Glen

by : DON YOUNG

PART 1

GLEN requires a little more introduction than HUNSLET, as does any 5 in. gauge 4—4—0, for there is formidable competition from L.B.S.C.'s immortalised MAID OF KENT, a truly wonderful engine. I will try to make a few comparisons later on, to show that GLEN does have a few things going for her, but first let me say something about the prototype.

The GLEN's were designed by Reid for service on the West Highland line of the North British Railway, and were a notable success from the outset, employing sound Scottish locomotive engineering practice of a good steaming boiler allied to a rugged chassis, the perfect combination for hard work, and longevity. The character of Scottish Locomotives was established largely by Dugald Drummond, who later gravitated South to become C.M.E. of the London and South Western Railway. At Eastleigh in 1953/4 I became very conversant with his M7 Class 0—4—4's and the T9 'Greyhound' 4—4—0's. As a fitter I was very critical of the massive weight of components, like rods and motion, after working on the Gresley 'Pacifics,' though I cannot recall an instance of a bent side rod on a Drummond engine, whereas this was not unknown on Gresley engines. On the footplate though, there was little one could criticise on the straightforward Drummond designs, one of my most exciting moments being to take an M7 out of Winchester in full gear with full regulator, a crescendo of sound and not a trace of slipping!

Reasons for Glen

Coming back to terra firma, over many years I have received requests to produce a design for a Scottish Locomotive, indeed correspondents addresses brought home to me that there are more exiled Scots than native ones. Anyhow, the mad panic to get my business off the ground in 1975 continued into 1976, and I was ever seeking further designs that required minimum expenditure. The first exercise was to obtain the major dimensions of a whole array of Scottish Locomotives, wheel diameters and cylinders in particular. This was not as easy as it sounds, taking up a lot of valuable time, and initial results were disappointing, for none of my existing castings seemed to fit. Dimensions for the N.B.R. 'Scott' and 'Glen' proved elusive, and I had to resort to purchasing drawings from the Oxford Publishing Company to establish these. At the particular time I was reduced to that sick joke about Scotsmen of counting the pennies, for I have never found this fine race other than generous, but the drawings provided by O.P.C. proved a fantastic investment. By adopting a scale of 1 in. = 1 ft., GLEN not only utilised the major castings from my Lancashire and Yorkshire Radial Tank Locomotive, LANKY for short, but used a virtually identical boiler into the bargain, a double bonus. From this point onward my enthusiasm knew no bounds.

Now these fine Locomotives were 'work horses,' and I wanted the 5 in. gauge version to follow suit, and in this the experiences with Gordon Chiverton's superb MAID OF KENT proved invaluable. The strongest feature of M.o.K. is undoubtedly the boiler, as in any successful design, yet the Belpaire firebox is not the easiest, at least in my humble opinion. So I thought the round top version of GLEN to be superior, at least from the constructional point of view. By adopting E11 draughting I knew there was a firm foundation on which I could build. A combination of 80 p.s.i.g. boiler pressure and 1 5/8 in bore cylinders allows for maximum power utilisation on a 5 in. gauge 4—4—0 to the limit of adhesion, and 6 in. diameter wheels were in favour of GLEN; all that remained to be sorted out was the valve gear. Back in 1949 I started a 5 in. gauge MINX, which I had to hand over to Gordon Chiverton to complete whilst I was learning something about full size Locomotives at Doncaster. This MINX was built with Joy valve gear, and has always given a good account of herself. Gordon went on later to build MAID OF KENT, and for variety fitted her with Stephenson valve gear, operating the valves through rockers, L.B.S.C. having specified both types of valve gear for this pair of Locomotives. Where the MINX had been a complete success, the MAID as built was a total disaster, and I learnt a lot about valve gears in getting her to perform in the approved manner. Chief among these revelations was that the rocker fulcrum position was extremely critical. Before this investigation it was a mystery to me why some engines gave such obviously good valve events, whilst others were 'sick' all being built from the same drawings. What did emerge was that a cumulative error of 1/16 in. between rocker fulcrum and expansion link below gave an almost perfect result; it was building strictly to drawing that caused the trouble. So the troublesome MAID blossomed forth in tremendous fashion, and I became her keeper for a year whilst Gordon circumnavigated the world. On an outing to the Southampton track I was cautioned for speeding, this with a load of 14 adults, some of whom have never ridden behind me since!

When Gordon returned, it was decided to enter her for I.M.L.E.C. at Southampton, this with great expectations. The result was a dismal failure, and a perplexing one, for all we proved was that with E11 draughting the MAID was capable of consuming vast quantities of coal, an unwanted record which still stands I believe. Back on the Isle of Wight she continued to perform with distinction, which made it all the more baffling, until on one Open day she was heavily loaded once more, and on starting Gordon leaned over and saw that the motion plate was moving. So the mystery was finally solved, and quickly rectified with dowel pins, but the experience did indicate the problems of Stephenson valve gear with rockers. So with the decision that GLEN should be a 'work horse,' one that could be built both easily and quickly, relatively speaking, Joy valve gear was the obvious choice by experience, allowing at the same time acknowledgement of another fine Scottish engineer.

Having said all that, I have no illusions of grandeur that GLEN will dent the popularity of MAID OF KENT; if I ever did then there would be a rude awakening! But I do feel there is a place for GLEN, in memory of a 50 year career spent climbing amongst those majestic Scottish mountains, a feat that will never again be repeated, and I am thankful that already model engineers from Scotland to Korea agree with me, among them a Mr. A. Reid, though unfortunately Abram is no relation to the originator of GLEN.

Although I shall, as ever!, be going off at a tangent at times, general strategy will be to press on with these notes so that series do not drag on for too long, which can easily happen with only quarterly appearances. Also I shall be presenting the drawing information in large blocs, a sheet at a time, to give really good value to readers. This does however mean at times that the script will become slightly out of phase with the drawing details, and this is just about to happen, for which humble apologies, and a promise that the instances will be kept to an absolute minimum. For all builders of GLEN, and may there be many!, the purchase of full scale drawings is highly recommended, they will amply repay the investment, and from these the script becomes completely logical.

When LBSC saw the drawings for my very first design, the 02 Class 0—4—4T FISHBOURNE as running on the Isle of Wight, he wrote to say she was an LBSC engine, as indeed she was, for my humble drawings were produced with reference to his work. I have a feeling that if the late maestro were still with us, the same remark would be passed for GLEN, and being a 'work horse' it would be basically true, for there is no point in altering a successful formula, though experience has taught me a few things, and some of them are reflected on the GLEN chassis.

The Frames

Originally I was in favour of the basic structure of the pair of frames with ends firmly supported by angle buffer beams, to L.B.S.C. specification. Early on though I became aware that the critical part of structure at the front end was in fact the cylinder/smokebox saddle area, this is the point where rigidity is most beneficial and a less rugged, and more authentic approach to the front buffer beam was feasible. Problems with the motion plate I have already referred to, and this is resolved by 16 bolt fixing, though there is nothing to stop a builder providing additional insurance with dowel pins. The 'machine' part of any Locomotive is between cylinders and driving axle, so if this area is properly constrained, then all will be well. On GLEN, besides the 'traditional' stay behind the driving axle, and ahead of the firebox, there is a horizontal stay above said driving axle, this being authentic, to tie the whole thing together. With a deep firebox, there is no way of tying the frames together between driving and trailing axle, so the length, and type, of support astern of this is critical, and here in my humble opinion the angle buffer beam is inferior to an authentic drag box. Full size Locomotive engineers obviously sought this to be a 'strong point' in their designs, and I am content to follow suit, for this does stiffen the frames at, and ahead of, the trailing axle. The only other feature to be mentioned, as we have already touched on the valve gear, is use of different sizes of horns and axleboxes at the driving and trailing axles, another touch of authenticity, though it will have nil effect on performance!

The GLEN drawings were produced at the time when metrication was gathering pace, and the material specified is two 30 in. lengths of 100mm x 3mm mild steel, which translated into English means 4 in. x 1/8 in. There is a lot of work in getting the frames complete to drawing, but no amount of talking from yours truly is going to help one iota here! Check one edge of one frame on the lathe bed for straightness and file as neccessary, using marking blue to check. Square off one edge and use these two prepared edges as datum to mark off the frame outline, and all the holes, remembering that accuracy here will pay dividends later on. Clamp the frames together, drill four or five holes through the pair, to 1/8 in. or 3/32 in. to coincide with the final use to which the hole is put, and fasten together with snap head copper rivets, hammered well down. Drill the remaining holes, and this must be done in lathe or drilling machine to get them nice and square, then saw and file the frames to outline, including the slots for the horns, these later being filed to pieces of steel flat as gauges. Part the frames and remove all burrs, this is vital to your well-being, then countersink those holes so specified, also tap the pair for the brake gear.

It will be noted that the frames are spaced 4 in. apart, as against the usual 4 1/8 in. The reason is to give added clearance behind the rear bogie wheels, this in lieu of a large, and very weakening, cut-out in the mainframes. With correct, and this means stiff, side control springing the GLEN will negotiate 32 feet radius curves quite happily at a safe speed, one that will keep your passengers smiling!

Glen

PART 2

by Don Young

Eureka; now readers can see what I was talking about at the end of Part 1, so I hope it all makes sense now. How weak those mainframes would be if a cut-out was provided in way of the rear bogie wheels, and besides not being authentic, there would be problems in attaching the motion plate. Although the profile of the Mainframes is rather complex, at least the end result is very pleasing, at least to my eyes.

Turning now to the Frame Plan, on one side or the other every chassis detail is shown, so builders have a fair idea of what is involved, and I would venture to say that it is not an awful lot, in fact the frames themselves will probably soak up more time than any other single component. Apart from my original 'Howler' of passing the front brake beam through the midst of the valve gear and for a change I found that particular error myself, it was not too difficult!, there is only one other clearance problem to be mentioned. This is the rod stay between the bogie frames at the back end, being rather adjacent to the anchor link lugs, as can be seen. When I came to detail the bogie, I lifted the rod stay above its correct position, so that a rivet could be fitted at each end of the bogie horn angle, and this was a mistake. I think the bogie assembly is stiff enough without this stay, but we can discuss this in more detail next time, when we come to the bogie itself. Enough of the preamble, on with construction.

Front Buffer Beam and Drag Beam

There is plenty of alternative on the drawing in respect of beam sections, so I trust all builders can locate something suitable; 1¼ in. x ⅛ in. would be my preference. Square off both beams to 7⅝ in. overall, then mark off all the holes in the Front Beam and drill to the sizes specified, filing the 3/16 in. square for the coupling hook, and tapping 5/16 in. x 40T for the buffers.

The double angle fixing feature to the mainframes is exactly the same as on DON HUNSLET, but instead of bolts, this time they are attached to the beam with 1/16 in. soft iron snap head rivets. Again a frame gauge will be very useful, to achieve the correct 4 in. spacing; this wants to be horseshoe shaped, from ⅛ in. gauge plate, say to the dimensions of the driving horn, but with the 1¼ in. slot becoming a 4 in. one.

I very much doubt if you will obtain ⅜ in. x ⅜ in. x 1/16 in. angle in steel, so use the brass alternative, it will be perfectly suitable. Rivet one of the inner angles in place, then use the frame gauge to locate its opposite inner partner. Offer up the frames and drill through the three No. 34 fixing holes, then clamp the outer pieces to the frames and drill these too. You can now bolt the whole lot together, to drill through and rivet the outer pair of angles to complete the front beam. The Drag Beam simply requires holes, those for fixing the valances being as per the front beam; plus a 1 in. ⅜ in. slot for the drawbar.

Bogie Bolster

The next item we come to is the Bogie Bolster, which I have indicated being fabricated from 2 in. x 5/32 in. (50 mm. x 4 mm.) steel flat. Square off one piece 4¼ in. long and the two flanges at just 7/16 in. Either clamp the three pieces together for brazing, or drill a couple of No. 44 holes under each flange in the main plate, spot through, drill and tap the flanges 8BA to about 3/16 in. depth and secure with round head screws; after brazing, simply file off the heads. Try to get the measurement over flanges slightly in excess of 4 in., so there is metal to be machined away.

Drill the 5/16 in. hole as shown, fit the vertical slide to the lathe carriage, with table along the axis instead of as more usual across it, then bolt the bolster to the table through the 5/16 in. hole. Set the bolster horizontal, and if you allow it to hang down about 1/16 in. below the vertical slide table, then it will level automatically when wound down onto the boring table, tighten the bolt, and lightly mill along the flange. Rotate through 180 deg. and repeat, this time using the frame gauge to arrive at the correct dimension.

Frame Stay

The Frame Stay is a gunmetal casting, and after rubbing a file over it, grip in the machine vice, on the vertical slide, and mill both end flanges to gauge. Tapping the holes, as for the bolster, must await assembly of the frames.

Frame Stretcher

This fabrication uses 1¾ in. x ⅛ in., or 45 mm. x 3 mm. steel flat; the main piece being about 3 25/32 in. long, and the two end flanges ¾ in. deep. Clamp together, or use the 8BA screw technique, then braze, when the stretcher can be gripped in the machine vice and ends dealt with exactly as for the frame stay.

Drag Box

The Drag Box takes our fabricating technique a step further, though again it is all simple pieces, ⅛ in. or 3 mm. thick. Top and bottom plates are 3 25/32 in. x 2⅜ in., which should be machined as a pair to these dimensions, so that the whole assembly will be nice and square. Side members are 2⅜ in. long from 1¼ in. wide flat; the back plate a full 4 in. overall from the same section. Drill the ¼ in. hole for the drawbar pin in the top plate only, make the two collars from ½ in. steel rod, then locate in place with a rusty piece of ¼ in. rod, so that the brazing spelter will not adhere to it. Now it is a question of either clamping together, or much preferable in this instance, the 8BA screw technique.

For large steel fabrications, indeed all of them really, mix the flux to a stiff paste and apply thoroughly to the joints, both sides of them, to exclude air and prevent oxidation. Almost any grade of silver solder will suffice, though I always find that Easyflo No. 2 gives good results. Scrub off the excess flux in running water, dry — the brazing torch does this quickly, then use an aerosol zincplate to give a light covering, to prevent rusting and provide a 'key' for the paint later on.

Most of the joints on the mainframes attachments are in shear, for instance the train will try to pull the drag box out of the engine, or vice versa. An application of zinc to the mating joint faces actually gives a stronger job, increasing the friction between the components, in fact this is used as a deliberate design feature in bolted structures. Back to the drag box, to either dog to the vertical slide to bring the sides to gauge, or simply file them.

Motion Plate

Just one further part is required, the Motion Plate, before we begin to assemble the frames, and this is another gunmetal casting that requires a minimum of machining. First mark off for the feed pump hole and then clamp to the vertical slide. Drill through the web at 9/16 in.

diameter, then use a ¾ in. end mill to spotface at the back, which removes part of the webs at the same time. Bolt through this central hole, set horizontal, then tackle the frame bolting flanges with a large end mill, say the ¾ in. one still in the chuck! Change to a much smaller end mill, about 3/16 in. diameter, and machine around the inside of the slide bar facings; you will have to finish the corners with files unless you have the luxury of a shaper; what a useful machine this can be to the Locomotive builder, LARGE or SMALL. Before removing from the vertical slide, use an end mill to clean up the back edge of the frame bolting flanges, then reverse and mill the front edge to give the required ¾ in. width.
The datum now exist to locate the anchor link fulcrums on the two cast lugs; mark them off and drill through at No. 13; I recommend you do this from either side for accuracy. The ⅛ in. slots for the anchor links can be cut with a slitting saw, though I would fit two hacksaw blades in the frame, saw out the middle of each lug, and complete with a key-cutting file to the link material as gauge. That is as far as we can go on the motion plate for the moment, though there is really nothing to stop you drilling the eight No. 34 slide bar fixing holes; only there are no slide bars yet!

Assembling the Mainframes

The front beam has already been attached, though do not leave in this flimsy state or you may regret it; we now want to tie the back end. Offer up the drag beams to the drag box, spot through, drill the 12 holes at No. 43 and tap 6BA; secure with hexagon headed bolts. Fit the complete assembly between the frames and clamp, then add all the other stays and clamp these in turn. Only parts of the frames can be stood on a surface plate to check for 'rock,' though you could add packing pieces to check the ends. It is now a question of applying a square at as many points as possible, including all the stays, and especially across the horn gaps. When you are satisfied, spot through every attachment, save the motion plate, at about four positions at each side, drill through at No. 43, tap 6BA and secure with screws; any type of head as this is a very temporary assembly. When the horns and axleboxes are complete and assembled, and you can check that the axles turn sweetly, then you can tap the remaining holes; save for the motion plate again, which must await completion of the cylinders.

