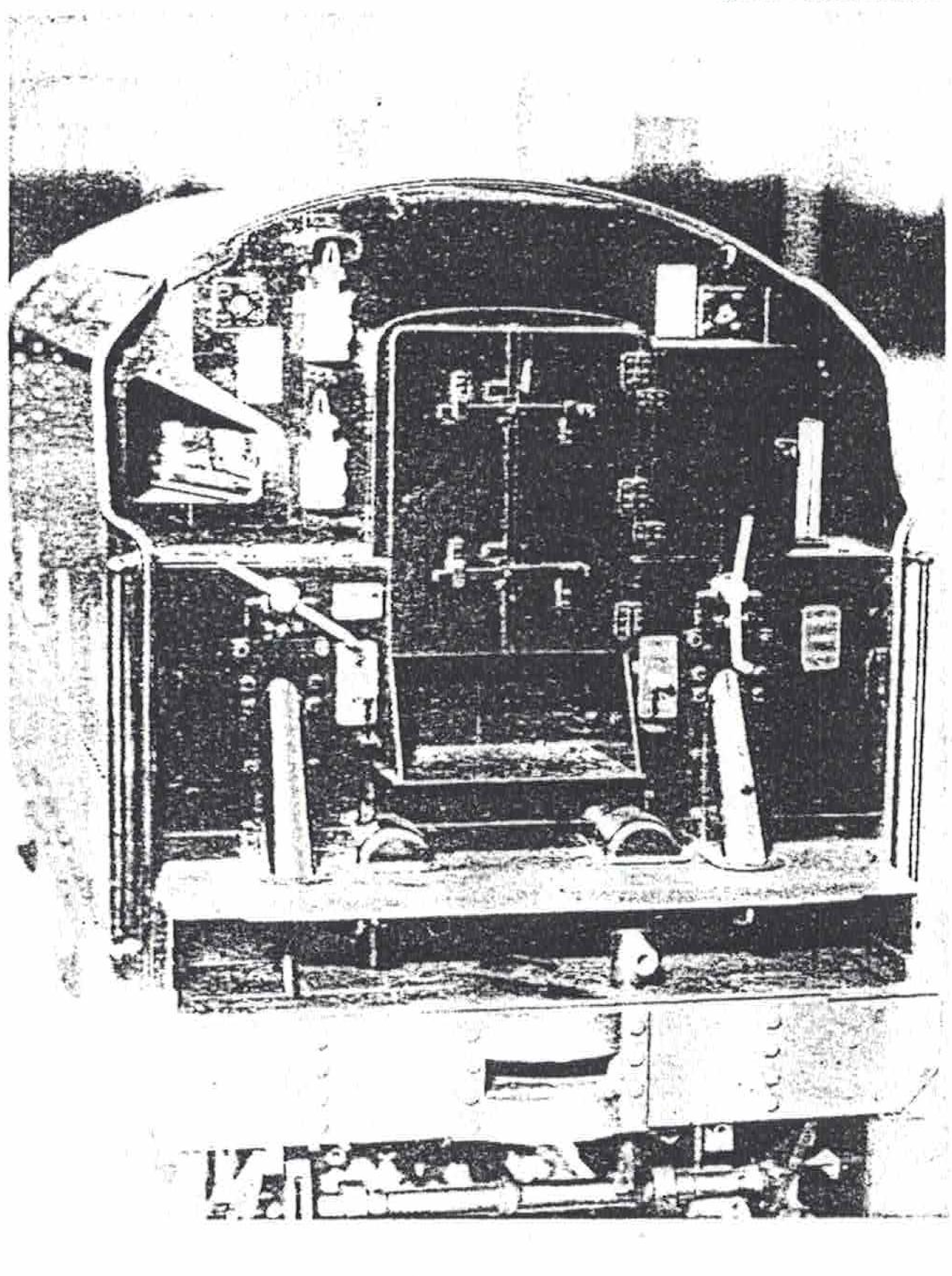
tewarts Lane: pairing off 'juniors' and sending them out on aturdays with a most arduous turn of duty ahead of them. But these were men at the peak of their physical power and ndurance; men who revelled in their responsibility. With peeds on InterCity routes so much higher today, allied to ne-man operation, it really is a job for the younger eneration, though of course there is no longer the ongestion on our lines of former years, more is the pity. All his to introduce such a humble object as the firehole creen!, especially as it does not properly perform its task, or it has little value in eliminating dangerous glare, more in protecting the driver's legs from the heat of the firebox, omething he might be glad of on a cold winter's night.
The main portion can of course be from 1.6mm steel sheet, providing it can be flanged as shown without cracking, ⅛ in. half round beading being sweated to same; that was easy!

**Running Boards and Steps**
I have already made reference to the side running boards in previous instalments, though they remain incomplete for lack of the front section and cab. This reminds me that I was taken severely to task for my detail of the reach rod shield by one of my readers, who tells me that it should be curved at the top, rather than flat as I have shown it. This had me searching frantically for evidence of same, and on the surface it appears I am wrong for 99% of BLACK FIVE's, and yet every detail was taken from Works drawings loaned me by Norman Lowe, so why was I wrong? The answer I think lies in the video on the BLACK FIVE's as reviewed in CLAS No. 54, for I am almost positive that I detect one reach rod shield of section to my detail, having 'frozen' the shot and stared at it for hours on end!
For the centre section of front running board, start with a piece 4¾ in. x 4⅛ in. from 1.6mm steel sheet and trim to length to fit to the smokebox saddle. From the same section material, bend up the stepped portion in front of the smokebox door, trim off the flanges and drill the row of No. 44 holes. Offer up to the saddle, spot through, drill and tap 8BA and secure temporarily in place. We now have to join the two pieces at the lower flange, which is best achieved using 1/16 in. copper rivets, and I suggest the spacing could be as for the bolting flange above, though reference to the engine of your choice may reveal something different.
For the side sections of front running board, start with two pieces each 6 in. x 2 7/16 in. from 1.6mm steel sheet. Mark them off in the flat to include the 'waisting' down to 1 15/16 in. width, sawing and filing as a pair, then bend up to drawing. Offer up to the engine and again trim off the excess to place, then bend up the valance angle to suit. Usually when you try to pull brass angle to form a radius, it distorts quite badly, in which case cut out the offending portion and replace with 1.6mm brass sheet, silver soldering the joint and then fashioning to match. In any case, it requires a wee block to be silver soldered on at the front, so that you can attach the valance to the buffer beam. Rivet the valance to the running board, bend up the wee step and rivet this in place. As this complete section of running board has to be removed for piston and valve examination, it is bolted in place rather than riveted, quite a few of the photographs which have illustrated the series showing this feature quite clearly.
Every time I look at LMS steps, I am reminded of the total confusion I was caused by a proliferation of different styles on the Horwich 'Crab': they were bewildering! Although I could be wrong, again!, my impression of the BLACK FIVE is that they were uniform as I have drawn them. Bend up the back of the steps from 1.6mm material, after marking them out and sawing to profile, the steps themselves being best bent up from 1.2mm brass. The upper step on the front pair is as shown on a very early drawing and I see that later on these had the same ½ in. backing flange as the rest, which will make them easier to rivet in place. There is a stay from each back to the mainframes, which is bent up from 3/16 in. x 1/16 in. strip, and this is best done to place, using some of the published photographs as a guide.

## THE CAB
And so we come to the last major assembly, the Stanier style cab which is so distinctive, though it owes much of its origin to Horwich, making an interesting comparison with that specified for my E. S. COX.

### Cab Front and Sides
It seemed wrong to label this as the 'spectacle plate', for there is very little spectacle about it! I suggest you cut this out from stiff card in the first instance, and it must be in two pieces as drawn, offering up to the boiler, etc. and only transferring to 1.6mm steel sheet when satisfied. You will probably be far better off making the cut-out for the reach rod into a slot, then you can just slip the front over same, which brings me to the window cut-outs, including those on the cab sides. If you add ⅛ in. all round at the front spectacles, you will see the surround comes very close to the edge, making fixing to the cab side rather difficult, indeed there is a case for silver soldering the joint between them, rather than using the traditional method of angle attachment. For the cab sides, I have shown the full window aperture, which requires ⅛ in. to be subtracted from same all the way round to allow for the half round beading. This brings up the question as to whether all the windows should be fixed permanently in place, or whether the rear side ones should be on slides, as per prototype. Windows have no practical use on a 5 in. gauge BLACK FIVE, especially one that has been built to earn its keep, which has been my primary intention, rather than life in a glass case, so I will leave this decision to you the builder, as I am impatient to see your engine in steam!
Looking at the cab side, you will see a sort of alcove containing the handrail, though whether this also had the

Question: To what gauge has this Stanier 4,000 gallon tender been built?



purpose of protecting the crew from draughts I cannot say. I would suggest that it be bent up with the side in a single piece, this ahead of making the cut-outs for the windows and completing the profile, then you can use the bends as your datum. The seat box is self-explanatory and would come nicely from a length of 1¼ in. square tube, the brass variety with square corners, otherwise it will have to be fabricated. The box is topped off with an ⅛ in. thick wooden seat, and as that on the driver's side is unsupported, I suggest it be permanently hinged downwards out of harm's way. The 3/16 in. half round beading will have to await erection of the cab roof, as it matches with same.