Driving and Trailing Horns

The mainframes being assembled, we now have the inspiration to tackle some of the more delicate machining work, starting with the Horns. Apart from dimensional differences, which I mentioned right at the outset, both driving and trailing horns use the same machining operations, from gunmetal castings.
The best way to get the 'feel' of a casting is to rub a file over it, and follow up with a rule to assess the machining allowances; this will be time well spent. The first operation is to finish to thickness, 19/32 in. for the driving pair and 9/16 in. for the trailing ones, and this can best be accomplished by turning in the 4 jaw chuck. For this description I am assuming that the driving horns are cast as a pair, though they may in fact be supplied singly, as two patterns are in existance, and it just depends which castings are currerntly in stock. Generally, machining is along the same lines for either, except that the instruction to cut in halves must be ignored for single castings; obvious I hope!
Fit the vertical slide, and with outer face of the casting towards the chuck, bolt through the central slot, using clamping bars about ⅛ in. wider than the finished slot. Set the casting horizontal, checking with a rule at several points along the cast slot, then mill around the outer, flange, profile, to tidy this up. Now concentrate on the 3/16 in. spigot, gradually milling right round, to get the horns a tight fit in the gaps in the frames. The dimension over spigot is missing from both details, this being semi-deliberate, for rather than an actual dimension, it is the tight fit in the frames that is important. Next start milling the slot for the axlebox to size, 1¼ in. for the drivers and 1 in. for trailing, though again the actual slot dimension is relatively unimportant; what is vital is to get those ⅛ in. 'lips' exactly equal, so use a micrometer to achieve this. As you proceed, move one clamping bar at a time, to complete the slot, except for the top corners. There is no need to identify these horns when separating, for they cannot get mixed up, so saw the casting in halves, fit the machine vice to the vertical slide, and mill the hornstay flanges to give the correct overall height. At the same setting, you just might be able to clean up the top corners of the axlebox slot, but be careful, and revert to filing before anything untoward happens.

Hornstays

All four Hornstays are from ½ in. x ⅛ in., or 12 mm. x 3 mm., BMS flat; cut to length, marked off and drilled, but leave the holes specified to finish at No. 9 opened out only to No. 12 for the moment. This will allow you to spot through onto the axleboxes accurately. Clamp each hornstay in turn to its alloted horn, with inner faces coinciding, spot through, drill the horns and tap either 2BA or 4BA to drawing specification; fit hexagon headed bolts.

Fitting the Horns

We now have a very rigid horn and stay assembly, which can be fitted to the frames without fear of the weaker sides of the horns 'toeing in.' Ease a horn into its slot if necessary, to remain a tight fit therein, then clamp in place. Never drill all the fixing holes at once, but only two or three at a time. For the driving pair we need ⅛ in. snap head iron rivets about ⅜ in. long, and two simple tools. The first is a length of 5/16 in. steel rod that just protrudes above the top of the vice jaws; no more than ½ in. Use a 3/16 in. drill to 'dimple' it to accept the rivet head; do this by hand and rotate the drill brace around in circles as well, and you will be surprised how neat a spherical cup results. The second requisite is a 4 in. length of ¼ in. steel rod, drilled No. 28 to about ⅜ in. depth at one end.
Separate the frames, of course!, fit a rivet from the inside, and set the 'dolly' in the vice. Put the other tool over the projecting rivet shank, and apply a couple of good blows with a hammer, to draw the horn in full contact with the frame, then hammer the shank down into the countersink. If the river overfills the countersink, you will quickly learn by how much to reduce the rivet length to correct this and crop to suit, for this means less work with a file to get a nice flush surface on completion. Work from the top and down each side to firmly attach each horn.

Axleboxes

Axleboxes come next in line for treatment, being the cast gunmetal sticks that A. J. Reeves and Co. (Birmingham) Ltd. specialise in. They are of the 'solid' type, with the underhung springing so much favoured by LBCS, indeed at the time that the full size GLEN's were designed, it was also a fairly common practice in 4 ft. 8½ in. gauge too. It is rather a pity that I cannot hand over to the late maestro himself at this stage, for his 'words and music' would provide greater inspiration than any by yours truly!
First chuck each of the two sticks in turn and reduce to 1½ in. x 27/32 in. and 1¼ in. x 13/16 in. section respectively, squaring off each end at the same time; now we can concentrate on the driving pair. Back to the machine vice and vertical slide, to begin milling the slot along one side of the boxes. Use a ⅜ in. end mill and first produce a slot to about 7/64 in. depth, gradually widening and deepening it to 19/32 in. x ⅛ in., the former dimension

to suit the driving horns. Position the slot by miking over the outer flange, leaving any slight discrepancy on the inside, though do be careful, for the inside crank webs are fairly adjacent to the boxes. Take note of the vertical slide micrometer collar readings when the final cuts are taken at the sides of the slot, then rotate the casting through 180 deg. and tackle the second side, producing the slot to 19/32 in. width and 7/64 in. depth and then taking light cuts to increase the depth until the casting just enters the horns. Repeat the process for the trailing axlebox casting, the slot being 9/16 in. wide and again ⅛ in. deep; with the outer flange ⅛ in thick.

Cut the castings into individual axleboxes, chuck one of the driving pair in the 4 jaw and face off to 1⅜ in. overall length; leave at this setting and face off the second box to identical length, this will help a lot with the next operation. Before moving on to this, face the trailing pair to an identical 1¼ in.

Find the centre of the outer face of one of each pair of boxes, by the 'X' method, diagonal lines from corner to corner; centre pop and scribe a circle at ¾ in. diameter for the driving axle and ⅝ in. for the trailing. Next cut four 1¼ in. lengths from ½ in. x 3/16 in. BMS flat, one for each slot on a pair of axleboxes. Hold the driving pair back-to-back, slip in the packing pieces, and chuck in the 4 jaw. Fit a scriber to the toolpost and set the boxes so that the scriber point traces the marked circle; it is surprising how accurate this type of setting can be, for the eye is a wonderful inspection tool. If the 4 jaw chuck will not accept both boxes, although you can alternatively bore one at a time, slackening and tighening just two of the jaws, this method is slightly suspect and a better way is to use an angle plate, bolted to the faceplate, and then clamp said pair of boxes to the angle plate.

Centre, drill through, and either bore right out to size using the axle material as gauge, or leave a few thous. to finish with a ¾ in. reamer. One thing I would say is that if your reamer is not in top condition, then boring alone will produce the best surface finish. Complete the outer box by turning the 1/64 in. raised face, then tackle the trailing pair in like manner, remembering to bore only to ⅝ in. diameter. To machine the raised face on the other two boxes, chuck in the 4 jaw, poke a length of rod in the axle hole, perhaps journal bearing is a more technical description! Anyhow, set this rod to run true with a dial test indicator (d.t.i.) and face off.

The next job is to mill the oil reservoir at the top of the boxes, so back to the machine vice and vertical slide, and use an ⅛ in. end mill to produce ⅛ in deep to drawing. Drill the three No. 60 oil supply holes and this particular phase is complete.

The next step is to fit individual axleboxes to their respective horns, a case of careful filing. Once the axlebox can be pushed right to the top of the horn slot, fit the hornstay, pack the box hard down onto it, then spot through the No. 12 holes, which latter can now be opened out to No. 9. Back again to the machine vice and vertical slide to drill the holes in the axleboxes at No. 22 to ¼ in. point depth and tap 3/16 in. x 40T. That completes the axleboxes, except for final fitting, and we need the spring pins to achieve this.

Spring Pins

The Spring Pins are 2 in. lengths of 3/16 in. steel rod, screwed 40T at one end and 2BA at the other. To insert into the axleboxes, fit two commercial brass 2BA nuts and tighten together, then use the outer nut to screw the pin hard into the axlebox. Transfer the spanner to the inner nut and continue tightening to release the pair, then remove. This operation does strain the nuts, so throw them away after all eight pins have been fitted, so they will not be inadvertantly used elsewhere.

We now have to relieve the axlebox side flanges, as shown on the drawing, so each box can rise and fall independently without jamming, which later could well derail our GLEN. Do this a little at a time, so that with a length of axle material fitted, each box can be lifted from between 5/32 in. and 3/16 in., achieving this without introducing side play into the boxes. Ease the No. 9 holes in the hornstays if necessary to ensure this free movement, for it is one of the most critical features of the whole Locomotive.

Spring Plates and Coil Springs

Whilst in this area we can complete the springing of the driving and trailing axleboxes, starting with the Spring Plates. These are simply 1 in. lengths of ½ in. x ⅛ in., or 12 mm. x 3 mm., steel flat which is drilled No. 10 at ½ in. centres and then finished by filing the end radii; a jig helps this latter operation. Take a length of ½ in. silver steel rod, chuck in the 3 jaw, and turn down to 3/16 in. diameter for 5/16 in. length, then part off to leave ¼ in. at the original ½ in. diameter. For the second piece, face, centre and drill 3/16 in. diameter to 5/16 in. depth and part off a ¼ in. slice. Harden both pieces, insert the spigot through one of the spring plate holes, feed on the collar, clamp in the vice, and simply file down onto the jig; very effective!

Springs can be wound from 1.2 mm. piano wire, about 6 turns per inch, over a 3/16 in. mandrel; alternatively use ready wound 'Terry' springs. Reeves have standard springs 1¼ in. long, which are perfectly satisfactory, though a little extra thread will be necessary on the spring pins to accept them. The day after I wrote that last sentence, I had a query from a GLEN builder in Honduras on that very subject, so I guess I must be 'cyclic'! Anyhow, slip the springs over their pins, followed by the spring plate, then apply nuts and locknuts to complete, albeit temporarily.

Coupled Wheels

I reckon this is the ideal time for a breather, so let us turn, literally!, to the Driving and Coupled Wheels. I am particularly proud of these iron castings, with their beautifully sectioned spokes, all due to the skills of Norman Lowe on the pattern.

Chuck, by the tread, in the 4 jaw and set to run true, then face right across the back; form as much of the flange as you can. Centre, drill through, bore and ream out to ⅝ in. diameter. Next obtain a broken or worn-out drill with taper shank to suit your headstock mandrel, say about 11/16 in. diameter, and saw off immediately behind the flutes. Tap the shank of the drill, very lightly, into the mandrel and turn down the protruding portion to ⅝ in. diameter, a tight fit in the wheel seat; fit the faceplate and bolt a wheel, through the spokes, onto same. Turn the outside of the tyre, and the crank boss, to final thickness, then rough out the tread, leaving about .010 in. for the final cut; repeat on the other three wheels. Leave the last wheel in place, take a final cut across the tread, then with the tool left at this setting, complete the treads to identical diameter on the remaining wheels.

The next job is to drill the crankpin holes, for which another simple jig is required. Cut a 2⅜ in. length from 1½ in. x ⅜ in. BMS bar, square off each end, and scribe a centre line along one of the 1½ in. faces. Grip in the machine vice, on the vertical slide, and at ¾ in. from one end and on the centre line, centre, drill and ream to ½ in. diameter. Advance the cross slide by .875 in., the crankpin throw, then centre again, drill and ream to ⅜ in. diameter. Chuck a length of ⅝ in. diameter silver steel in the 3 jaw and turn down for ⅜ in. length to a press fit in the ½ in. hole; if you fail to achieve the necessary press fit then use Loctite retaining compound. Before assembly however, part off to 1⅜ in. overall, reverse in the chuck and turn down to ½ in. diameter for ½ in. length, screwing to suit an available nut. Leave the nut in place when pressing home in the flat bar, then the threads will not be damaged.

To use the jig, insert through the wheel seat, from the front, and fit the nut; now orientate so that the crankpin hole will be in the middle of its boss. Dealing with the crankpin holes is really a job for the pillar drill, though with suitable packing I have always managed to employ the lathe to good effect. Choose a Slocombe centre drill with ⅜ in. shank to suit the jig, centre deeply and then drill out to 23/64 in. diameter before finishing with a ⅜ in. reamer.

My ideas regarding balance weights have changed somewhat since the drawing detail was prepared in 1976, so at least there has been some design progress! I still believe fervantly in not having balance weights cast integral, both to increase the versitility of the casting, which is sound economic sense these days, though the main reason is that a better casting results. To form balance weights these days, I use ISOPON P38, available from most garages, and introduced initially as a filler for dents in motor vehicle bodies; I used to think that was the best place for it, but experience in use has brought respect! Cut cardboard templates to the shape of the inner crescents, and wide enough so you can grip them over the wheel in the bench vice. Mix the Isopon to instructions and apply with the spatula provided, working right down between the spokes. It does not matter if the cardboard splays out, but do try to get the crescent surface reasonably smooth and accurate, as this will save time with a file later on. Allow to harden, a couple of hours is more than sufficient in most climes, then remove the cardboard.

Back to the mandrel and faceplate, bolting the wheel to the latter, and first face off at the back to be flush; Isopon turns sweetly to leave a polished surface which will accept paint. Reverse the wheel and face the front of the balance weight flush with the tyre, then with a 'V' point tool, the internal screw-cutting one from your set of turning tools, just pull the wheel round by hand over the segment between tyre and balance weight to produce the wee groove to drawing; or use a thin parting off tool made from a hacksaw blade. The alternative of course is to 'cast' in the balance weight at the outset, and then turn as one operation.

Crankpins

The Crankpins require some comment on my part, as well as description of their manufacture, for later wheels have a slightly raised centre wheel boss, which stands proud of that for the crankpin, whereas the drawing dimension of 1 3/64 in. assumes the crankpin boss being flush across the back of the wheel. So put a straightedge across the back of the machined wheel, measure down to the crankpin boss, and subtract this dimension from 1 3/64 in. to arrive at the plain length of ⅜ in. bright steel rod.

Turn down for 5/32 in. length to .236 in. diameter and screw OBA, then part off to give the necessary plain length; secure to the wheel with Loctite retaining compound. To complete this assembly, find thin washers ¼ in. o.d. that will fit over the OBA thread, or make them. Next make, or reduce in thickness commercial OBA nuts, to come flush with the end of the crankpin thread. On final assembly these can be better secured with a mild grade of Loctite, so they wont slacken in service, but can be removed on occasions when the coupling rods require re-bushing.

Coupling Rods

Talking of Coupling Rods, these are next on our list, for which we require two 10½ in. lengths of 1 in. x 5/16 in., or 25 mm. x 8 mm., BMS flat. On one of the 1 in. faces, on each piece, scribe a line along at 7/16 in. from one edge, then at ½ in. from one end, centre pop, drill through and ream at ½ in. diameter.

We are going to use the axleboxes as the gauge for our coupling rod centres, but first we need two simple aids. For the first piece, chuck a length of ⅝ in. steel rod in the 3 jaw, face and then turn down to ½ in. diameter, a good fit in the hole in the rod, over ⅜ in. length; part off to leave a ⅞ in. length of the original ⅝ in bar; this fits into a trailing axlebox. For the driving axlebox we need a drill bush; ¾ in. o.d. ½ in. bore, and about ¾ in. thick; this should be a close fit in the axlebox.

Separate the frames and pack both axleboxes on the one side hard down onto their hornstays. Fit the stepped mandrel to the trailing box, slide on the coupling rod, and then line up the scribed line on the rod central with the bore of the driving box; clamp in place. Fit the drill bush and using a Slocombe centre drill that fits snugly, centre deeply, then drill through and ream out to ½ in. diameter. Now, using the two ½ in. holes as datum, mark on the profile of the rod.

To machine coupling rods in the lathe, a substantial piece of square angle is the requirement, say a 12 in. length at 1½ in. x 1½ in. x ¼ in. section. Drill holes at about 2 in. centres in one face, to suit bolts for attaching to the vertical slide table. In the other face, drill two ⅜ in. holes at 9½ in. centres, and bolt the embryo rod to same, then erect to the vertical slides with bottom edge of the coupling rod towards the chuck. First, with a ⅜ in. end mill, machine out as much of the bottom profile as you can to line; the rod is too long to complete at one pass. Change to a Woodruff key cutter, No. 606 for preference, when you will be able to tackle the top edge of the plain portion. I should have said earlier that the angle, and consequently the rod, must sit perfectly horizontal, though this condition only begins to matter at this next stage, which is to mill 3/32 in. off the upper face of the plain portion, using the side teeth of a ½ in. end mill. Back to the Woodruff key cutter, to flute the rod to no more than 3/64 in. depth, the end of the flute to coincide with the step produced by the end mill one step earlier. Carefully move the rod along, set it horizontal again, and repeat the dose to complete the plain portion. Turn the rod over, support the centre portion with 3/32 in. thick pieces of packing, and mill the back face to give the required 3/16 in. thickness.

Rough out the two end bosses by sawing and filing, in fact the portion between the top edge and the oil boss should be completed this way. Fit the machine vice to the vertical slide, file or mill two flats on a length of ½ in. steel rod, and grip this in the machine vice as a mandrel. Slip a rod end over the mandrel, chuck a ⅝ in. end mill in the 3 jaw, and radius the rod end with same, pulling the rod towards you around the mandrel, never the other way.

At every stage of machining, clean off all the rags and sharp edges, to prevent a nasty accident to your hands. To complete the rods, drill No. 40 from the oil boss into the bores and tap 5BA for the wee oil caps.

Coupling Rod Bushes

The bushes are turned from ⅝ in. bronze rod to a really tight press fit in the rods, about .003 in. interference with a lead at one end, then centred and drilled through at ⅜ in. diameter; finally parted off at ⅜ in. thickness. Press into the rod to be 1/32 in. proud at each side, which means a washer between vice jaws and rod so the bush comes through O.K.; and prevents any unsightly marks at the same time! Drill No. 60 from the oil boss into the bore, then ream the bushes at ⅜ in. diameter; they will have squeezed in sufficiently to allow this, then we can use the rods as quartering the wheels later on.