## Cab Roof

The cab roof is a work of art, the rear portion being detachable full size for crane hooks to attach under the drag beam for ease of moving around the repair bays. This was a great improvement over LNER practice, which required removal of the complete cab structure for lifting purposes, even for an intermediate refit where the boiler was left in the frames, thus over the lifetime of an engine, the LMS ones were obviously more cost-effective.

Using rollers, the roof shape will fairly readily be obtained against the cab front as gauge, so produce both sections together, the rear portion to 2⅞ in. width, so that you can exactly match the profiles. Concentrating on the front, fixed, section first, this is 5 5/16 in. long and trimmed at the edges after rolling to 9¼ in. overall width. Bend up a length of 3/16 in. x 3/16 in. x 26 s.w.g. brass angle at the front, riveting to the roof, though there should not be need to attach to the cab front with more than a very minimum of 10BA countersunk screws. The stiffness is required at the rear end, this end piece being really massive and with a ¼ in. flange, which can only be fabricated. So mark off and saw out the vertical portion, filing the upper edge to match the cab roof to place, then cut a strip 3/16 in. wide from 1.6mm material, bend to suit the roof and silver solder to the vertical member. This will likely lead to some distortion, but as the material will be softened through being subjected to heat, you should be able to true it up again by hand pressure against the roof as your gauge, after which rivet in place. The 3/32 in. x 1/16 in. gutter strips can best be soft soldered in place, so tin both surfaces, then clamp the strip in place and run a soldering iron along the top of same so that the joint fuses.

Cab roof supports next, and if such small fabrications are not your forte, though BLACK FIVE has already given you a good grounding in same!, then mill from 7/16 in. square brass bar, silver soldering on the end flange and profiling the vertical web to drawing. Mark off and drill the four No. 44 holes, clamp to the front section of roof, bring up the rear section to make sure of the match, then spot through, drill and tap 8BA. The rear section of roof is cut away at the sides, so mark off and do this, bending up 3/16 in. half round brass beading to sweat to same, though leave this until the whole structure is ready for such treatment. Along the rear of the roof and on the upper face, is a length of 5/32 in. x 5/32 in. x 26 s.w.g. brass angle, which will bend easily to the required profile, there being a similar length of 3/16 in. strengthening angle at roughly the mid-point on the under side, though this is further stiffened by a 1.6mm vertical membrane which is ½ in. deep at the centre and blends to the angle at its ends. All we need now is those two 3mm thick blocks at the ends to complete attachment to the fixed portion, when we can sweat the whole lot together, though if maintaining the position of all the various items is a problem, then add a rivet or two at the outset to teach them manners. Drill a No. 44 in each of the outer blocks, offer up to the fixed section, spot through, drill and tap 8BA, and the Walschaerts version BLACK FIVE is complete as far as my description is concerned, though you can add finishing touches to your heart's content!

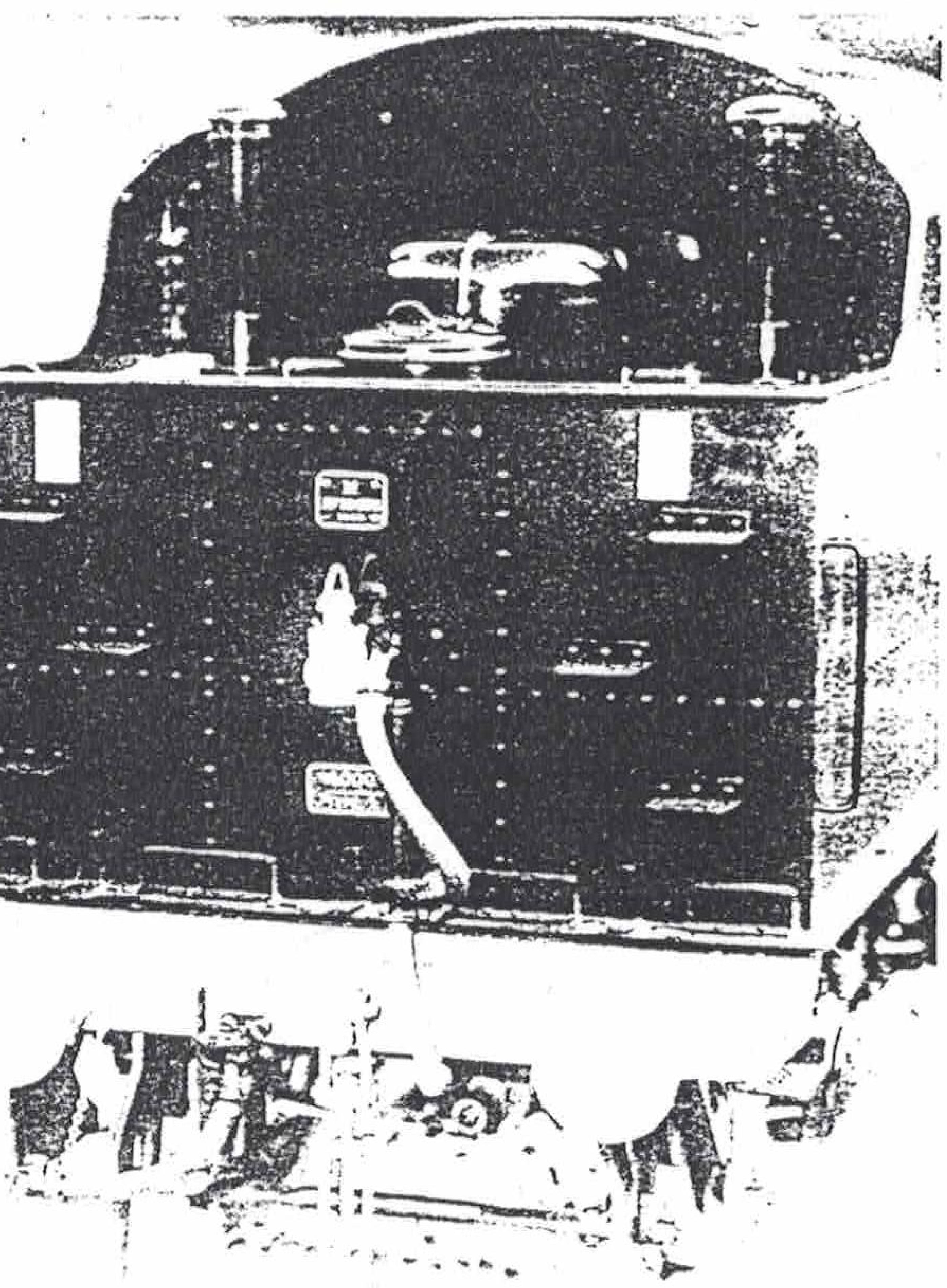
## Running in

If the evidence of the 1992 Midlands Exhibition is anything to go on, then a largish number of BLACK FIVE's will be reaching the track in rapid order, thus it seems appropriate to make some mention of running in procedure, though I will confine myself to the bare bones of same.

The day before the first light-up, fit the bottom of the smokebox, up to the level of the ring at the front and about ¼ in. below the bottom row of tubes at the back, with magnesium silicate, the stuff that heating engineers use in your domestic boiler. It is mixed with water and is rather corrosive, which is why it should be left until the last moment, so that you can rapidly dry it out. At the first steaming, don't think about opening the regulator, or using the injectors, but simply boil the water in the boiler, and if the water level permits, increase pressure to lift the safety valves, just as a check, then allow pressure to fall away, dropping the fire of course, blowing down at 10/15 p.s.i.g.: no higher than this. Such exercise is worth repeating a second time, as it helps remove the salts from all the brazing operations, meaning the boiler is less likely to prime and the water gauge readings quickly become reliable, plus copper filings and the like do not come over with the steam to such delicate parts as the piston valves and injector cones, where they can and will wreak havoc! Full size in marine practice, we used to blow the steam circuits through at boiler pressure before connecting to such delicate machinery as steam turbines, and you would be amazed at what could emerge on occasion.

Going to the track for the first time, the main thing we have to protect are the piston valves, it being perfectly legitimate to pour oil down the blastpipe, though do stand clear when you open the regulator, a better way being to prime through from the mechanical lubricators. Raise steam with the drain

Answer: This is the 5 in. gauge tender that couples to Fred Kennedy's No. 4767.



cocks open, always, and if an oil emulsion emerges rather than clear water, so much the better.
Even the most experienced builder will want the track to himself for the first run, in fact experience teaches this!, so that you can begin to get to know your engine, and make a note of any defect as it manifests itself without having to worry about holding up any other locomotives on the track. You may well have to do an accumulation test to satisfy the Boiler Inspector, in which case those early steamings before getting to the track will be of the greatest benefit, for those 'pop' valves really do their stuff, and will lift water a plenty if the salts were still present, worse still going over to the cylinders and removing the oil film from the piston valves, so be warned! BLACK FIVE though is a docile beast, Stanier saw to that in the initial design, so once you have the measure of your engine, I promise you will have a hugely enjoyable time, but then it is for you to tell me that, not the other way around, so have fun!!

# Out and About

## North Wales '92

Before I type a single sentence, I have a feeling that this year's report is going to read a bit like Penny Junor's infamous Moan Line on the BBC TV 'Holiday Programme', which will create the impression that ours was not an enjoyable stay, something that could not be further from the truth, for two of the three of us had a wonderfully relaxing time. Let me deal first with the contact Elaine and I had with the Rheilffordd Ffestiniog, for this is the opening question with all that I meet.
Barbara was rather slow in getting ready on our first morning with the Cangini's, the Friday after Bank Holiday, so Elaine and I took the opportunity to explore, arriving in due course at Tan y Bwlch. We stood alongside the fence as the first Up train of the day arrived, to discover is was hauled by a lovely dark blue painted LINDA with Joe Clulow aboard, he who had been dismissed from Boston Lodge not two years previous. I was to learn later that Joe is now a volunteer for footplate duties and not employed by the FR, but the immediate reaction was that it was good to see him back where he belongs.
On the following Tuesday morning, Barbara went to the local supermarket before we embarked on the programme for that day, managing to trip up in the process and damaging her right knee, which rather curtailed her activities thereafter, leaving Elaine and I to our own devices for much of the time. Thus on the Wednesday morning, we visited Boston Lodge for the one and only time during our stay, it being almost totally deserted. True, MERDDIN EMRYS was in course of preparation for her day's work, but in such an amateurish manner that I quickly lost interest and moved on. MOUNTAINEER was in the Engine Shed obviously languishing with some disorder, and BLANCHE was still in Works, though much progress had been made since our last visit a year ago. As we retraced our steps back to the Bentley, we came upon a group of youths whose job appeared to be pointing a wall, only the wheelbarrow containing their 'mortar' seemed composed of equal quantities of water and sand, with little or no cement in evidence; that just about summed things up at Boston Lodge in 1992.
Apart from exchanging hurried 'Good mornings' with Arthur Brooks as he sped past me on the Monday morning across the Cob, the first contact I had with a friend on the FR was on the Thursday morning, catching up with Evan who was driving the newly introduced to service, but unfinished, double Fairlie. The lack of a cab roof was immediately apparent, but Evan then went on to tell me there was also no handbrake, the engine having to be 'scotched' at night to prevent her running away. Evan also went on to tell me that he was fearful of his employment prospects during the winter months, such was the state of finances on the FR, which struck a sympathetic chord. Thus the next morning, with Barbara still in obvious pain, I determined that Elaine and I would ride the Festiniog, to help their cause.
We arrived at the Booking Office at 10.10 to catch the 10.45 to Blaenau Ffestiniog, my instruction being 'one full, one disabled, first class to Blaenau — and back'. 'One moment, Sir', a tapping of computer keys and then 'That will be £21.60'. That sounded about right to me, the concessionary fare for disabled being such as to give us first class tickets for the price of two full third class fares, so out onto the platform we went to watch Evan assembling the 10.45 train train and then shunting it into the platform. We waited for the lady guard to unlock the carriage doors and just before boarding, I checked our tickets — **we had been given two full third class fares!!** Our morning had been spoilt before it had begun, again this was the sole instance of no concession for the disabled in the whole of our travels in North Wales, and even worse was the fact we had been sold third class tickets when I had asked for first class.
The new double Fairlie was obviously master of the eight coach train, the exhaust note barely audible, and then we were held at Tan y Bwlch for an extended period, waiting for the first Down train of the day which was diesel hauled. This gave me opportunity to speak both to Evan and our lady guard on both locomotive performance and the tickets. Evan explained that the new Fairlie was only working on pilot valve, driving her was boring, plus with the open cab it was necessary to wear oilskins at times of heavy downpours, which heralded the skies opening! On the subject of tickets, the guard explained that Control was in rather a panic and preparations were in hand for a live TV Programme from a Down train the next morning and that they had failed to


Elaine rides the Festiniog in 1992; she was not amused.

# Black Five

## The fabulous Stanier Class 5MT 4-6-0 in 5 in. gauge

**Part 13 — The lone Stephenson gear example**

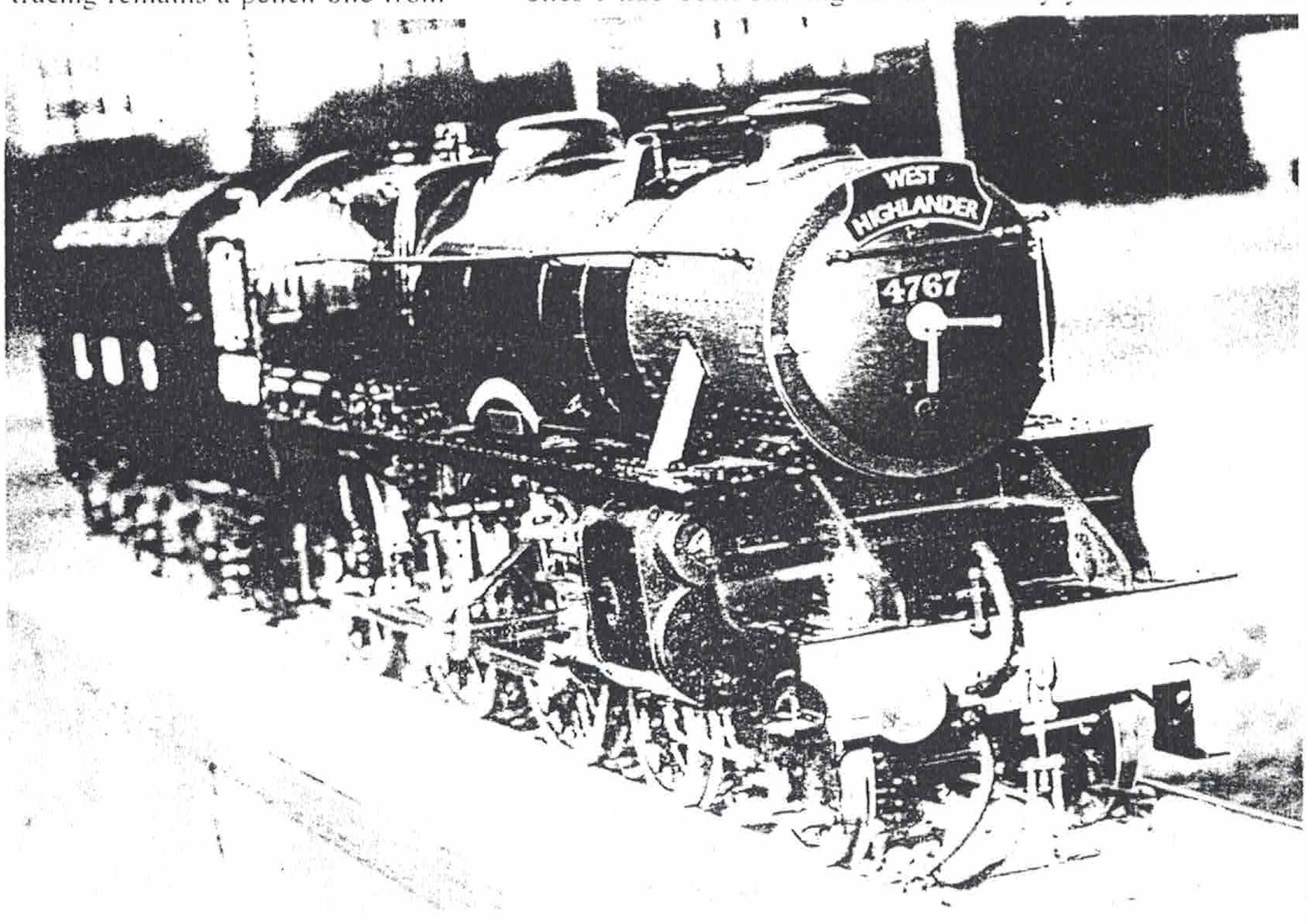
Maybe I am biased, for a reason that will become clear in a moment, but I reckon that No. 4767 represents the pinnacle of 4-6-0 development not only within the UK, but for the world as a whole, a statement which I now have to justify!

I first heard about this remarkable engine travelling on a train from Paddington to Chester, and it must have been at Wolverhampton that four enginemen joined the train, going home 'on the cushions' . . . I have no idea as to their home depot, though likely it was Shrewsbury, but it soon became clear they were all recovering from a rough trip and began to reminisce on previous experiences. The oldest driver present told of going on duty and immediately failing the engine he had been given, going to have a word with the Master about his misfortune. He was offered No. 4767 as replacement, which was only a BLACK FIVE, thus probably was a 'Royal Scot' turn, and climbing aboard he found the tender was full of slack, so back to the Master even angrier than before! He was told 'she was the best engine on Shed', he was guaranteed a good trip despite the coal, and so it proved, the driver's face lighting up with pleasure as he told his tale. It was probably late 1954 when I overheard this tale, and it was all of 22 years before I heard good things of this engine again, not being particularly conversant with LMS affairs in the interim.

When I spoke to Norman Lowe about a 5 in. gauge version of BLACK FIVE, he was insistent that I have a look at No. 4767, for he knew the engine throughout her career on BR metals and had the highest opinion of her work, as had the driver back in 1954. And so it was in the bundle of drawings that Norman so kindly loaned me, that details of the Stephenson valve gear were included. I remember that on my first look at the details, I thought that here was a draughtsman gone mad!, but as I looked deeper, so did my respect increase in leaps and bounds, until I was in raptures! As a mark of respect, my tracing remains a pencil one from that time in early 1977 until today, though likely now it will have to be committed to melinex, as it is beginning to show its age.