I may forget one instruction in correct sequence in my haste, so let me clear it right now. With the wheels correctly quartered, and the axleboxes hard down on their hornstays, it will be possible to turn the wheels easily with the rods fitted. But lift just one axlebox and the whole assembly will bind, and if the wheels as thus constrained from following irregularities in the track, then derailment will occur, something that must not happen after all our hard work! So when the assembly is complete, grip a 3/8 in. drill in the bench vice. drop a rod end over it, insert a length of 1/16 in. rod down one flute, and rotate the rod; this will pare a few thous. away from the bore. Be careful how you do this, as the drill might 'bite', but in conclusion each axlebox should lift the same 5/32 in. to 3/16 in. independently, as when we dealt with the axleboxes in their horns. If the bushes were left with reamed holes, they would quickly wear to the conditions we have produced; if your GLEN stayed in one piece!

Feed Pump

For strictly personal preference, injector feed only would be relied on for GLEN, fitting two of our Vertical type, one of 12 oz. capacity and the other 16 oz. However, a lot of builders still like to have a Feed Pump, so I just had to fit one between the frames; almost pure LBSC!

The body has a chucking spigot provided, so first chuck by the main part of the body and take a light cut over said spigot, to true up. Chuck by the spigot next, face off to length, then centre and drill 1/4 in. diameter to 1 5/16 in. depth. Follow up with a 23/64 in. drill and complete the bore with a 3/8 in. 'D' bit. Turn down the outside for 7/8 in. length to 9/16 in. diameter and screw 26T.

Next chuck by the inlet spigot, skim across the outlet face, then centre and drill right through at No. 31. Follow up with a 9/32 in. drill and then 'D' bit to 7/16 in. depth, tapping the outer 3/16 in. at 5/16 x 40T. Complete this part of the operation by poking an 1/8 in. reamer through the remains of the No. 31 hole.

Turn the body round and chuck by the outlet spigot, or you can first turn the main part of the outlet connection and use this as a screwed mandrel for the pump body. Drill 9/32 in. diameter to 3/8 in. depth and again tap the outer 3/16 in. at 5/16 in. x 40T. When the suction ball lifts it must not seat in the body above, so break up that slightly countersunk 'seat' with a small chisel. Inlet and outlet connections call for no description, save the same comment applies to the ball seating above the outlet; this can be prevented by four 'nicks' with a file. You can best orientate the inlet and outlet unions to place, for ease of piping up, so fitting these can be left until much later on.

The ram is from 3/8 in. rustless steel rod, with a pintle turned on the end to 15/64 in. diameter to give clearance. Cross drill at the other end at No. 31, then either mill, or saw and file, the slot to suit the eccentric rod. Turn the gland nut from 3/4 in. brass or gunmetal rod, using a small end mill or slitting saw for the 'C' spanner grooves, which are 3/64 in. deep. Centre, drill 3/8 in. diameter to 7/8 in. depth, follow up with a 1/2 in. 'D' bit to 17/32 in. depth and tap 9/16 in. x 26T before parting off. Pack the gland with PTFE or greased water packing.

The eccentric rod is built up from 1/4 in. x 1/8 in. BMS flat, though I suggest you make up an 'eye' at the ram end, this from 3/8 in. bronze rod, being a 1/8 in. slice drilled and reamed at 1/8 in. diameter. Braze the three pieces together; if the rod is slightly too long then you can skim off the bolting face; too short and you just add a shim at the same point.

Eccentric Sheave

The Eccentric Sheave is one instance where metrication will help, for 40 mm. is slightly greater than 1½ in., giving a deeper groove. Whichever material you choose, chuck in the 3 jaw, face, centre and bring the tailstock into use. There is only the pump eccentric to be dealt with, and it is not too heavily loaded, so an ordinary parting off tool, ground square, will be adequate to produce the groove. First reduce for 3/8 in. at the outer end to this 1 3/8 in. diameter, take a note of the micrometer collar reading on the cross slide, then repeat for the groove itself, before parting off to give both a gauge for the mating strap, and the embryo sheave; face off the latter to thickness. From the centre, and you can leave a wee 'pip' to indicate this when facing off one side, measure out 1/4 in. and centre pop. Chuck in the 4 jaw with this pop mark running true, then centre, drill through, bore and ream to 3/4 in. diameter.

As the complete crank axle is specified as assembled with Loctite high strength retaining compound, then this form of fixing could equally apply to the sheave, though there is nothing against using a 4BA cup point socket grub screw in lieu. I guess readers are aware by now that I am very much in favour of Loctite, having proved its fantastic properties in industry as well as in miniature, though I have two reservations. The first is I wish they would not keep altering the numbers, for at this point in time I believe one should read '636' for '35' on the drawing detail, but for how long I wonder? Secondly I believe Loctite has a 'shelf life,' though this is never publicised, in that some packs retain their properties throughout, whilst others harden almost as soon as opened, which is most annoying for such an expensive product.

Eccentric Strap

We now come to the last component in this particular session, the Eccentric Strap, for which Messrs. Reeves will be able to provide a suitable gunmetal casting. Grip in the 4 jaw, face one side, then saw in halves, mill the joint to get towards the final shape, then clamp together, drill through No. 34 at top and bottom and secure with 6BA bolts. Back to the 4 jaw, to face to thickness and bore out to gauge. Clean up the profile with files, mill the seating for the eccentric rod, then drill No. 30 for the oil reservoir and No. 60 into a bore. Drill and tap the 8BA holes from the rod and at that point I can take a breather; see you in three months time with the Cylinders and Motion.

BOOK REVIEW

'THE NARROW GAUGE' —

published by the Narrow Gauge Railway Society, price 75p inc. P. & P., and available from The Membership Secretary, Mr. P. Slater, 'Hole in the Wall,' Bradley, Ashbourne, Derbyshire.

We were sent Magazines No. 82 and 83 for review, and from previous knowledge of the publication, they are typical. The information contained therein is intended to keep Society Members abreast of current happenings on the Narrow-gauge scene, to relate the history of all facets of Narrow-gauge — the Railways themselves, Locomotives and rolling stock, this on an international scale. Details are also provided for modellers, though as this description implies, this is of most value to those who build in the smaller scales, and use electric rather than steam propulsion. There is however much data contained in the many photographs, and text, the latter being well researched, helpful to the builders of miniature steam Locomotives to Narrow-gauge prototypes, and with different treatment of this most fascinating of subjects, there will be little or no duplication between LLAS and THE NARROW GAUGE.

It was interesting to find old friends joining in the correspondence columns, for instance Rodney Weaver and Bob Sloan (U.S.A.), both extremely knowledgeable on the subject of Narrow-gauge. If any reader has not yet been 'converted' to Narrow-gauge, then THE NARROW GAUGE will certainly help.

D.Y.

Glen

by : DON YOUNG

Part 3 — Axles and Cylinders

One or two astute readers have pointed out that the success or otherwise of a constructional series depends not only on the script and drawings, but on photographic evidence; this latter had been sadly lacking with GLEN. I must take the major portion of the blame for this short-coming, for though we have handled a deal of machining work for GLEN's, and even a complete boiler as built by Reg Chambers, never once did I point the camera in the right direction. At last I have been saved, as the illustrations bear witness, so especial thanks to those who have solved the problem for me. First to the Real Photographs Co. Ltd. of Broadstairs, Kent, who have kindly provided me with photographs of the full size GLEN's of a quality which even the printers comment on as excellent; you should hear what they have to say about some of my work! But to really set the seal I have to thank Marshall Dickson for his superb shots of Abram Reid's GLEN DOUGLAS, both are members of the Glenrothes Society. The most telling comment again came from the printers — "We can't tell the difference between the SMALL and the LARGE LOCOMOTIVES." I guess that sums up my feelings too!

Coupled and Crank Axles

On with construction, starting with the coupled axle, which is simply 6 in. finished length of ⅝ in. diameter bright or silver steel rod, centred at each end; wish all the parts were so easy to describe!

Thanks to 'Loctite,' crank axles have lost all their terrors in manufacture, for gone are the days of critical interference fits, heating crank webs and pressing stub axles into them squarely before the heat transfered. Start by squaring off a length of ¾ in. bright steel rod to 6 in. overall and centre at each end; these latter must be accurate, so if your 3 jaw chuck is suspect, revert to the 4 jaw and set true with a d.t.i. Mount the axle between centres and carefully tighten the 4 jaw onto it; there is no need to invest in a lathe carrier and catchplate, though by all means use them if they are at hand. At the outer end, turn down to .623 in. diameter for 21/32 in. length, this to give clearance for the Loctite, so it can function correctly. This of course does leave the problem that with this clearance, the wheel when fixed can wobble though I have found that by ensuring it is fitted hard against the shoulder, results are satisfactory. Anyone worried on this aspect can always leave a raised portion at each end of the seat to firmly locate the wheel, though this is getting back to the accuracy required in pre-Loctite days. Reverse the axle and repeat the dose, to give a dimension of 4 11/16 in. over shoulders; the main component is complete.

Turning now to the crank webs, in the days when the drawing was prepared, metrication appeared to be advancing fast, so I took advantage of this to specify a 40 mm. x 8 mm. section, this being slightly more accurate to scale than the 1½ in. x 5/16 in. alternative I now give, though personal preference remains with the metric section, a Whiston standard stock item. Cut four 2¾ in. lengths from the chosen material, scribe a centre line along two pieces, then grip a pair in the machine vice, on the vertical slide. At 13/16 in. from one end, on said centre line, centre, drill out and ream to ¾ in. diameter. Advance the cross slide by 1.125 in. and repeat the dose, then tackle the second pair; it would be as well to stamp them for identification. Staying with this set-up select a short stub of ¾ in. rod and file two flats on same so it can be gripped firmly in the machine vice. Rough out the ends of the webs with saw and files, grip very tightly with a 'Mole' wrench, and finish the end radii with an end mill over the mandrel just made. If this is too much for your nerves, make up a template and file down to this.

Take a pair of webs and use three pieces of 5/16 in. square bar to space them the correct distance apart, located clear of the holes. Fit lengths of ¾ in. rod through said holes, to check alignment, then clamp firmly together. Measure over the webs to check the length of crankpin, it should be 15/16 in., then part them off from your ¾ in. axle material. The pin and its holes should now be wiped clean and a squirt of Loctite Primer 'T' applied as further degreasing, it also acts as a catylst to further increase the strength of the Loctite No. 636 now to be applied, when the pin can be slid home and left to cure. Loctite expands as it solidifies in confined spaces, so the strength of the joint is by the hoop stress it induces, just like a press fit, so additional keys or pins simply tend to break down the 'hoop' and weaken rather than add to the joint; I recommend this be avoided. Bring the second crank assembly up to this stage; you can handle them after a few minutes quite happily, but allow an hour to be absolutely certain.

Next throughly clean the main axle, apply Primer T where the first crank assembly is to be fitted, do likewise to the mating holes, apply Loctite 636 and assemble, locating to the dimension shown. The eccentric sheave comes next, and although there is no special orientation, I suggest it will look better if you locate it at 180 degrees opposed to the crank already fitted, then you will be able to set the whole on a surface plate to cure. For the second and final crank assembly, leave on the surface plate, and use a square on the webs to set them upright, allow to cure again, this time overnight. To complete, all you have to do is cut away the surplus axle between the crank webs, either by saw and file, or you can mill flush if you prefer.

Cylinders

We now come to the cylinders, which up to and including the valves are exactly the same as for my LANKY design, which I recently described in 'Live Steam' Magazine. The changes are in the steamchest, which can be more generous, as per the teachings of Andre Chapelon; also in the exhaust arrangement. This latter posed a problem, as the centre line of the chimney is well ahead of that of the cylinders, and previous experience has shown me that 'S' bend blast pipes are less than ideal, there being insufficient length for the exhaust to straighten before reaching the nozzle, so it is not central to the petticoat pipe. Two solutions appeared possible, one being to drill an internal exhaust passage forward in the block, and turn it upwards at the correct spot under the chimney. It appealed to me less than the arrangement I have adopted and show hereabouts, and though I prefer an unimpeded exhaust, at least the steam will emerge vertically from the blast nozzle. Apart from this one feature, it was nice to be able to draw up cylinders which have already proved themselves in service, so we can at least move forward with confidence.

Cylinder Block

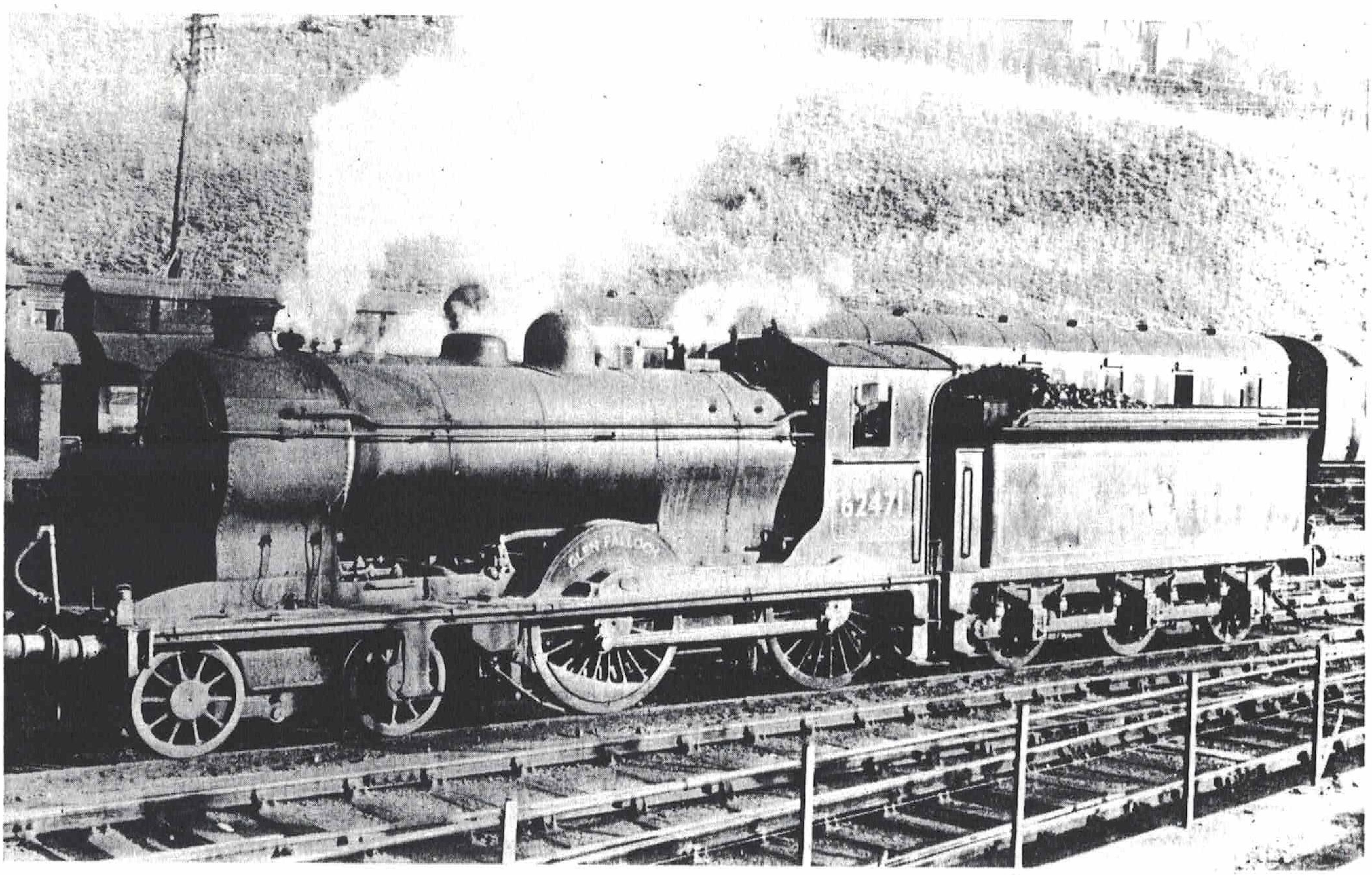
Most of the work is in the cylinder block, so let us tackle this as far as we can go as a first step. The casting is available either in gunmetal or iron as the builder prefers; clean up the faces with a file to assess the machining allowances provided; I hope you will agree they are generous. Establish the height of the port face on the casting, scribe around, then chuck in the four jaw and with the scriber under the toolpost, trace as much of this line as possible to check that the casting is sitting properly. Change to a round nosed tool and turn down to line, getting the best finish possible, for this is the working surface for the valves. Using the cored bores as reference again, work out the frame attachment faces, and again scribe around the block. Still in the four jaw, with a piece of soft packing protecting the port face, set to machine a bolting face, checking squareness back to the port face. Complete to line, reverse in the chuck and machine the second face to your frame gauge; we are winning. The fourth face to be tackled is that for the front cylinder covers, again in the four jaw, facing across and checking for squareness before completing to line.