To turn back the clock again, this time to 1964, I read in E. S. Cox's BRITISH RAILWAYS STANDARD STEAM LOCOMOTIVES that he considered the Stephenson BLACK FIVE to be a waste of time, she being simply an LMS 'Hall', and there were plenty of those at Swindon to make comparison with. It was at this point in time that I made contact with Stewart Cox and over the next three years ahead of my beginning literary career in Model Engineer, we discussed many aspects of locomotive design, including valve gears and events in cylinders, from which I formulated certain ideas, ones which I was then able to prove practically. The following 10 years were as a lone wolf in the wilderness, many 'experts' being critical of my work on valve gears, as indeed they still are today, though thankfully DYD builders are less so, having discovered the proof of the pudding! It was though on Drawing No. D47/17665 of 3rd July, 1947 that I found proof that what I had been doing in miniature had its exact counterpart in full size, and on an engine that is performing as brilliantly in 1993 as when built back in 1947; I danced around the office!!

Recently I wrote about the Swindon version of Stephenson valve gear, where the lead did not become positive until around 50% cut-off, but on No. 4767 it was positive all the way! In full gear, with a travel of $6\frac{5}{8}$ in. ($\frac{19}{32}$ in. in 5 in. gauge), the lead was $\frac{1}{16}$ in. positive at the front port and $\frac{3}{64}$ in. at the back. At 20% cut-off which is the ideal running one, valve travel was still a healthy $3\frac{27}{32}$ in. ($\frac{11}{32}$ in.), whilst the lead had become equal at $\frac{3}{8}$ in. (.033 in.); in mid gear it was $\frac{13}{32}$ in. at the front and $\frac{25}{64}$ in. at the back, which to all intents and purposes works out at .036 in. in 5 in. gauge. All these figures were music to my ears, for they were the very ones I had been striving for in the early years, as I still do




This 5 in. gauge No. 4767 GEORGE STEPHENSON was photographed fresh from her triumph at the 1991 ME Exhibition: just look at all the detail! Sadly for yours truly, she will never be steamed in the UK, for both builder Fred Kennedy and No. 4767 have emigrated to New Zealand in retirement, both having spent some years out there in the 1980's, thus No. 4767 has now travelled approaching 50,000 miles, none of them in steam!

today, and it meant that certainly for the first time and probably for the last, I could convert a valve gear from full size to scale without making a single alteration. I have no idea as to the genius who produced the design, it was likely one man working on his own on the drawing board, and even those in authority such as E. S. Cox, missed its significance, thus it was left to the footplate crews to wax lyrical on the superiority of this engine. It bears comparison with the great works of Chapelon in transforming good engines into even better ones, but this time the hero went unsung; that is until now!! Let me turn this design symphony into 3D metal, before I run out of my allotted space.

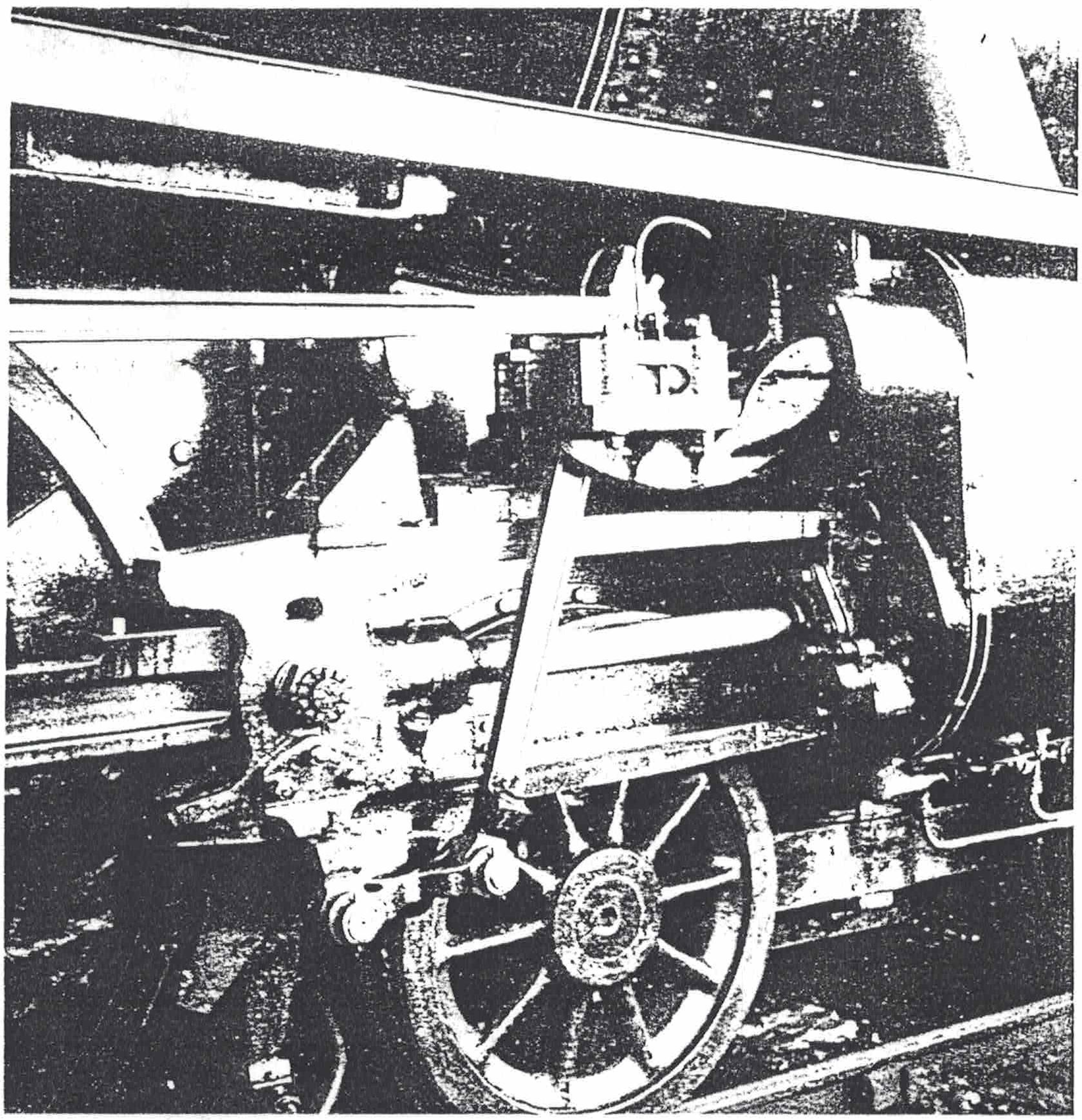
### Detail alterations

These are all features to which I should have made reference in the series which up to now has covered the Walschaert version BLACK FIVE's, but as builders of No. 4767 will have made their decision right from the outset, and Sheet No. 12 forms part of the Drawing set, such omission should not be embarrassing. Although listed by note on Sheet No. 12, I will run through the changes necessary, to draw proper attention to them, just in case!

Generally, ignore any piece parts detailed for the Walschaerts valve gear, starting at the drop arm on the crosshead, going back to the return crank and upwards to the weighshaft. Then for a reason which is not immediately apparent, though it ties into the valve events, the connecting rod is shortened from 12 in. to 11½ in., which is the only major alteration from a full size production point of view and may well have been the reason why the engine remained unique. To compensate for the shorter connecting rod, both slide bars and piston rods have to be extended to suit, and again these were impediments to further Stephenson link gear engines in full size, though not in miniature! The most fundamental change in 5 in. gauge is in reduction of the piston valve heads from .343 in. to .320 in., again very little on the surface, but something that will transform the performance of your No. 4767! Full size, exhaust clearance was provided, but being only a matter of 1/16 in., scaled down this is something we can forget about in 5 in. gauge. Apart from that, there is only the matter of repositioning the five No. 34 holes in the mainframes for attachment of the suspension link support, to the dimensions given. From now on we have a clear road into the new piece parts.

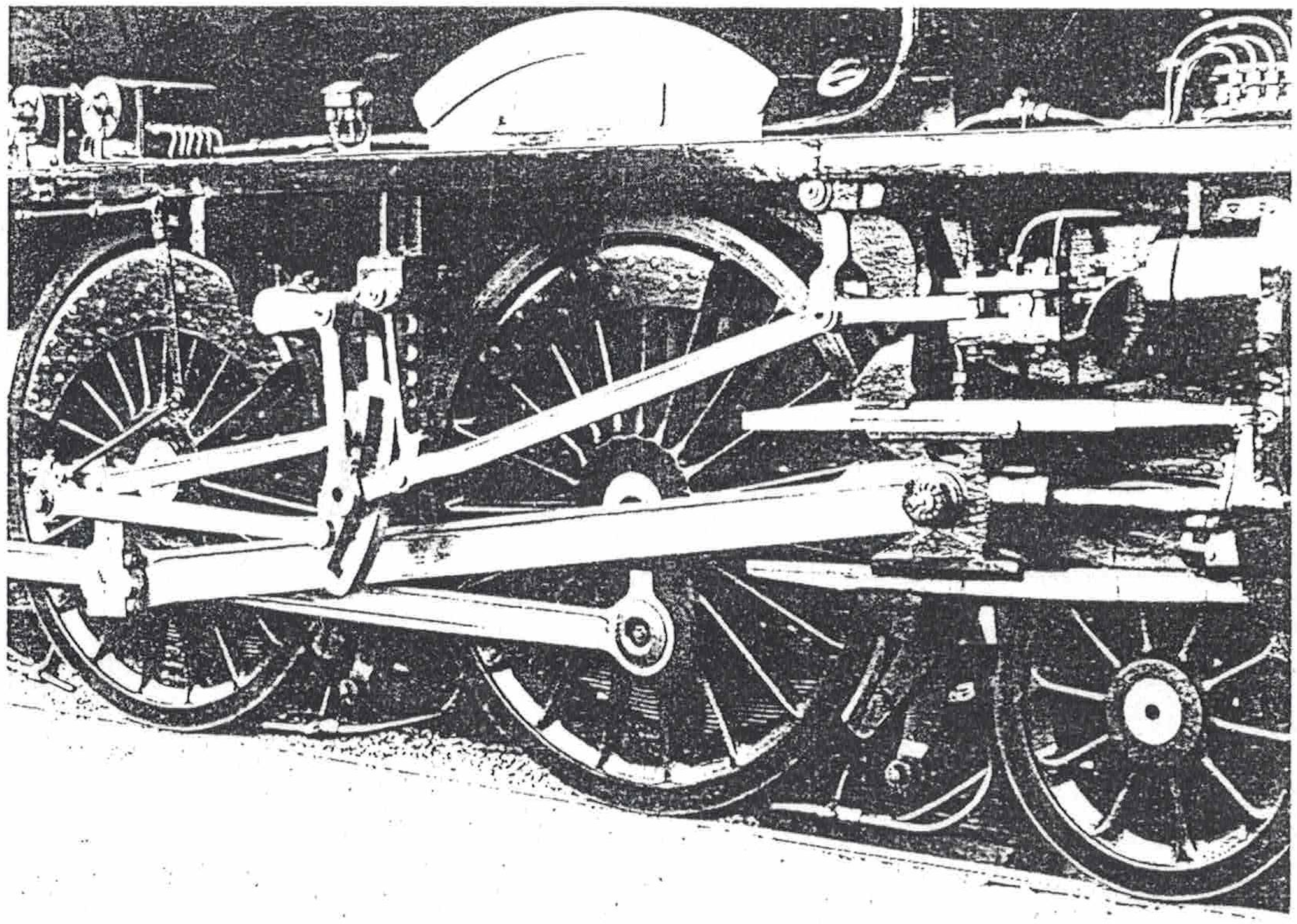
### Driving Crankpin and Weighshaft

The driving crankpin is familiar to all who have worked on LNER engines, though I was conversant with the LMS method of securing the return crank from working on the Ivatt Class 4 'Moguls' that we built at Doncaster before the advent of the 76000 series of BR Standard 2-6-0's. When I drew up the gear in 1977, metrication was supposed to be upon us, thus I made use of what were supposed to be preferred sizes, only to find 16 years on that they are still as elusive as ever! So turn the crankpin up from ⅝ in. diameter BMS bar to the dimensions given, and the rotary table that Norman Lowe recently made will come in handy again for milling the ⅜ in. square on the end of same. Don't fit the



This is intended as a refresher course as to what a Walschaert geared BLACK FIVE looks like in the crosshead area and makes an interesting comparison with GEORGE STEPHENSON to the right.

Over the past few years, so many photographs have come in covering BLACK FIVE's that they have become well and truly muddled up. I have a feeling that I took this shot of GEORGE STEPHENSON at Carnforth when newly named, but certainly could not swear to it.



crankpin to the driving wheel as yet, as we have to make the eccentric cranks and their setting jig ahead of this.

The weighshaft too is a variation on a theme, the loose coupling between the two halves being replaced by one that is forged integral with each piece. With the luxury of the Myford 254V plus, I would now turn the weighshafts from 7/8 in. diameter steel bar, though in ML7 days the flange would be brazed on and then turned to size. Although I mention that the weighshaft can be in one piece, when of course the coupling becomes a dummy, it does make life a lot easier to be able to split into halves for erection, when a length of 11/32 in. silver steel rod will aid alignment of the weighshaft bearings.

### Suspension Link Support and Bearing

Before we get stuck into the actual valve gear, provision has to be made to hang some of the bits, so let us make the suspension link support next, it being rather a tricky fabrication. These sort of fabrications lend themselves to a degree of pre-machining, leaving little to be done after assembly, so let us start with the business end that couples to the suspension link, for which we require a length of 3/4 in. square BMS bar, though not the free cutting variety which contains lead, as this is not capable of being silver soldered, or rather it silver solders OK, only to fall apart weeks later, so be warned! Square off the ends, then measure in a full 1/4 in. from each, take to the machine vice on the vertical slide to centre, drill and ream through at 5/16 in. diameter. Turn the bar through 90 deg. to mill the 1/2 in. wide slot, keeping the two side flanges of identical thickness, then deal with the outside faces of same, removing 1/32 in. of metal with the side teeth of your chosen end mill. Still attached to the parent bar, radius around the 5/16 in. reamed hole, then back to the 4 jaw to part off at the 7/16 in. dimension shown, when you will have to complete the profile with files.

Bearings next, for which chuck a length of 3/4 in. diameter bronze bar in the 3 jaw, face and turn down to 5/16 in. diameter, a tight fit in the reamed hole, over a 3/32 in. length. Centre, drill and ream 3/16 in. diameter to 5/16 in. depth, parting off to leave a 1/16 in. flange. Mark off and drill the pair of No. 44 holes, then fashion the flange around same, offering up to the blocks just made, to spot through, drill and tap 8BA, checking alignment with a length of 3/16 in. silver steel rod.

Back to the fabrication, for which we need the main member back to the frame fixing flange, this from 1 in. x 1/8 in. BMS flat. The 1 3/8 in. dimension from the centre of the bearing to the top plate is quite critical, as this will form a datum face, so if the top plate will be from 2.5mm thick material rather than the 3/32 in. specified, do make allowance for same. Although a building jig is very feasible in making up the suspension link supports, such would destroy the reasoning for the use of fabrications, which is to tack pieces of metal together ahead of welding them up. I don't have the facility to tack weld, but the edge of 1/8 in. thick plate will easily accept an 8BA thread, thus my fabrications are built up this way using 8BA round head screws, so deal with the main member, then the top plate, followed by the bottom edging, which is 3/8 in. x 3/32 in. steel strip and bent to place. There are two 1/4 in. x 1/8 in. stiffening webs above the bearing block, which leaves just the frame bolting flange, which is from 1 1/4 in. x 1/8 in. BMS flat, the overall width of the fabrication being increased by a few thous to allow this face to be cleaned up after silver soldering together, which is our next task.

Mix Easyflo flux to a stiff paste and apply around all the joints, making sure there are no 'misses', otherwise there will be rapid oxidation and the spelter will not flow. Heat as quickly as possible to a dull red, feed in Easyflo No. 2 and watch it flash around. Now allow to cool, scrub under running water to remove all excess flux, dry with a gentle heat and spray on a coating of zinc from an aerosol can. Take to the machine vice on the vertical slide to mill across the bolting face to arrive at the 1 11/16 in. dimension, then mark off and drill the datum hole at No. 34, offer up and bolt to the mainframes, dealing with the remaining four holes.

### Valve Rod Suspension Link Bracket

Although it is possible to bend up the base of this bracket from 5/8 in. x 3/32 in. steel strip and braze the bosses to same, the end result might be too inaccurate, so let me describe the easier alternative. Square off a length of 5/8 in. square steel bar and ½ in. from each end, 1/64 in. off centre, cross drill 3/8 in. diameter. Take to the machine vice and vertical slide to mill a 7/16 in. wide slot, keeping the side lugs of equal thickness; the slot being 37/64 in. deep. Next chuck a length of 3/8 in. steel rod in the 3 jaw, face, centre, drill and ream 3/16 in. diameter to 7/8 in. depth, parting off an 11/16 in. slice. Braze this to the base of the bracket, still attached to the parent bar, then back to the machine vice to remove the redundant 3/8 in. portion in the centre. On to the 4 jaw, to part off the bracket, then complete to drawing with files.

### Weighshaft Bearing

The weighshaft bearings are made exactly the same way as those on Sheet No. 6 for the Walschaert engines, description of which appeared in LLAS No. 50. There is but one difference and it is the most important one in that the weighshaft is raised by 1/16 in., thus what was 5/8 in. on the Walschaert engines becomes 9/16 in. on No. 4767.

### Valve Rod

Although the valve gear components can now be made in any order you choose, I am going to start at the cylinder end and work my way back, as that way the degree of difficulty increases as we proceed.

The valve rod is from 5/8 in. square steel bar, so grip in the machine vice on the vertical slide and a full 3/16 in. from one end, centre, drill and ream through to 3/16 in. diameter, moving on 2.031 in. by cross slide micrometer collar reading and repeating. Turn the bar over and drill 6.0mm to form the end of the slot, getting as close as possible to the 11/32 in. dimension. We now require that length of true angle on which we milled the connecting and coupling rods, so set it up and clamp the bar to same, first milling to the .103 in. dimension. Turn the bar over and pack it up to be level, then mill down so that the end boss is 7/32 in. thick, the hole for the end of the slot giving indication of where to complete milling this face. It hardly seems worth the bother of fluting this rod, but that is what our intrepid designer/draughtsman specified, so we must follow suit to be authentic, so change to a Woodruff key cutter and first mill away metal at the far side away from the chuck to establish the edge of the rod, then deal with the flute before changing to an end mill to deal with the edge closest to the chuck, arriving at the 7/32 in. dimension. Remove all burrs and sharp edges, then cut from the parent bar and radius both ends over a mandrel with an end mill, completing the profile with files. In the oil reservoir block, centre pop, drill No. 48 and tap 7BA, continuing into the bore at No. 60 and removing any burr with a reamer, then grip in the machine vice on the vertical slide to deal with the 7/32 in. wide slot. Left that way, the rod will have a short service life, so caseharden both ends and run the reamer through again, using plenty of cutting oil so that the reamer does not suffer damage in the process.