At the back cover face, cut hardwood bungs to fit the cored holes and drive them in flush with the face. Mark on the bore centres and scribe circles at $1\frac{5}{8}$ in. diameter to represent the finished bore size. It is rather doubtful if you will be able to chuck the casting for boring in the four jaw, in which case fit the faceplate and bolt an angle plate to same. Sit the port face on the angle plate, pack the front cover face away from the faceplate so that the boring tool can pass right through, then make up a clamping bar to fit across the block, with two bolts down through slots in the angle plate. With a scriber under the toolpost, move the angle plate around until said scriber accurately traces the bore circle. In doing this you have checked the angle plate does not foul the lathe bed; now run the lathe at a slow speed, in back gear, to check if the eccentric loading causes any stress, adding counterweights as found necessary. When satisfied, change to direct drive, poke a large drill through the hardwood bung and then change to a boring tool which is long enough to pass right through the block. Take a fairly heavy cut in the first instance, to get under the skin of the casting, using the finest feed possible. Carry on at a speed and cuts, that strain neither the lathe, or your nerves; that is the best advice that I can offer.

Approaching size, and for '0' ring fitted pistons, this needs to be a fairly exact, traverse at least four times at the same tool setting to remove any taper induced by 'tool spring,' then check the bore size with internal micrometer or vernier calipers. Carry on to size, getting the best surface finish you possibly can; it should be like a mirror. Move on to the second bore, moving only the angle plate on the faceplate to achieve this; do not release the clamp for the bores must be parallel to each other. Complete boring and then face across for the back covers and to give the required overall length of 2 15/16 in.

The ports come next, so mark them out on the block, transfer the angle plate to the vertical slide, and bolt the block down through the bores, using large washers or a clamping plate at the top. Check that the port face, facing the chuck, is square across the lathe axis, and also that at least one group of ports can be milled without moving the angle plate; you should be able to tackle both groups at the same setting. Start with the exhaust ports and drill two 7/16 in. holes in each to 5/16 in. point depth. Change to a $\frac{1}{4}$ in. end mill and machine to depth along the centre of the port, gradually widening it until a piece of $\frac{1}{2}$ in. square material enters as your gauge; at the same readings complete the second exhaust port if at all possible. This will leave rounded corners at the ends of the port, which can well be left, although their radius can be reduced by use of smaller end mills, even eliminated with a small chisel, though this latter will have to await removal from the lathe.

For the steam ports, drill five 5/32 in. holes in each to 5/16 in. point depth in the first instance, then change to a 5/32 in. end mill and open out into a slot. These small end mills are very flexible, so watch it does not wander across the scribed lines, adjusting the vertical slide if necessary to avoid this. Once the port is to full depth, the end mill will follow a straight line except at



GLEN FALLOCH in B.R. days, with snifting valve situated immediately behind the chimney.

the extremities, and the way to avoid problems here is to tackle the ends first with an even smaller end mill; 3/32 in., or even 1/16 in. if you have the courage! Open out the flanks of the port, as equally as you are able, until you can just push a No. 16 drill into the slot; this means you have .010 in. to go. Use your micrometer over this drill and the gauge inserted in the exhaust port; you can see how close your dimension is to the perfect figure of .875 in. Take final cuts to arrive at this, and the 3/16 in. port width, accordingly. Armed with this knowledge you can now cut an identical port in the second group, and tackle the other pair in like manner, all with minimum fuss and maximum accuracy. Keep this set-up for a moment, to centre and drill at 35/64 in. diameter, to ¾ in. point depth, for the central exhaust exit, tapping at ⅝ x 26T to a full ½ in. depth.

There are but two more operations to deal with before laying the block aside; first turn through 180 degrees to bring the bosses for the drain cocks to the fore. Lightly skim with en end mill, mark their positions, then centre and drill at No. 22 to ¼ in. maximum point depth, following up with a 3/16 x 40T plug tap. Those No. 55 holes are best drilled back from the bores, so lightly centre pop and then drill by hand. That leaves only the connecting holes from the exhaust ports into the central exit; centre pop and drill ⅛ in. pilot holes. Open out in stages to 5/16 in. diameter, then grip a 5/16 in. end mill in your hand-drill and elongate to arrive at a generous passage, taking care not to damage the port edges. A larger plain hole will do equally well, but I did not specify same due to the proximity of the cylinder bore, not wanting to precipitate a disaster!

Cylinder Covers

The front covers are relatively simple, so let us get these out of the way first. Grip the casting by its periphery and clean up the chucking spigot, then grip by said spigot. Face right across and turn the periphery to size, before concentrating on the spigot to suit the bore. Try to get this a really good fit, for although it does not matter here, it is good practice for the rear covers to follow. Change to a knife edge tool and scribe the bolting circle at 1 15/16 in. diameter, then pull the cover away from the chuck so that you can face across and part off the chucking piece. Scribe on a line to give that 1 in. dimension from the centre of the cover; saw nearly to line and complete by milling. For the second cover, repeat the process to leave a small overlap, so that the edge can be eased with a file to allow both covers to seat. Scribe further lines from the block to show the relief required at the frames; saw and file, or mill, this away to leave a small clearance, for ease of cover removal after paint has been applied to the frames. Mark off and drill the nine holes No. 30 as specified, offer up to the block, mark off and drill the pair of common holes, then spot through, drill and tap the block at 5BA to 3/16 in. depth.

The rear covers follow exactly the same procedure up to and including the scribing on of the bolting circle. Do not reset at this stage, but face off the bolting surface, just a light skim, then centre, drill 6 mm. diameter to at least 1 in. depth and follow up with a ¼ in. reamer before parting off the chucking spigot. Grip by the periphery in the 3 jaw and poke a length of close fitting ¼ in. rod into the hole, to check it is running true with your d.t.i.; use the 4 jaw if there is any problem. Face off the gland boss and countersink, then use a ⅜ in. 'D' bit, which has the sharp corners stoned to a small radius, around 1/64 in., to form the housing for the 'O' ring; again surface finish is important. Take care to get the common joint between the covers a close fit, and maintain a vertical joint line, then we can finish the covers.
Bolt through the central, piston rod, hole to the vertical slide and set the joint edge vertical. First mill all around the boss, to 1⅛ x ⅝ in. section, then rough out the recessses to accept the slide bars, finishing with 1/16 in. end mill. This leaves a small radius in each corner, which although it is possible to remove most of it, is not worth the effort, the solution being to file a mating chamfer on the slide bars, so they seat correctly. The slide bar fixing holes will have to wait awhile, but apart from this there is only one major job left on the covers, relief in way of the end of the passages, so we had better deal with the latter as the next step.
Between the tapped holes for cover fixing and in positions indicated, first file a 45 degree chamfer to approximately the shape shown; centre pop at 3/16 in. centres for the steam passages. Drill initially at No. 41 to break into the steam port; if this is not in the right position, open out to No. 30 for about 1/16 in., just enough for an ⅛ in. end mill to enter. Using the end mill in the hand-drill, you will be able to correct the error, before opening out to the final size of No. 20; repeat for all eight passages. To ensure free entry from the passages into the cylinder bores, the covers must be relieved, so coat the block with marking blue and push on the covers to give a clear impression; scribe on this outline. Grip in the machine vice, over the two flats, and use an end mill to complete. Forgive my stressing such an elementary point, but it has been the cause of more than a few red faces over the years!

Piston and Rod

Rough out a piston blank, including the 'O' ring groove, then centre and drill 7/32 in. diameter to ⅝ in. depth. Follow up at Letter D, or 6.3 mm., to 15/64 in. depth, then tap ¼ x 40T before parting off. I suggest the piston rods be made 4⅛ in. long initially, so face off to length, then screw ¼ x 40T for ½ in. at one end, using the tailstock die-holder and opening out the split die to give a tight thread in the embryo piston. Fit said piston and first face off to thickness; this will help the piston tighten hard up on the thread. Next turn the outside to a good sliding fit in the chosen bore, before finally giving attention to the 'O' ring groove. For this latter a tool 3/16 in. wide, of parting off tool form, ground square with 1/32 in. radii one of the corners, is ideal. Run the lathe slowly, that means in back gear, feed in the tool and use plenty of cutting oil. Rub away the top corners of the groove, so it will not trap the 'O' ring; .010 in. radius is not much! Slip on the 'O' ring, assemble in the bore and fit the covers; joints for these I always prefer to be from brown paper soaked in linseed oil.

Of course, with cast iron cylinders, piston rings may be used, grooves being machined as described for HUNSLET, the rings themselves be available from A. J. Reeves and Co. Ltd.

Gland Plate

To complete this part of the assembly, albeit very temporarily, we need the piston rod gland plates. Mark them off on brass sheet, drill all the holes, then saw and profile to drawing. Slide over the piston rod, hold against the gland boss, spot through, drill and tap for 10BA hexagon bolts; the 'O' ring can be fitted later.

Steamchest

This steamchest is just a plain box, for apart from cast-on bosses more than doubling the price of the casting, due to requiring a split pattern and mould, it is easier to machine the plain box and add the bosses later. Grip in the four jaw and machine across one of the bolting faces; reverse and complete to thickness. If your machine vice is both large and sturdy enough, grip in this on the vertical slide and mill around the outside; otherwise clamp to an angle plate. The stepped portion on the back face is to accept the smokebox back plate, this latter from 2.5 mm. copper. So this determines the step in one direction, and in depth it comes down to the valve spindle bosses, a dimension of ⅜ in. more or less. With this face still towards the chuck, mark off for the bosses, and the oil delivery check valve tapping, dealing with the latter first. At the boss positions, centre, drill through and tap 7/16 x 26 or 32T.

Whether gunmetal or cast iron be the steamchest material, start off with ⅝ in. bronze rod for the valve spindle bosses. Chuck in the 3 jaw, face and turn down for 11/32 in. length of 7/16 in. diameter and screw to suit the chest; part off at ⅞ in. overall. Chuck an old ½ in. length of ⅝ in. rod, face centre, drill and tap through at 7/16 in. 26 or 32T; screw the embryo boss into this adaptor. Face off the give 7/16 in. stand-out then turn down the outside to 9/16 in. diameter, to leave a little fillet radius at the inner end, as shown. Centre and drill through at No. 13, following up at 11/32 in. to 7/16 in. depth; tap ⅜ x 32T before running a 3/16 in. reamer through the remains of the No. 13 hole. Screw into the steamchest and use liquid jointing compound to seal the threads.

To complete the steamchest, mark off and drill the twenty-four No. 30 holes for fixing to the block; offer up to the latter, spot through, drill and tap 5BA to 3/16 in. depth. Studs are 1⅝ in. long from ⅛ in. stainless steel rod, screwed 5BA at each end; the four corner studs want to be screwed for sufficient length so that the steamchest can be held firmly whilst the cover is removed for valve setting.

Steamchest Cover

Talking of the cover, this is a piece of brass sheet around 3/16 in. thick; I have specified 4.5 mm. as being the nearest, I hope!, readily available material. Cut to size, offer up to the steamchest and drill back at No. 30, then if the steamchest will not pass over all the studs, open out these holes to No. 29, even No. 28 if necessary. To complete, mark off the steam entry and exhaust fitting centres and deal with these as per drawing.

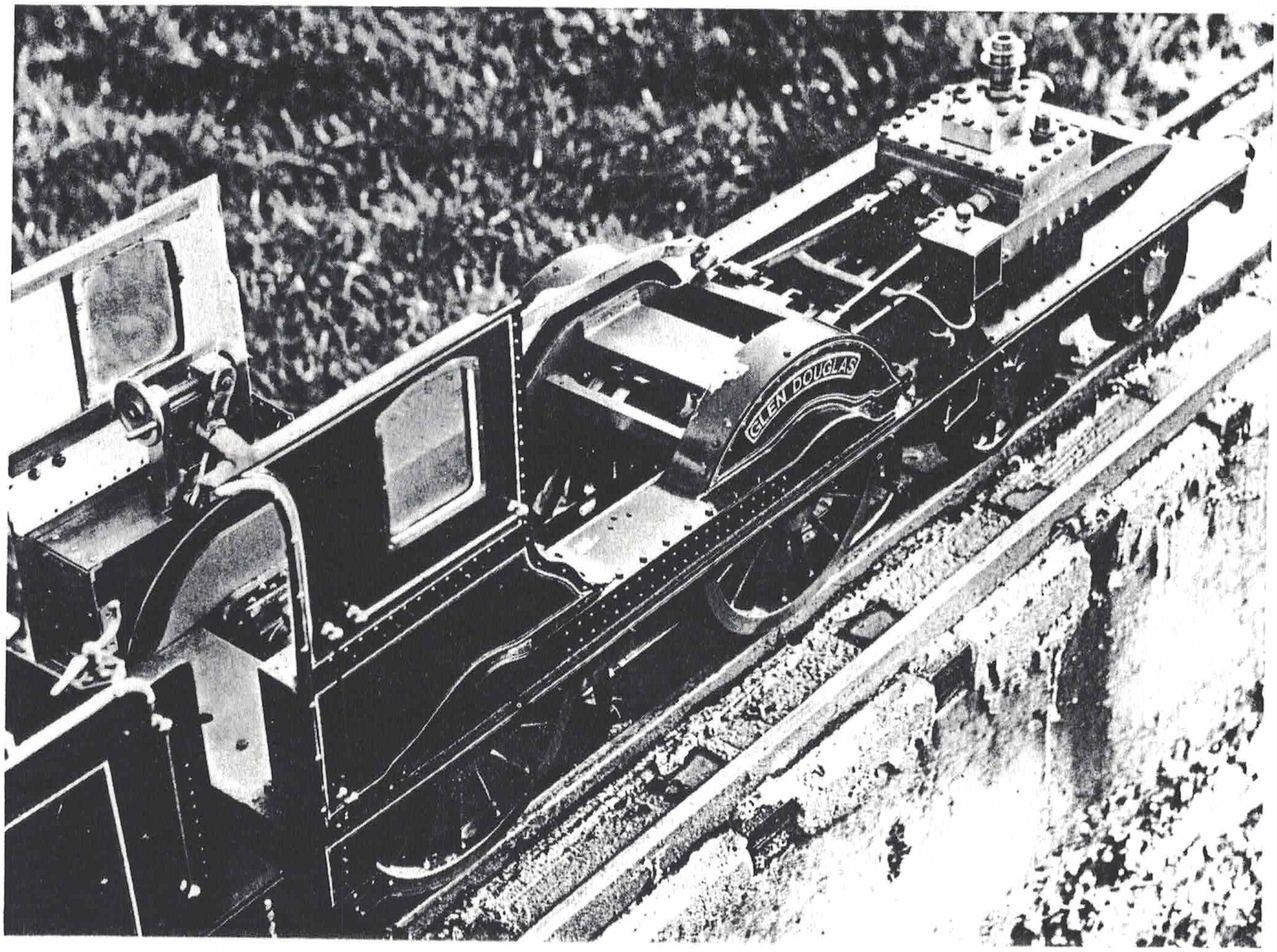
Exhaust Fitting and Flange

The exhaust fitting is plain turning, the only thing to watch being that the 1⅛ in. dimension coincides with the depth of the steamchest; the two flats for tightening into the block can be dealt with by filing. The flange is from the same ⅞ in. diameter bronze bar, 3/16 in. thick and tapped ⅝ x 26T; again the four slots for tightening with a 'C' spanner can be dealt with easiest with a swiss file, they will never be seen!

Valve, Valve Spindle and Gland

The spindles require no description, save that the tail-stock die-holder must be used to ensure the threads are square; the gland also is straightforward.

The valves are either iron or gunmetal castings, to choice, and the first operation is to chuck in the 4 jaw to machine the working face to a good finish. Reverse in the chuck and face off to the correct overall height of ⅝ in. Clean up the cavity to size with files, after which the two steam edges can be marked off and milled to line, checking with a micrometer. Tidy up the sides, keeping the cavity central, then mill around the top for the buckle; there is a step on the back to allow for the greater buckle depth here.



GLEN DOUGLAS under construction by Abram Reid. This is the first of a whole series of photographs by Marshall Dickson which will grace these pages.

Valve Buckle

Cut these from 1¼ in. x ⅜ in. flat brass section; this is a regular line from Messrs. Whiston's, and square off to 1 9/16 in. overall. Grip in the machine vice, on the vertical slide, mill away to form the step, drill out the centre and mill roughly to line, then file out to a close fit over the valve. Turn the back face towards the chuck, centre, drill and tap 3/16 x 40T for the valve spindle; the cylinders can now be assembled to check that all is in order.

Exhaust Box

The exhaust box starts life as a 2¼ in. length of 1½ in. x ¾ in. brass bar, though it could well be made from steel. First reduce the block to 2 5/32 in. x 1⅜ in. x ¾ in. and add the chamfers; that on the top face being to ensure free gas flow from the bottom row of tubes, and for ease of cleaning same. Now you can drill and mill out the cavity to approximately the shape as shown, to get the front edge flush with that of the steamchest cover, and also to clear the exhaust fitting flange. Remove the steamchest cover, clamp the box to same and drill back at the two positions; this pair of studs want to be about 2⅜ in. long. Mark off the other fixing holes, drill these in turn at No. 30, spot through, drill and tap the steamchest cover at 5BA; either studs or 1 in. long bolts can be used for fixing. The stub blast pipe being only ¾ in. long can be turned from bar as the alternative to tube, but I suggest you leave drilling the hole for same in the box until the smokebox is erected.