### Valve Rod Suspension Link

The ideal section for this link is ¾ in. x ½ in. BMS bar, so grip in the machine vice on the vertical slide and at 7/32 in. from one end and in the ½ in. face, centre and drill through at ¼ in. diameter, though you may ream this hole if you wish. Move on 1.031 in. by cross slide micrometer collar, centre and drill through at No. 13, then back to the machine vice and vertical slide. Use the side teeth of an end mill to arrive at the 1/8 in. thick portion between the upper bearing and the fork end, though you will have to complete this later with files. For the moment, use the mandrel and end mill technique to radius the top bearing as far as you are able, going a full circle at the ends of the bearing, which then provides you with the necessary guide to complete the profile at this end by filing. Now back to the machine vice to mill this end boss down to 3/8 in. thickness, keeping it nice and central, moving on to the fork end to reduce this in turn to 11/16 in. overall thickness, then saw from the parent bar. Now you can mill the 7/16 in. wide slot, this to suit the valve rod end, and I am afraid you will have to provide the relief shown with files, unless you are proficient in the use of those wee burrs in your electric hand drill. That leaves reducing the central part of the link down to the taper as shown, so saw as much surplus bar away as possible, and I would complete with files, though you may consider it worthwhile to set up and mill to line.

You know how I deal with bronze bushes, so chuck a length of 5/16 in. bronze rod in the 3 jaw, face and turn down over 1/16 in. length to a close fit in the link, then withdraw the tool a full .001 in. and reduce the next ½ in. length to this size. Turn away that end 1/16 in. then centre, drill and ream 3/16 in. diameter to ½ in. depth and part off a 3/8 in. slice, pressing it into the bore and running the reamer through again.

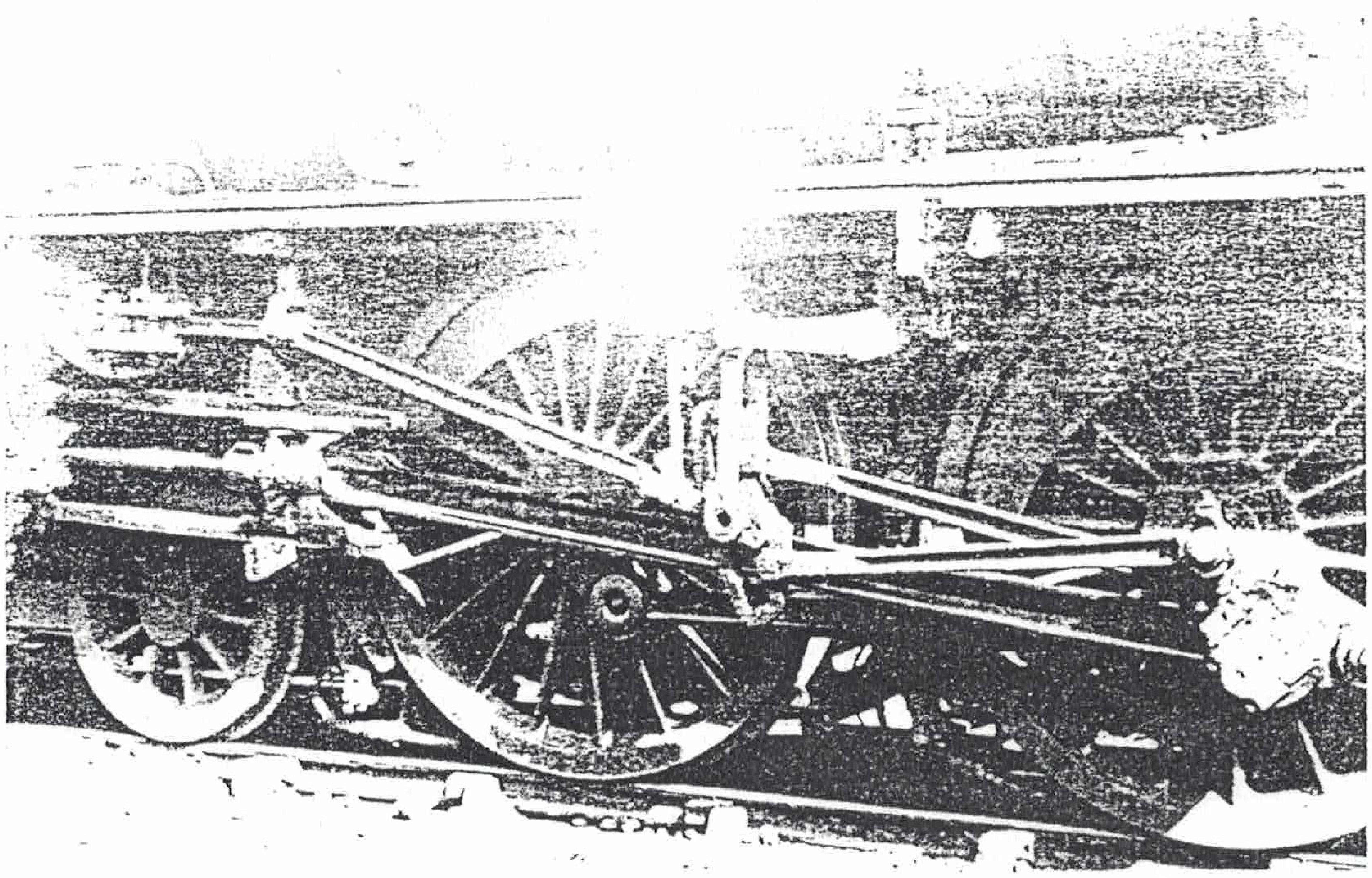
Erect the valve rod to its crosshead pin and assemble to its suspension link, when you can check the position of the valve rod suspension link bracket, noting that the fixings hand them as a pair, so don't be caught out!

### Suspension Link

The suspension link is a real work of art, and as one who drilled holes on piece work when at Doncaster, I can imagine that the draughtsman was none too popular with he who drilled the row of different size holes! With care, the link will come from ½ in. square steel bar, though if you are in any doubt, use the same 5/8 in. square as for the valve rods. At a full 3/16 in. from one end, cross drill to ¼ in. diameter, then move on 1.859 in. and cross drill 7/32 in. diameter. Radius the top end over a mandrel with an end mill, then back to the machine vice to mill down the slender portion, which scales at 3/32 in. thickness, though first go down to 1/8 in., have a look at the result, and then slim down further only if you have the courage to do so, for excess weight is not so important in 5 in. gauge as in 56½ in.! Next to those four odd size holes, which is easily done in the machine vice, after which turn the bar over and reduce to 15/64 in. thickness at the bottom boss. Saw from the parent bar, radius the lower end over a mandrel with an end mill, then complete the profile and deal with the oil cup tapping. Turn up and press in the bronze bushes, drilling the oil delivery hole through the lower one before running the reamer through both of them to finish the link.

### Intermediate Valve Rod

We are now into the swing of things and although the intermediate valve rod is going to produce a mountain of swarf, it follows a machining procedure with which we have now become familiar. Again the material specification is 5/8 in. square steel bar, initial length around 7 in. Deal with the three holes for the valve gear pins first, taking note of their differing sizes, which seems to becoming a habit! Use the true angle as for the valve rod and remove 1/16 in. from the back of the rod, leaving the front end boss as shown, then turn the bar over and reduce to 5/32 in. thickness; 7/32 in. at the front boss. Use 1/16 in. packing to support the rod along its full length, otherwise it will 'banana' with the treatment we are about to meat out. Luckily the rod is parallel back to the suspension link pin, so tackle the bottom edge with an end mill, then change to a Woodruff key cutter to deal with the upper edge at the same setting. Now you can use the same cutter to deal with the flute, and your eye is the best judge of what looks right, rather than sticking exactly to the scale 11/64 in. width; the 1/32 in. depth for that matter. Drill a ¼ in. hole at the end of the slot, then use the side teeth of the end mill to complete the outer profile at the fork end, including that very slightly raised portion in way of the suspension link pin. Saw from the parent bar, radius both die block and suspension pin bosses over a mandrel with an end mill, then complete the slot to your expansion link



This shows the state which the valve gear got into towards the end of BR days of steam and makes an interesting comparison with photographs taken when the engine was new as used in LLAS No. 54. Incidentally, no details of the double chimney as originally fitted have emerged.

material as gauge. Only the suspension link pin hole needs to be casehardened, the front hole being bushed as before, which means you can erect two further components: the valve gear is taking shape.

### Expansion Link and Trunnions

I might if I were coming to the expansion link detail fresh today, specify its thickness as 1/4 in. rather than 6mm, though the latter dimension does seem to be the optimum, so if you can have your piece of gauge plate surface ground down to same, then do just that.

Mark the link out carefully, drill the three No. 42 holes first for trunnion fixing, change to a 7/32 in. drill to deal with the eccentric rod pin bushes, then a row at the same size to start forming the 1/4 in. wide slot, using a square file to break the holes into one another. Now concentrate on the convex surface, filing down to line with a flat file and a nice sweeping motion, so that you do not end up with a series of flats. For the concave surface, change to a half round file and deal with this a little at a time, using a short length of 1/4 in. silver steel rod as your gauge, until it slides evenly from end to end. You will be surprised just how easy this is to achieve, and if you tilt the silver steel rod away from being perfectly square through the slot, you will find that it binds. Ease the ends of the slot as shown, saw out and complete filing the profile, then deal with the lubrication arrangement, pressing in the bronze bushes.

There are several ways of making the link trunnions, perhaps the easiest from 1 in. diameter steel bar. Chuck in the 3 jaw, face and turn down to 9/32 in. diameter over a 9/64 in. length, then centre and drill No. 22 to 3/8 in. depth. Start parting off at 11/32 in. overall, but only reduce to around 5/16 in. diameter, then mark on, saw and file out the profile. With care, you will be able to mill the 1/8 in. step to clear the intermediate valve rod before parting off, otherwise deal with this later. Offer one trunnion up to the expansion link, carefully check the 1/4 in. dimension, then drill No. 42 from the link through the trunnion and countersink the holes. Clamp the trunnions back-to-back, with a No. 22 drill through the bosses to check alignment, then drill the No. 42 holes through the second trunnion and countersink this also. Before riveting up the whole assembly, caseharden the trunnions thoroughly, otherwise they will be subject to heavy wear.

For the die block, chuck a length of 5/8 in. diameter bronze bar in the 3 jaw, face, centre, drill and ream 5/32 in. diameter to 3/8 in. depth. Start parting off a 6mm slice, but only reduce to around 5/16 in. diameter, before taking the job to the machine vice to rough out the profile by milling. Part right off and I am afraid the rest is hand fitting, after which drill and tap for the oil cup.

### Lifting Arm and Link

For the lifting links, we require four 2 3/8 in. lengths from 5/8 in. x 5/16 in. BMS bar. The initial drilling must be done in pairs, so grip in the machine vice on the vertical slide and a full 3/16 in. from one end, centre, drill and ream through at 3/16 in. diameter. Move on 1.891 in. by cross slide micrometer collar, to centre and drill through to 11/32 in. diameter. Bolt the embryo link to the length of true angle, to first mill away 1/32 in. at the back of the links as shown, then turn it over and use 1/32 in. packing to get it nice and firm on the angle. Use a clamp first, to reduce the top boss to 9/32 in. thickness, then bolt it in place before going on to reduce the centre section of the link down to 5/64 in. thickness, removing the bottom bolt to arrive at 9/64 in. thickness at this lower boss. Using a Woodruff key cutter and end mill, you can reduce the centre portion of the link down to the specified 15/64 in. width, though you will probably find it easier to simply saw and file to line, as the end mill may well 'pick up'. Radius the two ends over a mandrel with an end mill, going right around at the top boss to establish a true circle, though you will have to complete with files, then complete the profile at the bottom, this time tapping 10BA for a teeny oil cup. Caseharden around the 3/16 in. reamed hole at the top, then turn up and press in the bronze bush at the bottom, reaming to a good fit over the trunnion pin.

The lifting arms were forgings in full size, and what a pity such technique is not available to us in miniature, for it would make life a lot easier. Although it is just possible to machine them from 5/8 in. square steel bar, the barrel shape is so difficult to reproduce at the weighshaft end that I favour fabrication, for which we shall need a simple building jig. The base of the jig is, say, a 2 in. length of 1 in. x 3/8 in. BMS bar: at 5/16 in. from one end, centre, drill and ream to 5/16 in. diameter, then move on 1.312 in. to centre, drill and ream to 3/16 in. diameter. Fit 1 in. lengths of silver steel rod in each hole, and we require a distance piece for the smaller rod. Chuck a length of 5/8 in. steel rod in the 3 jaw, face, centre and drill No. 11 to 1/2 in. depth, parting off a 25/64 in.

slice. Fit same over the 5/16 in. pin and coat the jig with marking off fluid so that the spelter will not adhere.
The weighshaft boss is now straightforward turning and I suggest you make up a wee template to get the correct barrel shape, parting off at 7/16 in. after reaming the bore to 5/16 in. diameter; erect to the building jig. For the arm, the best section to use is 1/2 in. x 3/8 in. BMS bar, so first grip in the machine vice to deal with the No. 12 holes which will give us a datum. Choose what will be the outer face of the arm at the No. 12 hole, then remove 9/64 in. of material at the inner surface, followed by a further 1/16 in. to start forming the arm. Turn the bar over, pack it up securely, then plunge in with the end mill to arrive at the 3/32 in. thickness as shown. Although it is possible to pack the workpiece up to arrive at the tapered length, it will be quicker and easier to deal with this by filing, especially as you now have to bend the arm and scallop the other end to fit the boss, blending the arm into same, which is why we started off with the 3/8 in. thickness. This is going to take a lot of your time, but the end result will be well worth the effort, when in conclusion you can silver solder the pieces together.
Next drill the No. 41 clamping bolt hole, then back to the machine vice to mill the outer end boss down to 3/8 in. width, which is comparatively easy, as the arm is still 1/2 in. parallel bar. Although it just might be possible to radius around the No. 41 hole over a mandrel with an end mill, this is an exercise fraught with danger, a couple of 3/16 in. filing buttons being the sensible solution. Complete profiling the arms to drawing, the last operation being to slit down to the No. 12 hole as the means of clamping, either with a Junior hacksaw, or slitting saw if you are machine minded.

### Reverser Arm

The reverser arm detail should be lifted directly from Sheet No. 7 as shown in LLAS No. 51, though the distance between centres must be reduced from 1 5/16 in. to 1 1/4 in., this to compensate for the weighshaft being lifted that 1/16 in. as already mentioned, so don't get caught out. This means that another large chunk of the valve gear can be erected, though resist the temptation to pin the lifting arms to the weighshaft until the valve gear is complete, which will not be long now!

### Eccentric Rods

There is but one flaw in the valve gear design as I see it, and it is the very minor one in that the back gear eccentric rod has a solid eye at the return crank end, whereas the fore gear one is split. It would have been better in some ways had they been reversed, though this would mean a greater overhang at the return crank for the pin in greater use, so it is a case of swings and roundabouts.
With care, both rods will come from 3/4 in. square steel bar, though there will be a veritable mountain of swarf in conclusion! For preference, clamp together as a pair on the vertical slide table, as using the machine vice there will be too great an overhang, to first centre and drill through to No. 23 at 5/32 in. from one end, then move on 4.593 in. by cross slide micrometer collar to drill to 11/32 in. diameter, opening out the outer rod to 13/32 in. diameter at the same setting, and do be generous in the depth of this opened out hole, as there is metal to spare on the inner, back gear, rod. Now that you have the centres exactly coinciding, you can process the rods separately, dealing with the back gear one first. This follows processes already fully described for the Walschaert version BLACK FIVE, plus there is no offset involved, so I can safely leave this one to builders, concentrating my attention on the fore gear eccentric rod.
The datum face of the rod is the inner one at the fork end, and for all practical purposes the fork end is 15/32 in. thick, which gives you the starting point to drill the 6.0mm hole at the end of the slot at the fork end. Clamp or bolt the rod to the length of true angle, bolted to the vertical slide table, to remove 3/32 in. of metal from the back of the rod, lifting the end mill by .075 in. as you come to the rear boss. Turn the rod over, reduce to 15/32 in. thickness at the fork end, then deal with the rest of the rod to arrive at 7/64 in. thickness along its length. Set the rod over, to deal with its upper edge with a Woodruff key cutter, then deal with the flute to be parallel with same, and as the rod is so flimsy, I have suggested fluting to only 1/64 in. depth, though you can exceed this by a few thous if you so wish, when the completed rod will look so much better. Next set the rod over to deal with the bottom edge with an end mill to line, then change back to the Woodruff cutter to complete the flute.
At the rear end, saw away to leave the full hole and mill to be square, then mark off and drill the pair of No. 41 holes. The 7BA fixing bolts are turned up from 5/32 in. square bar, and if you do have a length of key steel by you, then this will be much preferable to ordinary mild steel. Now mill down at the front of the boss to the 3/8 in. dimension, the important thing being that the square headed bolts are a firm fit, so that they will not turn in service and come loose. It is well worthwhile turning up bushes to a heavy press fit in the 13/32 in. hole, for you have more than a 50% chance that they will stay in place when you file away exactly half of them, after which file on the 9/64 in. scallop, which reveals half of the No. 41 hole at the back of the rod, though you can leave this until the mating rod end has been tackled. That leaves radiussing the top and bottom of the flange, a job for filing buttons, when we must move on to the rod end.
Flat bronze bar is not readily available, which indicates a casting, indeed these would come nicely out of our boiler bush stick, so chuck in the 4 jaw, face and turn down to 15/16 in. diameter over a 3/8 in. length. Centre, drill and ream to 5/16 in. diameter and 7/16 in. depth, then part off a 7/32 in. slice, reversing in the 3 jaw chuck to clean up. Now you have to mill exactly half the reamed hole away, so get somewhere close to same, say within 1/64 in., then offer up to the eccentric rod with a length of 5/16 in. silver steel rod for alignment purposes, to drill back at No. 41 from the rod through the end, and you can rough out the profile of the rod end to ease the depth of drilled holes. Now it is a question of removing thous at a time, then assembling with the 7BA bolts and tightening hard down, until you can still turn the silver steel rod, but without 'slop'. From the datum established on the rod end, mark it out carefully, then mill the facings both for the retaining bolts and oil cup, drilling and tapping the latter 7BA and continuing at No. 60 into the bore, when I am afraid the rest is filing. Now you can complete the fork end of the rod, when we arrive at the point of no return, or rather the return cranks!