Slide Bars

These are 4 7/16 in. lengths of ¼ in. square steel, the chrome vanadium variety for preference; this latter does not require hardening and tempering for our purpose. Drill the No. 34 hole, chamfer the rear end, and that is as far as we can go for the moment.

Trade news and reviews page

Whiston's Catalogue No. 94

Casting my mind back nearly 25 years, I remember there was always a communal copy of Whiston's Catalogue in the Drawing Office in which I was then employed. It was used not only by us practising model engineers, who were very much in the minority, but also by the more affluent car owners, plus all engaged in D.I.Y. activities around the house. Even today, a glance in some of the tins containing my stocks reveals a myriad selection of nuts and washers; even a few of those superb bolts with heads two sizes smaller than standard, which were once a Whiston 'special.' More recent activities with the pen, rather than in the workshop, with consequent lack of orders, meant removal from Whiston's mailing list, so it was like receiving an old friend when List No. 94 arrived through the letter box.

The most noticeable change over the years is the decline of ex-surplus items, as one must expect, to be replaced by an ever growing number of regular lines, old favourites and new. Whiston's have asked me to make an important point that ex-surplus items, once sold out, cannot be repeated, so if you see something you would like, don't delay, send today. The other major change has been metrication, which is reflected in this List, indeed Whiston's must hold the largest stock of metric items, of all descriptions, available to the SMALL LOCOMOTIVE builder.

The only positive way to find what Whiston's have to offer is to send for their List, and please mention LLAS when doing so, for their range is far too great to make mention here. So I will confine myself to one section only, a new one listing various fasteners in 18/8 'A2' non-magnetic stainless steel, a most useful addition in my opinion.

A feature which must be appreciated by customers is that all prices are inclusive of post, packing and VAT; a brave decision, and a herculean task when preparing new Lists I am sure. This to me shows that Whiston's are 'U.K.' orientated,' whereas I feel they have great export potential, though maybe I am wrong and it is already being realised.

A. J. Reeves & Co. Ltd. 1980 Catalogue

I have only one criticism of Reeves Catalogue; at 50p post free (Overseas post extra at cost), it makes all the lesser suppliers literature look rather ridiculously priced! Knowing the costs, and time, involved in preparing our own Catalogue, I cannot help but marvel at the value for money given by Reeves in this respect, and recommend all LLAS readers to take advantage of same.

Reeves Catalogue is so comprehensive as to almost defy description; it includes virtually EVERYTHING necessary to set up a workshop, and then to build the SMALL LOCOMOTIVE of your choice; there is plenty to support those engaged with LARGE LOCOMOTIVES as well. The Catalogue I would sum up as being a reviewer's nightmare!

To be objective, there are three aspects of Reeves supply that are of particular interest to builders of Don Young Locomotives, two of them not mentioned in their Catalogue. First they support me, not only with their vast range of castings as listed, but by making several special ones to cover some of my later designs, which they do not list. This support extends to the supply of many castings for my stock; and particularly for my overseas builders, any item listed in their Catalogue, from which I am able to provide a service quite beyond my own means.

Copper Boiler kits are a Reeves speciality, and even at today's high prices, are still remarkable value. On several occasions I have worked up prices for customers; in all cases I found it worked out that the flanging carried out by Reeves appeared to cost nothing!, so have no hesitation in recommending this service to those who wish to build their own boilers.

ASHDOWN MODELS

We recently received samples of some of the specialised products marketed by Geoff Swift of Ashdown Models. These included really beautiful lamp kits to grace your 3½ or 5 in. gauge Locomotive, which were easy to assemble, and very realistic when painted. Name and number plates were notable for the depth of etching, and I guess by the selection provided there is excellent coverage; MOUNTAINEER particularly took my eye.

There was also a very useful collection of springs, some of which will be put to good use when I have time!, but the piece-de-resistance was the new 'Layaline' transfers, for lining out LNWR and BR Locomotives. Their application is a sponge and tweezer job, and I am definitely not the best qualified person to review such a delicate operation, though I did get results superior to those with a drafting pen and paint, which was my previous practice; there is hope for me yet in this department, especially as Geoff has promised to write something on the subject of painting and lining, something I am very much looking forward to seeing in these pages.

Glen

by: **DON YOUNG**

Part 4 — Bogie and Motion

Crosshead

Continuing with the details depicted on Sheet 4 for the moment, we come next to the crosshead, which, with careful setting up, can be machined from $\frac{3}{4}$ in. x $\frac{1}{2}$ in. BMS bar. Chuck truly in the 4 jaw, face, centre and drill Letter 'D' to $\frac{1}{2}$ in. depth. Turn on the $\frac{1}{2}$ in. diameter collar, it is $\frac{1}{8}$ wide, then continue for another $\frac{3}{8}$ in. at $\frac{7}{16}$ in. diameter. Mark off for the crosshead pin and drill this Letter 'J', then grip carefully in the machine vice to mill the $\frac{1}{4}$ in. wide slot to 13/32 in. past the centre of the hole. Rough out the end radius with saw and files, then complete by milling over a 7/32 in. mandrel, slightly reduced to enter the Letter 'J' hole. This leaves a nasty little bump where the sides of the fork meet the boss, and this can best be attended to with a file. The holes for the taper pins will have to wait awhile until assembly.

Crosshead Pin & Slipper

The crosshead pin is plain turning, to a tight fit in the crosshead, so let us attend to the slippers. These latter will almost certainly start life as a piece of $\frac{1}{2}$ in. square bronze bar; reduce the section to $\frac{1}{2}$ in. x 19/64 in. and square off four $1\frac{3}{16}$ in. lengths. Clamp in pairs to drill and ream the 7/32 in. hole, then it is back to the machine vice and vertical slide again. Grip one pair, pack off from the vice jaws so you can mill the 15/64 in. x $\frac{1}{16}$ in. recess, and mill this right along. Rotate the slippers through 180 deg. and repeat, arriving at the $\frac{3}{8}$ in. dimension.

Offer the slide bars up to the rear covers, packing them off by $\frac{1}{16}$ in. to arrive at the correct dimension, clamp firmly and then drill No. 34 from each side through the boss to meet in the centre; fit 6BA hexagon bolts. Fit the crosshead pin, slide on the slippers and push the complete assembly over the piston rod. Now it is a question of either removing a little metal from a slide bar at the boss, or adding wee shims, until the crosshead moves freely. You can now attend to the motion plate in similar manner, to get the crosshead moving sweetly along the whole length of the slide bars.

Erecting Cylinders & Wheels

Scribe the vertical centre line on the bolting face at one side of the cylinder block, and at $\frac{5}{16}$ in. down from the port face, drill and tap 5BA to $\frac{1}{4}$ in. depth; erect to the frames. Slide on the motion plate and position this to drawing, clamping in place. Before drilling any further holes, check with a straight edge from the piston rod, or use an extension on the piston rod itself, back to the driving axle, to check that $\frac{13}{16}$ in. dimension as shown on the mainframes detail. When satisfied, spot through, drill and fix both the cylinders and motion plate to the frames, also attending to the slide bars at the motion plate; a big step forward!

The wheels have been laying to one side for long a time now, so let us get them fitted, for soon now we shall be able to roll GLEN along the bench and move the pistons. Degrease the driving wheels and axle stubs, using Loctite Primer 'T', then apply Loctite No. 636 or whatever number has superseded it, to one of the axle stubs, slide on this wheel and assemble its partner 'dry'. Stand on the surface plate, with little packing pieces to stop the whole lot rolling about, set the crank on the side being dealt with vertical with a square, and align the wheel crankpin 180 deg. to same, sighting by eye from your square. Wait an hour and repeat for the other driving wheel; in the interim you can fit one of the coupled wheels to its axle; don't forget to slide on the axleboxes!

Erect the driving axle assembly and pack to 'nominal' working height, then do the same with the trailing coupled axle. On the side where the last wheel is to be fitted, have a smear of oil at the axlebox journal to prevent the Loctite doing an inadvertant job there! but degrease the protruding stub very thoroughly. Apply Loctite and slide on the last wheel, then slip on both coupling rods, rotating the wheels to check there is no binding. When the wheel is firmly secured, ease the coupling rod bushes to prevent binding when running.

By the method described the outside crankpins will not necessarily be 90 deg. apart; it matters not one iota whether the final result is 85 deg. or 95 deg., though I am certain you will do much better than this. Just remember that on the Gresley 'pacifics' the outside cranks were 120 deg. apart, and the engines ran sweetly, though this is not intended as license for GLEN builders to follow suit!

Connecting Rods

After the coupling rods, the connecting rods are easy, so start with two $7\frac{1}{2}$ in. lengths of 45mm x 6mm BMS flat. Scribe a line along $\frac{3}{4}$ in. from one edge, drill two $\frac{7}{16}$ in. holes at $6\frac{1}{2}$ in. centres, and the 11/32 in. hole for the Joy gear bush at 3 9/32 in. from one of them. If you do this in the machine vice, and use the cross slide as previously described, then this latter hole can be accurately positioned. Bolt to the piece of angle, on the vertical slide, set over and use a Woodruff key cutter to cut to line as far as you can get, though to be honest it is quicker to saw and file the whole profile, save for the small end radius, which latter can be dealt with over a mandrel. To deal with the 1 in. slot, turn the vertical slide through 90 deg., table along the lathe axis, grip the rod in the machine vice and mill to a piece of bar as your gauge. Drill the oil holes, then turn up the small end and Joy gear bushes to a very tight interference fit, reaming through after pressing centrally into the rod and drilling through the oil holes. The bridge piece is a rather fancy shape; just mill the two end lands and file on the radius. Drill the two No. 27 holes, offer up to the end of the connecting rod, spot through, drill and tap for 4BA hexagon head bolts, though you could well use a stud, with nut and locknut, for greater realism here.

Big End Brasses

For the big end brasses, first machine four pieces of bronze to $1\frac{1}{8}$ in. x $\frac{9}{16}$ in. x $\frac{5}{16}$ in. bare section, to be identical. Tin the joint face on each piece, clamp in the vice and reheat to join them firmly together for machining. Find the centre by the 'X' method, centre pop very lightly and scribe a circle at $\frac{3}{4}$ in. diameter; chuck in the 4 jaw with this circle running true, then bore out to a running fit to an odd piece of the crankpin material. Back to the machine vice and vertical slide to mill the groove all round to a tight fit in the rod. Separate the pieces, file a triangular nick to form the oil slot, and erect the rods.

Taking 'Bumps'

This is a very vital operation to prevent the piston pushing the cylinder covers off, so turn to front dead centre and then continue pushing the piston rod forward until it strikes the cover; scribe a line where the piston rod enters the crosshead. Turn to back dead centre and repeat, making sure the slightly over-long piston rod does not foul the connecting rod; scribe another line. Bisect the two, enter the crosshead to this latter line and we have equal clearance at each end of the bore. Now you can drill and ream for the $\frac{1}{8}$ in. taper pins to secure the crosshead to the piston rod, and cut the latter to final length.

Jack Link & Vibrating Link

Valve gear proper comes on Sheet 5, the drawing which accompanies this issue, but I found space for this pair of links on the previous sheet, and a lot more besides! so let me hurry on. The jack links are from $\frac{1}{2}$ in. x $\frac{3}{8}$ in., or 12mm square, BMS bar; first mark off and drill the three holes to drawing, gripping in the machine vice on the vertical slide, and using the cross slide micrometer collar to get the .625 in. and 1.125 in. dimensions accurate. Mill the $\frac{1}{4}$ in. slots, completing the upper one with files, then radius the ends over a mandrel before finishing the profile; turn up and press in the bush.

Vibrating links are plain pieces of 12mm x 3mm BMS strip, or $\frac{1}{2}$ in. x $\frac{1}{8}$ in. if metrication has not reached you yet. Clamp together in pairs and drill the holes as for the jack links, then radius the ends and complete to profile.

The Bogie

Space is at a premium, as ever! but at least after the mainframes those for the bogie are a piece of cake, and again of pleasing shape. The only point to be mentioned is the No. 22 hole for the rear cross stay, which latter if omitted means said hole should be 3/32 in. diameter for another rivet; I think readers can see now what I meant about the massive bogie centre.

Bogie Centre

This beautiful casting is available from Messrs Reeves, being the one that I specified for JERSEY LILY originally, and requires little machining. First chuck in the 4 jaw and face right across the top, then either deal with the bolting faces in like manner, or bolt through the centre slot to the angle plate, attach to the vertical slide, and mill to size. Part of the slot can be dealt with by milling, though it is almost as easy to file out to a piece of 1 in. bar as your gauge.

Assemble the frames and centre, clamp firmly together, then check for squareness befores potting through, drilling and tapping for 6BA countersunk screws. To complete the centre, drill the two $\frac{3}{8}$ in. holes for the side control springs, and scallop at the bottom to clear the pin.

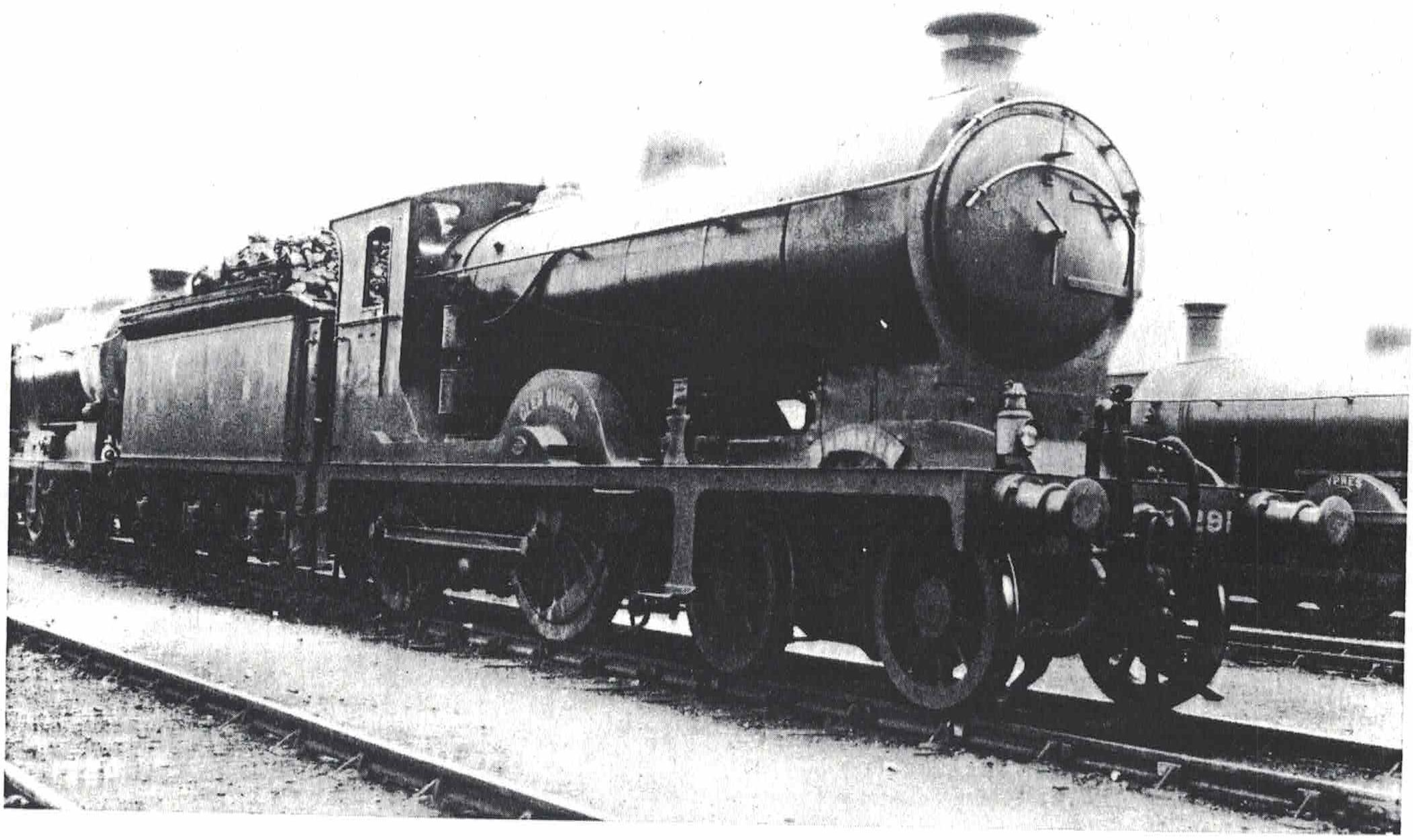
Cross Stay and Bogie Buffer

The cross stay is simple turning, so on we go to the bogie buffer, again a Reeves casting. Chuck in the 4 jaw, face off and turn the $1\frac{1}{2}$ in. raised face, then centre and drill through at $\frac{1}{2}$ in. diameter. Reverse in the chuck and face off to thickness, then turn the ends square, and if you are set up correctly you will be able to drill and 'D' bit the $\frac{3}{8}$ in. spring pockets at the same time. Strong side control springing is very necessary on GLEN, as it is on any 4-4-0, so on reflection it might be better to start with springs $1\frac{1}{4}$ in. free length and grind them down if necessary; remember that the rear bogie wheels must stay clear of the mainframes. With correct springs I know all will be well, as the clearance is proportionately greater on my $3\frac{1}{2}$ in. gauge DERBY 2P that Steve Titley has demonstrated and described so well for me.

Horns and Axleboxes

Horns are from $\frac{5}{8}$ in. x $\frac{5}{8}$ in. x $\frac{1}{8}$ in. bright steel angle, with little pieces brazed on to accept the hornstays. After brazing,

Photograph courtesy Rail Photographs Co. Ltd.



lightly mill the working faces to true them up; there is bound to be some distortion.
For the axleboxes, I would use 1 in. square bronze bar, in fact I should have dimensioned the raised boss at 3/32 in. to allow for this! and extended the ball on the equaliser beam ends by 1/32 in. to compensate. Square off four 1 $\frac{1}{16}$ in. lengths, mark the journal centre on one piece and chuck to run true. Centre and drill through at $\frac{1}{2}$ in. diameter, there is no real need to ream this hole, then turn on the raised face. Slacken two jaws only and repeat the operation for the other three boxes. Next mark off for the top boss, chuck one box again and profile, making up a 'D' bit with a spherical end to form the cup, then drill the oil hole; repeat the dose on the other boxes.
Sort out into pairs, back to back, and poke a length of $\frac{1}{2}$ in. rod through the bores, then grip in the machine vice on the vertical slide. With a d.t.i. in the chuck, check that the $\frac{1}{2}$ in. rod is square across the lathe axis, then mill the slot at the side facing the chuck in each box, to 3/32 in. depth. Rotate the whole assembly through 180 deg., pack from the slots to the back of the vice, and mill the second pair of slots, to fit snugly in the frames. Erect them, clamp the horns in place, drill through and rivet.

Bogie Axles, Wheels and Hornstays

Each axle is from $\frac{1}{2}$ in. BMS rod, centred and turned down at each end; the wheels also are plain turning, no crankpins, or quartering, to worry about here! Assemble them with Loctite, not forgetting to slide on the axleboxes, then erect and check for smooth rotation. Cut the hornstays from 16mm x 3mm, or $\frac{5}{8}$ in. x $\frac{1}{8}$ in., BMS flat, drill the No. 27 holes, offer up to drill and tap the horns 4BA to suit.

Bogie Hanger and Spring Pins; Bogie Retaining Plate

All four items are plain turning, plus the bogie pin wants a couple of special nuts from $\frac{1}{2}$ in. A/F hexagon bar, when the bogie can be erected, and you can roll your GLEN chassis along the bench; or take it to the track. We still have to spring the bogie however before I can give my pen a short holiday.

Equaliser Beam

The beams themselves are cut from 40mm x 2.5mm steel strip, or 3/32 in. sheet, to the lovely shape shown; either all four together, or a pair at a time. Drill through at two positions No. 33, tap the inner beam 4BA and then open the outer beam out to No. 11. If you make up $\frac{1}{2}$ in. long spacers from $\frac{1}{4}$ in. o.d. thin wall tube you can assemble each pair with their hanger pins.
Chuck a length of $\frac{1}{2}$ in. square steel bar truly in the 4 jaw and turn on the spherical ball to suit the cup in the axlebox, then part off to leave a 9/32 in. plain portion. Reverse in the chuck, centre and drill through at No. 60 for oil supply, forming a small reservoir with a 7/32 in. 'D' bit. Assemble to the ends of the beam, clamp in place and braze up.

Spring Hanger Block

Instead of those tubular spacers, you could have made up the spring hanger blocks, from $\frac{1}{2}$ in. x $\frac{3}{8}$ in. BMS bar. Chuck truly in the 4 jaw, face, centre, drill No. 33 to $\frac{1}{2}$ in. point depth and tap 4BA; part off at $\frac{9}{16}$ in. overall. Grip in the machine vice and drill the No. 11 cross hole for the hanger pin, and then I recommend you file the radius to complete, although it is possible to screw in a long 4BA bolt and then mill over a mandrel; the correct hanger bolts are 1 in. long.

Spring Buckle

We are approaching completion of the bogie, so on with the buckle, cut from $\frac{1}{2}$ in. square steel bar. Starting from the bottom, first drill the No. 11 hole and radius over a mandrel, then mill the two flanks. At the top, the buckle itself has to be reduced to $\frac{3}{8}$ in. length, so mill this also, and blend into the radius with a file. The easiest way to produce the slot is to drill an 11/32 hole and open out with files, to your spring material as gauge. Saw off to length then drill and tap 6BA for a cup point socket grub screw, this latter to retain the spring leaves.

Spring Leaves

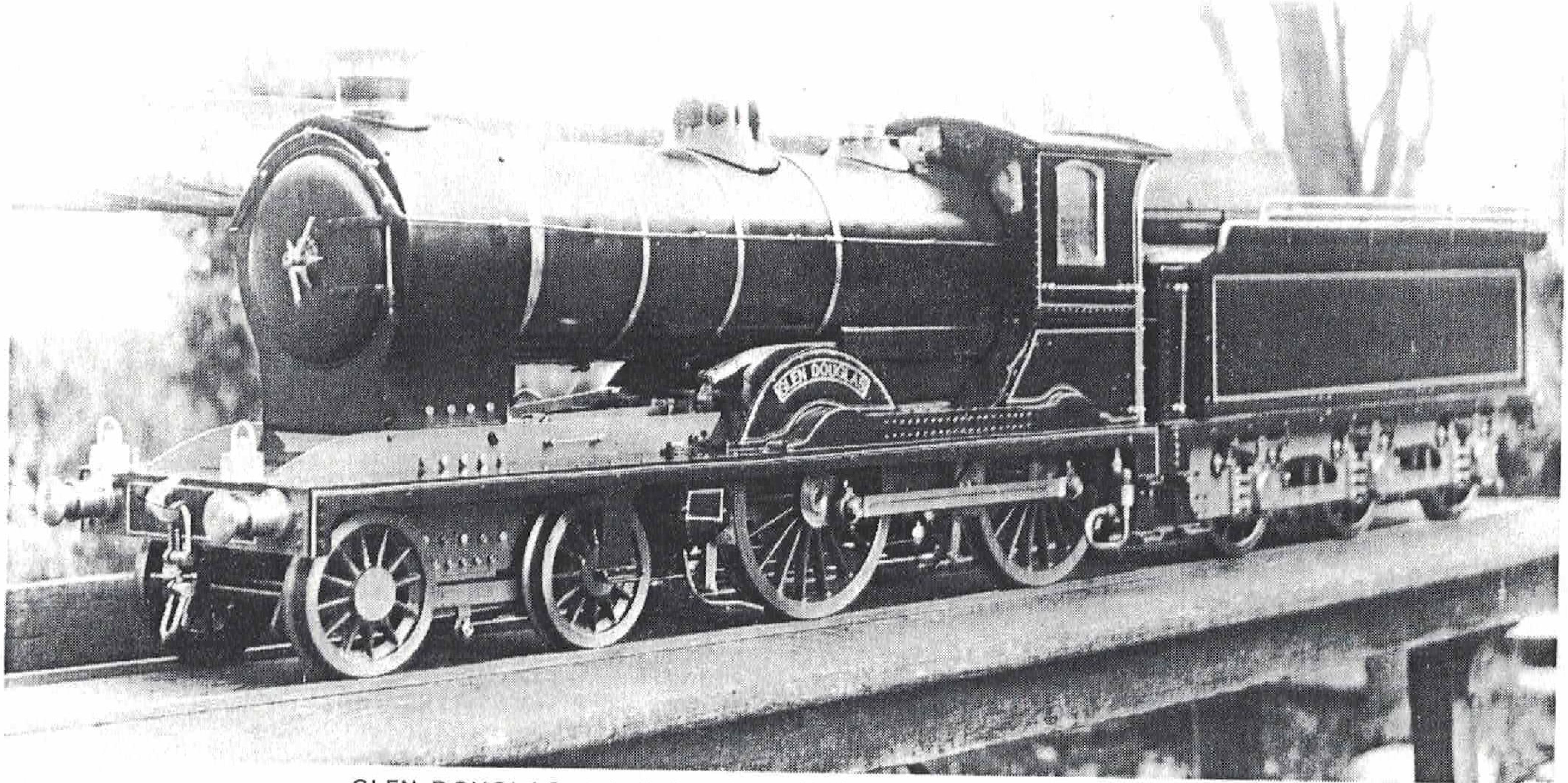
The top spring leaves, there are two of them, are 4 $\frac{1}{2}$ in. lengths of $\frac{3}{8}$ in. x 0.28 in. section hardened and tempered spring steel strip. How to cut holes in these to accept the hanger bolts, without first anealing? Hold the end of a leaf over a block of lead and centre pop, a smart blow or two, at $\frac{3}{16}$ in. from one end. This will create a lump on the other side of the leaf, so file this away, when a tiny hole will appear, though it may take two or three attempts to achieve this. Once there is a hole, it is a simple matter to open it out, 2 or 3 number drill sizes at a time to No. 27, and then elongate slightly with a swiss file to make sure the erected assembly will resemble the drawing detail. Cut another leaf, 2 in. long, from the same spring steel for the bottom of the spring, only it is inverted, then use $\frac{3}{8}$ in. x 1/32 in. Tufnol strips for the remainder. To preform these latter, coil inside a circular pipe tobacco tin or similar and pop it into the pressure cooker for a few minutes; that is the 'Hugh Couldwell' method, and very good too, if you can gain the necessary domestic permission! The proof of this spring will come on completion at the track, so be prepared to substitute a spring steel leaf to two for Tufnol ones, which means the cup point grub screw need not be tightened hard down as yet.

Joy Valve Gear

Moving on to Sheet 5, illustrated in this issue, it was problems with the connecting rod that led to the demise of Joy valve gear, for as cylinder sizes increased, so did piston loadings, and knowledge of removal of stress concentrations, and the problem of metal fatigue, was insufficient in those days to effect the cure. This is a great pity, for the events of Joy valve gear are ideal, fast opening and closing of the valve followed by a long period of 'dwell'. For SMALL LOCOMOTIVES, stresses become acceptable, so we can take full advantage of this on GLEN. One or two builders have commented that two of my humble designs fitted with Walschaerts valve gear have what they feel to be excessive die-block slip, yet nobody complains about Joy gear, which was deliberate, and ultimate, die-block slip! The two designs I refer to are MOUNTAINEER and LUCKY 7, from prototypes built by ALCO and Baldwin, though recent evidence seems to indicate that both are of Baldwin design. Study of these, and many other Baldwin designs, shows this king among Locomotive builders deliberately designed in die-block slip in the cause of improved valve events. I did not fully appreciate this point at the time of drawing MOUNTAINEER, merely scaling from full size and checking the events, which were excellent; it was only when a builder showed me how to 'improve' the gear, though not in my opinion, that the penny dropped. So what looks at first sight to be bad design is not always the case, and I reckon Joy valve gear is a perfect example of this.
Manufacture of both jack and vibrating links has already been carried out, so let us move on to the most difficult of all the items, the slide shaft.

Slide Shaft

Recently a special 'ring' pattern was produced for the slides, and castings taken from same. However, this has not been added to the castings list, by reasons of cost and machine capacity required, and as each builder requires only a small



GLEN DOUGLAS as built by Abram Reid nears completion in this photograph by Marshall Dickson. The boiler is by regular advertiser Reg Chambers.

segment of same, we propose to machine the ring and cut into individual slides, when their cost per set will not exceed that of an unmachined cast ring. That in fact takes care of the most difficult part of the whole slide shaft assembly, so we can now move forward with confidence.

The yoke starts life as a $3\frac{5}{8}$ in. finished length of $\frac{5}{8}$ in. x $\frac{1}{2}$ in. BMS or bronze bar, with width reduced to $\frac{9}{16}$ in. Grip in the machine vice on the vertical slide and mill the $\frac{1}{16}$ in. deep recesses in the four positions indicated to accept the slides; these must be a very tight fit therein to avoid movement during brazing. Before carrying out this latter operation, first mill or file the yoke to the section shown, and press full $\frac{3}{8}$ in. lengths of $\frac{1}{4}$ in. silver steel rod into the outer slides as fulcrum. It is also a good idea to fashion the reversing arm from 12mm x 3mm, or $\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat and attach to the L.H. outer slide with a single screw, then this can be permanently fixed with silver solder. To complete the slide shaft, mill or file the cut-outs between each pair of slides, as clearance for the vibrating links.

Slide Shaft Trunnion and Die Block

The first item is turned from odd ends of gunmetal or bronze bar, the flange being $1\frac{1}{8}$ in. diameter. I have shown the holes first drilled in the trunnion, to be spotted back onto the mainframes, but this means separating the latter, so the process may be reversed with advantage. Complete the trunnion by cutting away a portion of the flange.

For the die blocks we first need four $\frac{1}{2}$ in. finished lengths of $\frac{3}{8}$ in. x $\frac{1}{4}$ in. bronze bar, the thickness being reduced to .24 in. to give a working clearance. Clamp in pairs to drill and ream the 5/32 in. hole centrally, then file the flanks to get the die blocks a tight sliding fit in, you've guessed it!, the slides.

Anchor Link, Radius Rod; Valve Buckle and Pin

I have just described manufacture of valve gear links for HUNSLET using simple 'pin and plate' jigs, and exactly the same is required for GLEN, so I can move on to the valve buckle and pin.

The latter is plain turning, and the buckle starts as a length of 11/32 in. square steel bar. At $\frac{3}{16}$ in. from one end, cross drill and ream at 5/32 in. diameter, to suit the pin just made. Next mill, or saw and file, the $\frac{1}{8}$ in. slot to accept the radius rod, then radius the fork ends over a mandrel. Saw off at $\frac{11}{16}$ in. overall and chuck truly in the 4 jaw, with a piece of packing in the $\frac{1}{8}$ in. slot, to turn the spigot, face off to length, then centre, drill and tap $\frac{3}{16}$ x 40T to suit the valve spindle. The complete valve gear can now be assembled, using plain lengths of 5/32 in. silver steel rod where pins have not been detailed; before we can set the valves however, we need the 'control' part of the gear – reverser and reach rod.

Reverser

In keeping with the Scottish tradition of massiveness, GLEN's reverser could I guess be called 'sturdy'. The stand is a steel fabrication, starting with the base, a $1\frac{15}{16}$ in. length of $\frac{1}{2}$ in. x 3mm (or $\frac{1}{8}$ in.) section. For the two end posts, cut two $1\frac{13}{16}$ in. lengths from $\frac{1}{2}$ in. x $\frac{1}{4}$ in. bar and square off one end. Clamp together, drill and ream right through at $1\frac{1}{2}$ in. from the bottom to $\frac{3}{16}$ in. diameter; separate and open out one piece to 9/32 in. diameter, tapping $\frac{5}{16}$ x 40T. Fasten the three pieces made so far with a couple of 8BA screws up from the base, then cut the centre web from $\frac{3}{16}$ in. material to a tight fit between the uprights, again securing with a couple of 8BA screws. Braze up, using the technique for steel fabrications already described, then clean, file off the screw heads, and drill the No. 11 fulcrum hole in the web. The fixing holes to the cab splasher will have to wait awhile yet, but for the purposes of setting the valves, I will assume this is complete and in position, when we can bolt the stand firmly in place.

Front bearing and pivot pins are plain turning, but the reverser screw needs a little explanation. Chuck a length of $\frac{1}{4}$ in. steel rod in the 3 jaw, reduce for $\frac{1}{8}$ in. length to .086 in. diameter and screw 8BA; reduce the next $\frac{1}{2}$ in. to $\frac{3}{16}$ in. diameter, filing the square to suit the hand wheel, which latter we have yet to produce. Screw the next $1\frac{1}{2}$ in. of rod at $\frac{1}{4}$ Whitworth and part off at $2\frac{3}{8}$ in. overall, before reversing in the chuck, facing off to leave $1\frac{7}{16}$ in. of thread, and turning up the front spigot to suit its bearing.

Reverser Nut, Link and Wheel

The nut is a length of ½ in. square bronze bar, with the 5/32 in. spigot turned integral to 7/32 in. diameter. Grip in the machine vice and cut the recess to suit the centre web on the stand, then clamp firmly in place hard against the rear post of the stand, spot through, drill the nut to No. 4 and tap ¼ Whitworth.

The reverser link is built up just like the other fabricated valve gear links, only this one has two arms, so the jib needs an extra hole. Make the upper arm with a plain hole at 1in. centres in the first instance, then you can complete profiling before brazing, leaving the hole to be elongated when the reverser is assembled, which is now!

That leaves just the wheel, which can be a simple disc, or completed to drawing, to be realistic. This reverse wheel will receive a lot of your attention when driving, possibly too much so on an up-and-down track!, so it deserves much loving care, this being the reason for the stainless steel material specification.

Reach Rod

What did I say about the superiority of forked end reach rods on HUNSLET! Well, at least this one has a pressed in and brazed spigot at the rear end. Set the reverser and valve gear in mid gear, then measure the reach rod centres. Braze a 5/16 in. square block of steel, ⅝ in. long, onto a length of ⅜ in. x 3mm (or ⅛ in.) flat, then set as shown and machine the forked end. Measure back and drill a No. 13 hole at the back end, turn up and press in the pin, giving it a touch of silver solder for additional security.