### Eccentric Cranks and Setting Mandrel

I am afraid I still think of these as return cranks, though of course they are really eccentric cranks, the main one just looking like a Walschaert version, though thank goodness its manufacture mirrors that for DONCASTER, thus is very familiar to me.
Material requirement for same is a length of 1 in. x 3/8 in. BMS bar, so back to the machine vice and vertical slide to first drill a 9.5mm hole at 13/32 in. from one end, then move on 1.141 in. by cross slide micrometer collar, to centre, drill and ream through at 1/4 in. diameter. The outer face at the square is a datum, so mark off for the No. 34 holes from same, going back to the machine vice to drill them through. Use the length of true angle to mill to the specified thicknesses, then saw from the parent bar and radius the 1/4 in. thick boss over a mandrel with an end mill, holding the workpiece securely with a 'Mole' wrench. Mill flats in way of

the 6BA fixings to drawing dimensions, turning up bolts from 7/32 in. square bar to suit; the rest of the profile you will have to complete with saw and files. We now have to split the crank at the square end, using a slitting saw, and as you approach completion of same, drill a 1/16 in. hole at the end, the position of which you can only locate to place, after which it is back to the slitting saw.

I only know of one way to tackle the square and that is with a square file, but the 9.5mm hole being just about exact to size is the perfect guide to same. Just like in full size, if you use a wee wedge to prise the square open, as you approach size, so you will be able to ease the crank onto the square end of the crankpin for final fitting, getting a perfect result, in fact this is a job which always gives me a lot of satisfaction, having done the same task many times in full size, and in the same way.

The back gear eccentric crank by comparison is easy, the main effort being in to arrive at the required material section of 15/32 in. x 7/64 in. You may well want to start with 1/2 in. wide material, as this gives a little latitude over positioning of the holes, so grip in the machine vice on the vertical slide and 1/4 in. from one end, centre, drill and ream through at 1/4 in. diameter, then move on .500 in. and repeat. Radius one end over a mandrel with an end mill, then saw from the parent bar, grip with a 'Mole' wrench and deal with the second end. There now follows some very accurate turning, both in sizes and surface finish, and although silver steel would be preferable for the pins, because of the inherent difficulty in obtaining a decent surface finish, 5/16 in. mild steel rod will probably be your chosen material.

For the setting jig, chuck a length of 7/8 in. diameter steel bar in the 3 jaw, face and turn down to 3/4 in. diameter over a 5/8 in. length, a very good fit in the driving wheel seat. Part off at 1 3/8 in. overall, reverse in the chuck, and turn down over a 1/2 in. length to .322 in. diameter. Having applied Mr. Pythagorus to the solution of setting the eccentric crankpins, if our starting point is inaccurate, then we shall fail, thus the crank throw at the driving wheels, which of course means all six of them, must be 1.250 in. as opposed to 1 1/4 in., though you should have already arrived at this through use of the drilling jig.

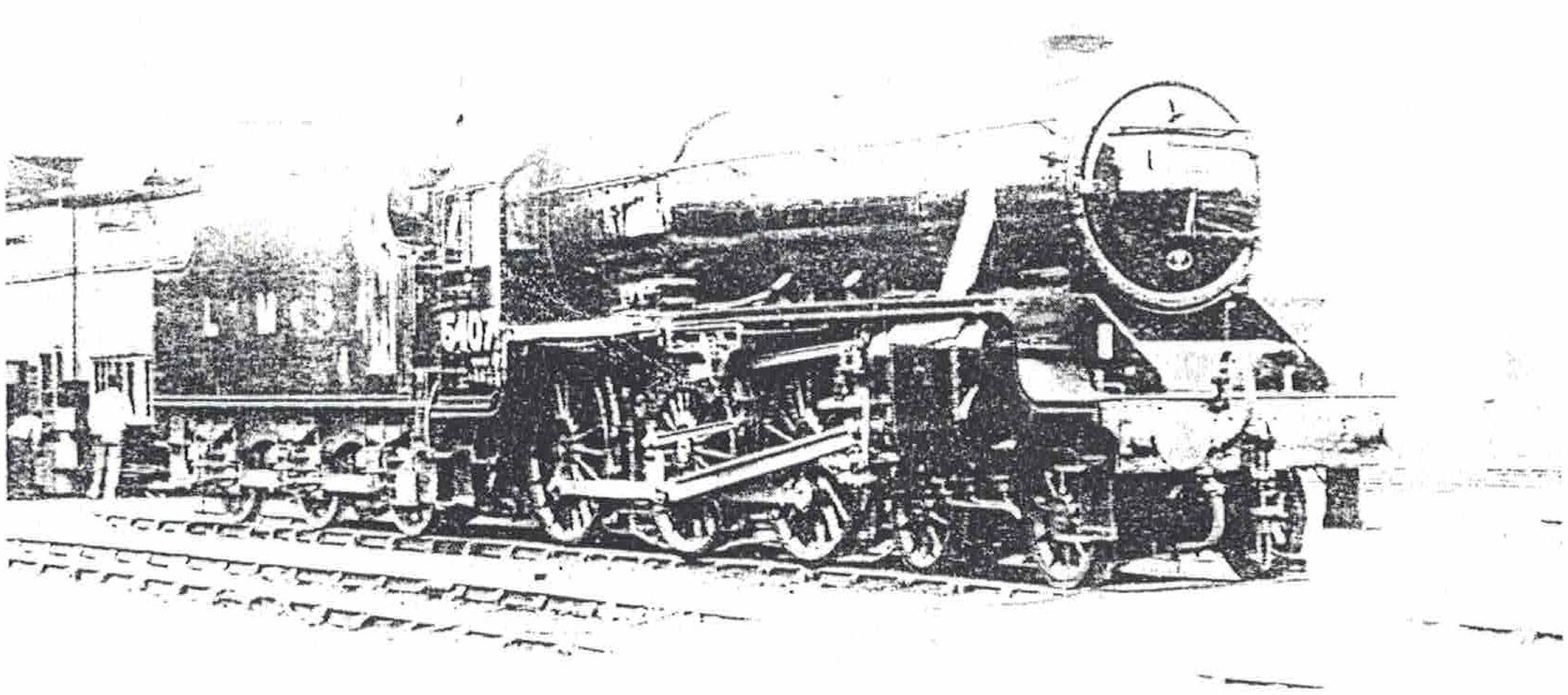
A 'dry' run is now the order of the day before we think about assembling permanently, so fit the eccentric cranks setting mandrel into the wheel seat, followed by the main eccentric crank and pin, then bring up the back gear eccentric crank with its pins, checking against the valve gear arrangement drawing that everything looks as it should. When Sheet No. 12 was produced, I had no hesitation in specifying Loctite No. 35 as the medium for joining all the crank components together; permanently, but since it has been superceded, at least for us hobbyists, I am less sure about the replacement No. 638; certainly No. 601 is not suitable for this duty. On the other hand, brazing would be far too messy, plus the alternative Permabond A118 has only marginal strength above what is required here, though it would help to slightly knurl the pins to increase the strength of the resulting joint. Oh, that No. 35 was still available to us; it would solve all my problems!

Now that you know exactly how the various piece parts come together, thoroughly degrease, then apply the chosen fixative, assembling quickly before curing starts, leaving well alone for at least 24 hours afterwards. Saw away the redundant pins from the eccentric cranks, file flush, and you can complete assembly of the valve gear, using headed pins and collars where indicated, this to details as given on Sheet No. 7 which appeared in LLAS No. 51. Turn up and fit the brass oil cups as detailed and that completes manufacture.

**Setting the Valves**

It usually takes several paragraphs to explain setting of Stephenson valve gear, altering the angle of advance of the eccentrics until the correct events are obtained. This time they are already set, thus there is hardly any room for manouevre, so first set each side of the gear with the die block in the mid-point of the expansion link, then drill through lifting arm and weighshaft, securing with a taper pin. Still in mid-gear, bring the reverser to the same setting, then measure the length of reach rod and make as previously described. Leaving the engine in mid-gear, turn to the dead centres in sequence, blowing up the drain cock tapping as previously described and measuring the lead, then centralising the valve in the steamchest. You can carry out further checks for equal lead at the working cut-offs, finally checking the result in full gear, though any inequality here will matter not one iota.

As far as I am aware, the only completed 5 in. gauge No. 4767, or rather No. 44767, is the magnificent example by Commander Fred Kennedy, R.N., now retired. That bit about retiring carries a sting in its tail, for having spent a part of his service career in New Zealand, Fred has decided to emigrate to Auckland, indeed No. 44767 has now travelled upwards of 36,000 miles without turning a wheel in anger! Despite all my pleas, the engine remained crated after her success at the ME Exhibition, and I am still waiting to sample the performance of the Stephenson BLACK FIVE, which I am certain is going to be something very special! Fortunately, other examples are fast approaching completion, judging from what I saw at the 1992 Midlands Exhibition, so I live in hope!!




I have chosen this photograph by Tom Goulding to say farewell to BLACK FIVE, No. 5407 being my favourite member of the class. Describing the engine has been hugely enjoyable, and with the number currently under construction, hopefully they will become more prolific at DYD rallies in the years ahead.