Setting the Valves

Leave the engine in mid gear, remove the steamchest cover, turn the wheels, with the driving axle packed at 'nominal' working height, and centralise each valve for equal port opening, a figure of around .030 in. That is the sum total of setting Joy valve gear; builders will appreciate its economy, as much as my pen does!

Lubrication

This I can deal with in a few lines, for the Mechanical Lubricator and Oil Delivery Clack are from our Fittings range, so please place your order in good time to avoid disappointment! All builders wishing to make their own lubricators can follow the drawing details.

The mounting bracket is bent up from 1.6mm steel, with two webs brazed on; again the mainframes can be drilled first, rather than the bracket, with advantage. The link is plain at one end and forked at the other, and we have made enough of this sort of component of late for me to skip description of same. Press in an ⅛ in. pin at the lubricator end, couple to the valve buckle pin, and pipe up with ⅛ in. o.d. copper tube. Incidentally, the skilled coppersmith makes up a template for all but the simplest pipes, from wire, and translates this into the finished product. This is the way to get the most pleasing result, and is to be recommended.

A few missing pieces

by: **DON YOUNG**

Working for other editors over the years, one of the golden rules I was taught was always to look forwards, never backwards. As rules are made to be broken, and I have already shattered quite a few! I trust a brief recap will be found in order? The reason for asking is partly that some really excellent photographs had to be omitted from earlier issues, due to lack of space, and my heart is not hard enough to simply discard them, so here goes.

The first is that of the R.H. side of the 5 in. gauge B.R. Standard Class 2 No. 78019 by David Palmer, a fitting partner to the cover of LLAS No. 3. Now I can add my comments on both builder Fred Palmer and his Locomotive, which had been held over.

When I think of Fred Palmer, the word that springs to mind is **'precise'**, and I guess if I were allowed one word to sum up the man, this would be my choice. In our correspondence and all too infrequent discussions over the years, in which Fred has been of the greatest help and encouragement to me, there has always been close attention to detail. This I feel was equally apparent in his kind contribution, and I am only sorry that the cover photograph on LLAS No. 3 did less than justice to the tremendous craftsmanship displayed in No. 78019. Another example of the precise way in which Fred works was the letter that accompanied his article, giving details of his working life, the majority of which was spent with the leading Machine Tool manufacturer in Birmingham, Cincinnati. Now we can begin to see the background for all that precision, for Fred rose from an initial position as a Jig Borer to become Superintendant of the Tool Room, and completed his career before slightly early retirement as a Planning and Methods Engineer.

Lest the picture I paint of Fred Palmer be considered 'flat', let me dispel this by saying that he is motivated by enthusiasm, and among his many interests are LOCOMOTIVES LARGE & SMALL, witness his membership of the Severn Valley Railway Society, plus a vice President of the Sutton Coldfield and North Birmingham M.E.S.; the founder of the latter I believe. The cover photograph on LLAS No. 3 was in fact taken at the Club track, this information being recorded to avoid a lynching party being despatched to the Isle of Wight, led by Secretary Mick McKie!

Also in No. 3 a couple of interesting photographs could not be fitted into 'A Dream Fulfilled', and this I now hasten to rectify. There is an exciting sequel to this particular story. Late one Sunday evening I sat down to browse over some of Ollie Johnson's sketches, and began doodling with the calculator, reducing the main dimensions to those for SMALL LOCOMOTIVES. When I came to 4¾/5 in. gauge the whole thing suddenly gelled, such that less than 24 hours later I had a General Arrangement of both Engine and Tender. On the Wednesday evening I showed this rough drawing to members of the Portsmouth M.E.S., and on the spot Bill Edwards decided to build. The net result was that in less than 4 weeks a complete drawing set came into being, and Bill had started to build his PORTER. With any luck at all the drawings will have been checked by building of the prototype before they appear in LLAS. For the general response has been as enthusiastic as Bill's, and it solves a problem that had been worrying me since the inception of LLAS; something ideally suited for the beginner. PORTER will follow the HUNSLET's, but for those wishing a preview, the drawings are available.

I guess the last photograph, by Alan Bealing, shows yours truly making his get-away with Steve Titley's DERBY 2P!

Glen

by: DON YOUNG

Part 5 — Brake Gear and Boiler

Continuing on Sheet 5 for the moment, we come to the brake gear, which is the last assembly to be tackled on the chassis.

Hanger Bracket

The hanger brackets are quite straightforward, so take a length of $\frac{5}{8}$ in. diameter steel bar, face and turn down for $\frac{1}{8}$ in. length to $\frac{5}{16}$ in. diameter and screw 40T; part off at 29/32 in. overall. Chuck an odd end of $\frac{5}{8}$ in. bar in the 3 jaw, centre, drill through at 9/32 in. diameter and tap $\frac{5}{16}$ x 40T. Screw in an embryo hanger bracket, complete turning to profile, but leave the $\frac{1}{16}$ in. hole for the split pin until the hangers are ready; our next job.

Brake Hanger and Beam

When metrication was being rather forced upon us a few years back, I chose 10mm x 4mm section for the hangers, though it is now more likely that $\frac{3}{8}$ in. x 5/32 in. will be the choice. Tackle in the same way as for the jack and vibrating links on the valve gear by first drilling the holes, radiusing the ends over a mandrel, and then completing to profile by filing. Following on from this, the brake beam will be made from $\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat, shaped and drilled as shown, the end stubs either being spigotted to the beam ends, or slotted as shown, before brazing in place.

Brake Shoe

There is little point in producing a ring casting for the brake shoes, as these can best be made from 1 in. x $\frac{3}{8}$ in. BMS bar. Mark on the profile, drill the No. 30 pin hole, then file in the concave radius to suit the wheel, easing the inside edge so it does not bite into the root radius between tread and flange. Next saw out individual blocks and file to profile. The 5/32 in. slot is important in that the shoe must not be allowed to 'trip', and the top corner dig into the wheel tread when running backwards, so rough out the slot with an $\frac{1}{8}$ in. end mill, until the hanger enters freely, erect all the bits made so far, then ease the bottom of the slot until a No. 30 drill can be poked through, but the shoe does not tilt other than to come in correct contact with the wheel.

Pull Rods

There is no beam between the front hangers, or it would foul the valve gear, the front pull rods attaching directly to the bottom of the hangers, for which they require a 90 deg. twist after manufacture. The alternative, and it has much to recommend it, is to make all three pull rods as for the rear one, so I will describe manufacture of the latter only.
Take a $\frac{3}{4}$ in. length of $\frac{5}{16}$ in. square BMS bar and braze it to a length of $\frac{3}{16}$ in. x 3/32 in. strip. Drill a No. 22 hole for the pin, and another at No. 30 at the end of the slot, then saw down to this latter hole and file to the brake beam as your gauge. The secret of effective brake gear is that everything should be a fairly sloppy fit, no precision engineering is required here. Radius the fork end over a mandrel, then blend in as shown. Next fashion two pieces from $\frac{3}{8}$ in. x $\frac{1}{8}$ in. steel strip for the other end of the pull rod.
For the front pair, clamp all four brake shoes to their wheels, then complete the pull rods to length, clamping the end pieces in place to braze up. To complete the rear pull rod we need the brake cylinder and shaft.

Brake Cylinder assembly and Brake Shaft

The brake cylinder body and bottom cover are plain turning from gunmetal castings and call for no comment. The piston also is straightforward, though a couple of features need to be explained. The first is that although a groove is specified, as for soft packing or an 'O' ring, I find that left just as it is, water does tend to get trapped in the groove, and this acts as a very good pressure seal. The other thing again concerns water, and it is always difficult to convince 'unbelievers' that you can apply 80 p.s.i.g. of steam at the brake valve, yet get no response in the brake cylinder, this due to 'water lock'. Those of us who have experienced this palpitating phenomenon know it is vital to keep the cylinder drained, and to this end I have specified an $\frac{1}{8}$ in. ball valve in the piston itself, kept from floating up into the cylinder by the wee retainer. This little condensate valve really does work, and is infinitely better than fitting a screw-down drain valve, or cock, for the one time you need emergency braking, the valve is sure to be open, and all the precious brake effort will go to atmosphere.
The combined arms of the brake shaft I would machine from 1 in. x $\frac{5}{16}$ in. BMS bar, drilling the holes first, then filing the slot before milling and filing down to reduce the section to $\frac{3}{16}$ in., and then profiling to drawing; turn up the shaft, and braze up the assembly. The trunnions are bent up from $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. (or 3mm) flat and the bearing bosses turned from $\frac{3}{4}$ in. diameter bar; I recommend you step the latter to fit a $\frac{1}{2}$ in. hole in the trunnion plate, this to locate for brazing. Assemble the whole under the drag box, make up the little push rod to connect brake piston to shaft, then complete the rear pull rod. Typical brake gear pins are in fact detailed with the Tender, in fact those of you who have been wondering why Sheet 2 of GLEN has yet to appear can worry no more; it is the Tender. For just as the builder can go 'off the boil' once the engine is complete, so too can the designer, so just like the astute builder, I too try and get the tender out of the way early on.

The Boiler

Talking of doing things early, when time allowed me to build SMALL LOCOMOTIVES, I always tackled the boiler first, and the cylinders second, knowing that with these two major components sitting there, completion was assured.
The GLEN boiler is very straightforward, and should not cause any problems, especially as Reeves supply the complete kit including flanged plates. Those with insufficient nerve to play with expensive copper, and the even more expensive silver solder, can do no better than call on the expert boiler-making service provided by regular advertiser Reg Chambers. Reg in fact made the prototype GLEN boiler for me, and it now rests on the chassis of Abram Reid's GLEN DOUGLAS, to the satisfaction of all concerned.

Barrel

For those who wish to build their own GLEN boilers, start with the barrel, gripping in the 3 jaw chuck by the bore, and with a knife edged tool, at the chuck end, cut down close to the jaws before removing and filing the last bit. Reverse in the chuck and repeat to achieve the required $11\frac{5}{8}$ in. overall tube length. Run a file around the entrance to the bore, for there is bound to be a substantial burr here, and nothing is worse when turning the smokebox tubeplate to a tight fit than to find that once it enters the bore it rattles.

Transfer the tube to the 4 jaw chuck, grip a scriber under the tool post, bring it up to the chuck, turn by hand until it strikes a jaw, then scribe a line along the barrel. Turn through 180 deg. until the scriber strikes the opposite jaw, and repeat; you now have top and bottom centre lines. On the top centre line, centre pop at the dome and scribe a circle at $2\frac{5}{16}$ in. diameter. Centre pop around the inside of this circle and drill initially at around No. 40, gradually opening out the holes until they begin to break into one another, when you will be able to break out the centre piece. Next take a course round file and begin opening out the hole towards the scribed circle. To hold the tube securely for working, my bench has a wooden top, and at the front edge is a really stout length of steel angle. Part of the reason for this was to stop small screws and the like from falling to the floor, but it also works against me when trying to sweep up swarf! Anyhow, it is very useful for holding tube against, and if you put a block of wood hard behind the tube as well, lightly nailing to the bench top, it is held very securely.

Before completing the dome opening, we need the bush as a gauge, so chuck in the 3 jaw, face the gunmetal casting, and bore through to $1\frac{5}{8}$in. diameter. Next grip by the bore and part off a 5/32 in. slice for the flange, before facing again and turning down to $2\frac{5}{16}$ in. diameter over a $\frac{7}{16}$ in. length. Open out the barrel to suit this spigot, a nice close fit, and check that the bush penetrates fully into the barrel at the sides; if not, then lengthen said spigot. Chuck by the bore again and face off at the top, turning down to $2\frac{3}{8}$ in. diameter at this stage if you did not do so earlier. Hold the bush in the barrel and scribe around inside to scallop as shown, otherwise there will be difficulty in fitting the regulator.

Outer Wrapper

That takes care of the barrel, so let us move on to the outer wrapper. Take the piece of 2mm copper sheet provided and trim off to $6\frac{1}{2}$ in. width if necessary. Scribe on the top centre line, lay over the barrel with centre lines coinciding and lightly clamp in place, just enough pressure to hold the two bits together. Now you can gradually pull the wrapper around the barrel to start forming it.

Throatplate

Next take the flanged throatplate and first file to suit the barrel, then put a file over the side flanges to bring them to size if necessary and roughen them slightly for brazing. Mark on the vertical centre line, then continue to pull the wrapper around, starting the reverse bends so that the throatplate can slide along as your gauge. I find if you clamp the wrapper to the barrel at the start of the reverse bend, you can then just ease it back by hand and arrive at a nice blending radius; also it is best to work the copper at this stage as supplied, rather than anneal it and lose the natural springiness. We are ready to start putting things together.

Assembling the Outer Shell

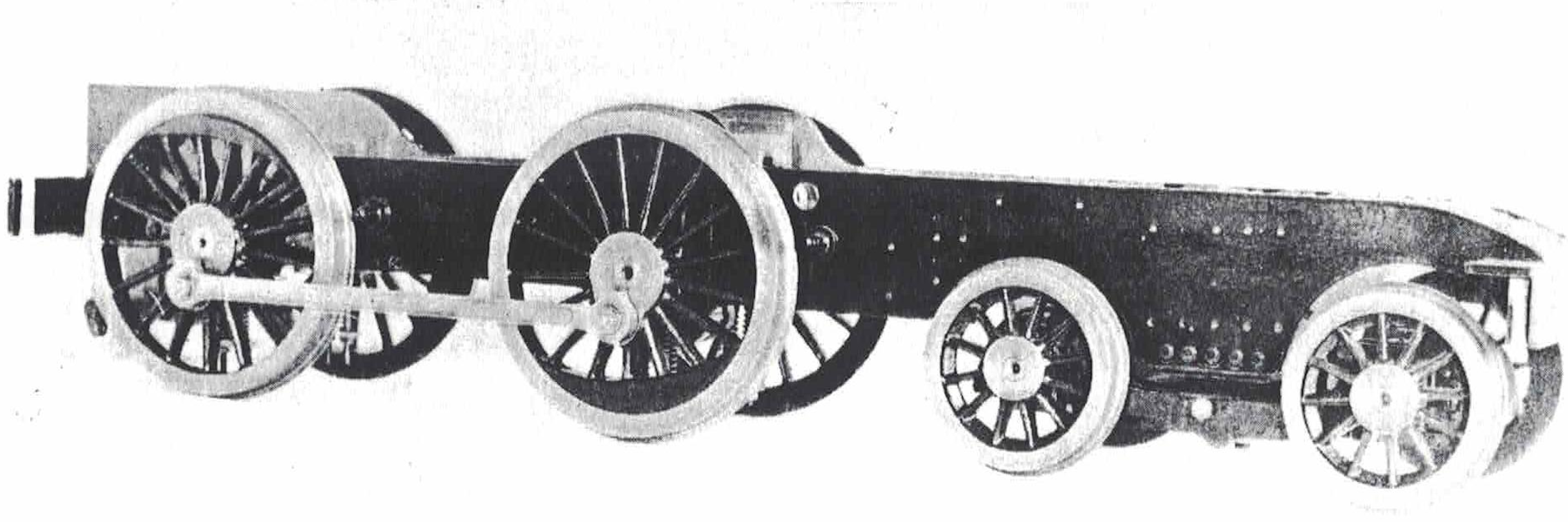
Clamp the throatplate to the barrel, with centre lines coinciding, and drill a No. 41 hole through flange and barrel on said centre line; fit a 7BA bolt. At about 1 in. each side of this first hole, drill two more and fit further 7BA bolts; remove the first fitted bolt. Countersink the flange, poke a 3/32 in. diameter snap head copper rivet in from the inside, and support the head on a piece of bar held horizontally in the bench vice. To make sure the rivet head is in close contact with the barrel we need a simple tool; a 6 in. length of $\frac{5}{16}$ in. steel rod drilled No. 38 at one end to about $\frac{1}{2}$ in. depth. Hold this over the projecting rivet shank and give it a sharp blow or two, before rivetting the shank over into the countersink. If the rivet is too long, and it wants to be $\frac{3}{8}$ in. initially, simply crop it off after insertion. Repeat the dose until the throatplate is firmly in place, though the assembly is more than a little fragile at this stage.

If the throatplate 'ears' have not been blended into the barrel, which should have been done prior to forming the wrapper, then do this now. Holding the wrapper in place, you will see that it projects past the throatplate side flanges, and this must be trimmed away, a matter of between $\frac{5}{8}$ in. and $\frac{3}{4}$ in. If in any doubt about this, make a dummy wrapper from stout card and trim until you achieve a nice even lap joint all the way around; card is cheaper to scrap than copper! You can now rivet the wrapper to barrel and throatplate using the same techinque as when fitting the two latter components together. To check that the wrapper is being fitted correctly, hold a straight edge along it in various positions, projecting over the barrel, when you will be able to see any tapering; use the flanged backhead as a further check.

Brazing the Outer Shell

We are ready for our first brazing operation, and thanks to the propane torch, very little preparation is required. For this size of boiler the 40 oz. and 70 oz. burners will more than suffice for the main joints, with a 10 oz. 'neck' burner for the stays, so that you can work inside the firebox. For a brazing table I use an old dustbin with a sheet of asbestos millboard across the top. The only tool required is a large pair of pliers, old ones with no nasty teeth on them to damage the copper. A copper boiler deserves best grade silver solder, and I use a combination of B6 alloy and Easyflo No. 2, both Johnson Matthey products, though there are others which conform to the same British Standards and are thus equally suitable. To hold the pickling solution,

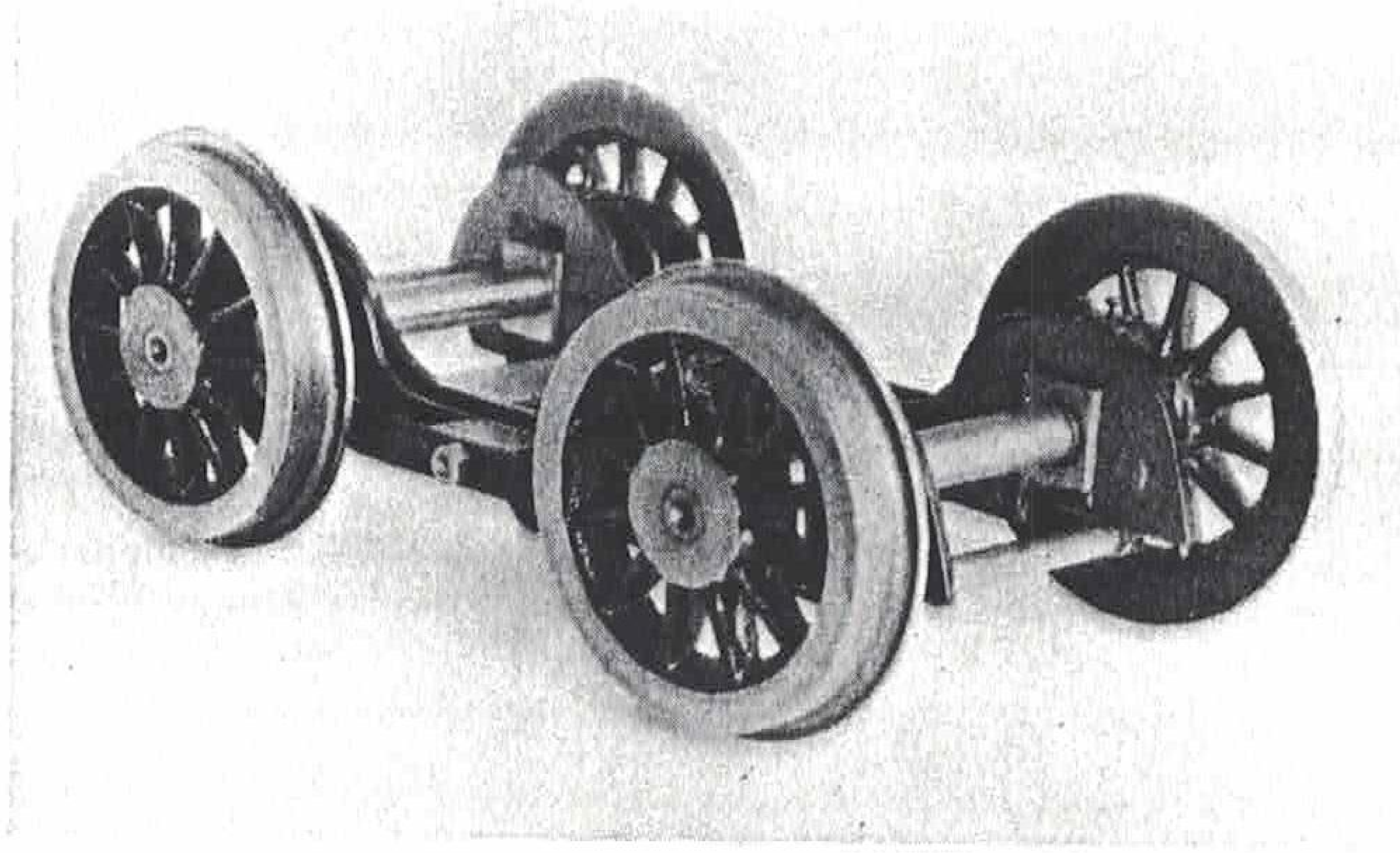
This GLEN chassis is under construction by David Grant of Brentwood, Essex



a large plastic container in which the boiler can be completely immersed is ideal, the pickle itself either being a ready mixed one as reviewed in LLAS No. 2, or water to which sulphuric acid is added, NEVER THE OTHER WAY ROUND.
Put the boiler in the pickle whilst you make the final preparations, including mixing the flux to a paste which whilst not being too stiff, will not run all over the place when applied. Take the boiler from the pickle and wash under running water; apply the flux to completely seal all the joints to be tackled, including the dome bush, against oxidisation of the copper. Light the 40 oz. burner, get a big flame going, and heat the whole assembly evenly. Best results are obtained in poor light conditions, in fact a cold winters' evening was about perfect for both operator and boiler in the old days of the 5 pint blowlamp! When the copper begins to glow a dull red, increase the burner pressure and throttle back on the burner valve, to arrive at a less diffused flame, and concentrate this on a bottom corner of the throatplate. Move the flame ahead of applying the spelter and work right round the joint; this will happen quicker than it has taken me to pen this sentence if the copper is clean. Do the dome bush next, allow to cool a little, then immerse in the pickle for as long as it needs to remove excess flux, etc.; wash off and dry.
If the spelter does not run freely, do not try to press on regardless, but stop and pickle again. Inspect each joint as you proceed for complete penetration, and if in any doubt, rectify it before going any further; to ignore this advice is to court disaster.

The Firebox

The firebox comes next, so take the two flanged end plates and tidy them up. The firehole ring attaches to the backplate, so turn it up from the tube provided, mark on and cut out the hole to accept same as at the dome. Support the tube on a block of lead and carefully peen over the projecting lip; do not anneal the tube unless you absolutely have to. Tube centres will be marked on the front plate, though as with all things it is best to stick to the adage of 'measure twice, cut once'. Drill 27/64 in. diameter at 16 positions for the firetubes and ream out to $\frac{7}{16}$ in. diameter. It is unlikely that you will have the necessary drills and reamer to tackle the two superheater flues, nor that you can swing the tubeplate in the lathe to bore the holes to size, so a slightly different approach is required. Before tackling this though cut all the tubes to length, squaring them off in the lathe, and use course emery cloth on the ends to clean them up.
Back to the tubeplate, to scribe on circles at the flue diameter. Next drill out to the largest size available, clamping the plate to a block of hardwood so that a circular hole results. Clamp between two blocks of hardwood in the bench vice and then file out the hole to size, using the flue tube as your gauge, to finish to a nice tight fit.
On to the firebox wrapper, trimming if necessary to $5\frac{1}{2}$ width and then scribing on the top centre line. Scribe further lines $1\frac{1}{8}$in. each side of this to show the start of the top corner radii. Grip a length of $1\frac{1}{4}$ in. diameter bar horizontally in the bench vice, cramp the wrapper to same, and pull round, using the scribed line as reference for the start of the bend and trying to place over the end plates. The larger reverse bend I would again do by hand as for the outer wrapper. Move to the other side and do exactly the same, making sure the wrapper is a close fit over the end plates, that is far more important than 'losing' the centre line, as this latter can be scribed on again in a new position. Trim the wrapper legs, and of course the end plates, to length, then rivet up as for the outer wrapper, using a minimum number of rivets, and making sure they do not come in way of the girder stays or foundation ring.
The section of copper for the front portion of the foundation ring is $\frac{1}{2}$ in. x $\frac{5}{16}$ in., this may require machining from the



The completed Bogie from David Grant's GLEN

nearest available commercial section, which is easy if you use paraffin as cutting oil. Trim to fit neatly between the throatplate flanges, then scallop away the centre to allow the firebox to come within $\frac{3}{8}$ in. of said throatplate, as per drawing. Erect the firebox, clamping down over the foundation ring, and with calipers, measure the required depth of the crown stays. Bend these up from 2mm copper strip and rivet back to back in pairs, the $\frac{7}{8}$ in. holes being optional, though they do help promote a better flow of steam, especially towards the safety valves, thus reducing the chances of water lifting off with the escaping steam. If the stays sit flat on top of the firebox, do not attach them to same, but simply cramp in place; otherwise, use the minimum possible number of rivets. You will see the wisdom of this statement if you try to fit rivets, for the heads have to be outside the box, and you have to 'nobble' the projecting shank using a length of rod. Assemble the firebox in the outer wrapper again and check upper flange contact; you will be able to carry out any small final correction a bit later on when the copper is softened after heating, but do check that you are close to success at this stage, it being a vital feature of a safe boiler of this design style.
You can now pickle the firebox and braze up, taking care not to burn the copper between the tube holes, a greenish tinge in the flame indicates you are fast approaching danger. After pickling again, the firebox should be a nice salmon pink all over, with no dark patches, when we can fit the tubes.

Fitting the Tubes

Find a taper pin that will slip into the bore of the firetubes, fit a tube in the firebox tubeplate and lightly expand in place with the drift. If you apply a coat of Vaseline to the drift, then it will come out fairly easily when you give it a light sideways tap. Do the same with all the firetubes, then fit the two flues, before sliding the smokebox tubeplate over their outer ends, only we have to complete said tubeplate to be able to comply with this last instruction.
Deal with the tube holes as at the firebox, turn up the steampipe bush and fit this also, then drill two 9/32 in. holes at the stay centres. Grip in the 3 jaw chuck by the inside of the flange and turn to a tight sliding fit in the barrel, squaring off the lip of the flange at the same setting. You can now braze in the bush using the B6 spelter, which I should have said earlier that you use throughout up to this stage, though revert to the lower melting point Easyflo No. 2 if you experience any difficulty.
Make rings from your Easyflo No. 2 spelter to drop down over each tube to the firebox end, then fit the smokebox tubeplate and check that the tubestack is both square to the firebox tubeplate and parallel with the firebox wrapper, to ensure the whole will assemble snugly into the outer shell once the

next brazing operation is complete. Mix the flux to a fairly runny paste, so it will penetrate all round the tubes, get your 40 oz. burner going with a much less fierce flame and begin warming around. Just keep going until the Easyflo rings melt and you see full penetration inside the firebox, feeding in more spelter if needed to achieve this. Allow to cool slightly, tap off the smokebox tubeplate, and anneal the outer ends of the tubes before pickling, cleaning, and inspecting once more.

Erecting the Firebox

Assemble the firebox inside the outer shell, clamp the front foundation ring in place again, and check that the girder stay flanges are in contact with the outer wrapper along their full length, adjusting as necessary. When satisfied, drill three No. 30 holes through throatplate, foundation ring and firebox tubeplate and secure with $\frac{1}{8}$ in. snap head copper rivets, heads inside the box, and hammering down into countersinks in the throatplate. In all these operations, remember that the shape of the rivet head in conclusion is not important, only that it must be in close contact with the plate.

The side sections of the foundation ring are from $\frac{5}{16}$ in. square copper bar, so cut these to length and fit to place with 3 or 4 rivets. On top of the outer wrapper there are three holes to accept the safety valve and manifold bushes. These with advantage could have been drilled before finally fitting the firebox, allowing the inner girder stay flanges to be scalloped to allow said bushes to slide neatly in place. To complete this phase of boiler construction, fit the smokebox tubeplate so that the tube ends are at least $\frac{1}{16}$ in. proud and expand them as at the firebox.

Mix up plenty of flux at this stage, apply at the girder stays/outer wrapper, foundation ring, smokebox tubeplate/tube ends. Lay the boiler on its back, with firebox projecting over the edge of the brazing table, and light the 70 oz. burner, for we now have a fair weight of copper to heat up. Play the flame on the outside of the outer wrapper in way of the girder stays and look inside the boiler to see the area begin to redden. Provided the stays are in the correct close contact, they will come up to a uniform temperature at the flanges, when spelter can be fed in and will run right through the joint.

Transfer the flame to the foundation ring area and tackle this next; you will be able to see that full penetration occurs at least on the side sections. Carefully lift the boiler and stand upright, to tackle the smokebox tubeplate, then turn again to bring the three bushes on the outer wrapper to the top and fit these as well. This is the most prolonged brazing operation of all, so if things begin to get 'sticky', stop, pickle, clean up and take it in stages.

Fitting the Backhead

We are almost home and dry, so offer up the backhead, scribe back through the firehole ring, and cut the hole to a neat fit over the spigot. Before peening the latter over, make and fit the bushes, fixing them as a separate brazing operation with B6 alloy. Now you can permanently fit the backhead and complete the watertight integrity by fitting the rear portion of the foundation ring. By now you will have become proficient with the propane torch, and no matter how many boilers you have made, not being a daily occurance it does take time to get back in the groove, so the Easyflo No. 2 should fairly 'flash' around these last joints!

Preliminary Testing

For the initial, air, test you can either tap out all the bushes, etc., and fit proper plugs, or make softwood bungs. At least one hole has to be tapped so you can fit a cycle inner tube valve, when you can inject a dozen pumpfuls of air; not too much, for those soft flat surfaces are not yet stayed. Immerse in water, when any leaks will show as tell-tale bubbles.

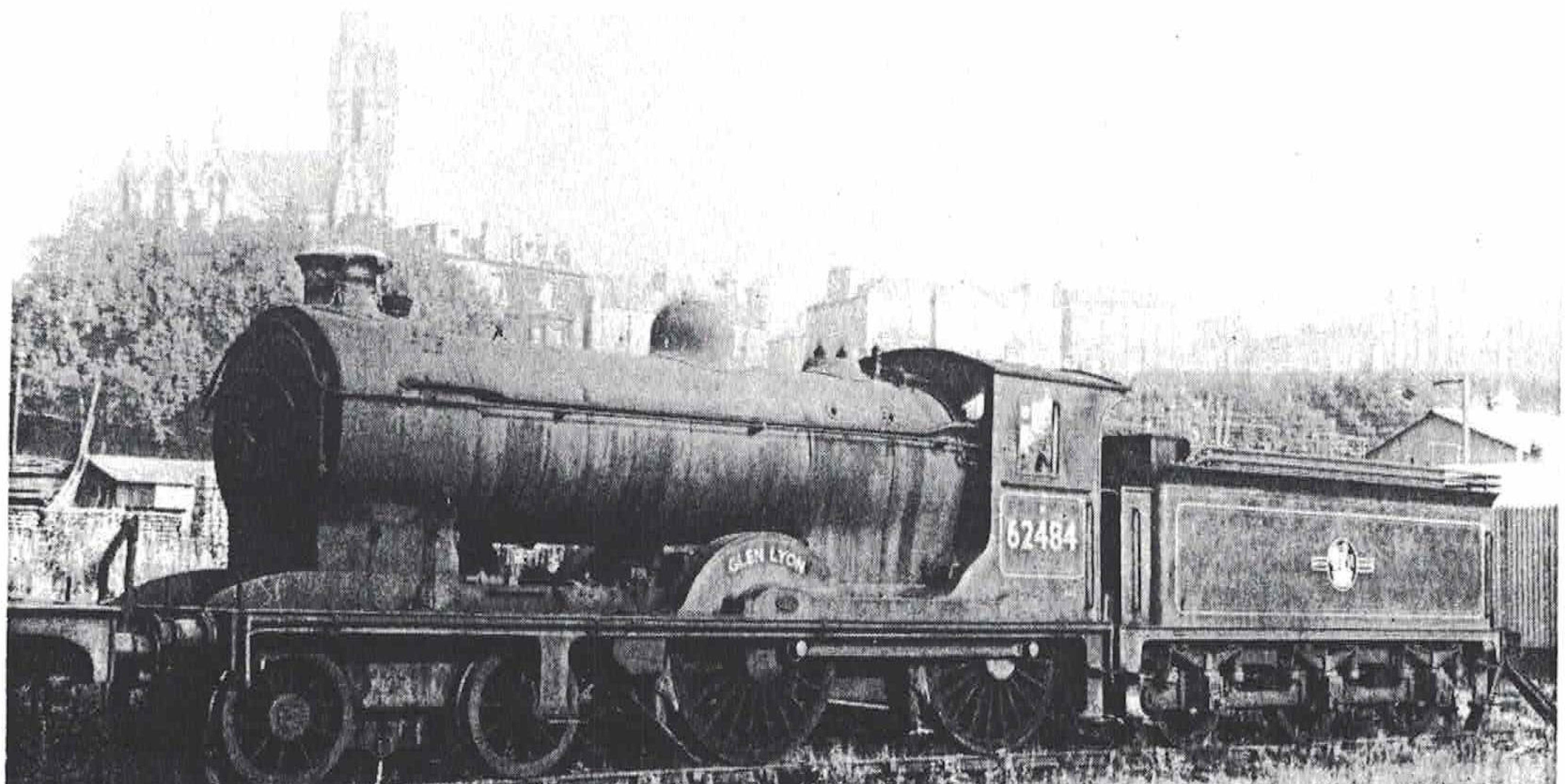
The Dome and Boiler Fittings

After all that the dome is a piece of cake, the only point to be mentioned being that the flange will distort during brazing, and this can easily be corrected by chucking the completed dome in the 3 jaw and facing across. Drilling, tapping and securing with 6BA bronze cheese headed screws, these to be home made, blanks off the largest opening.

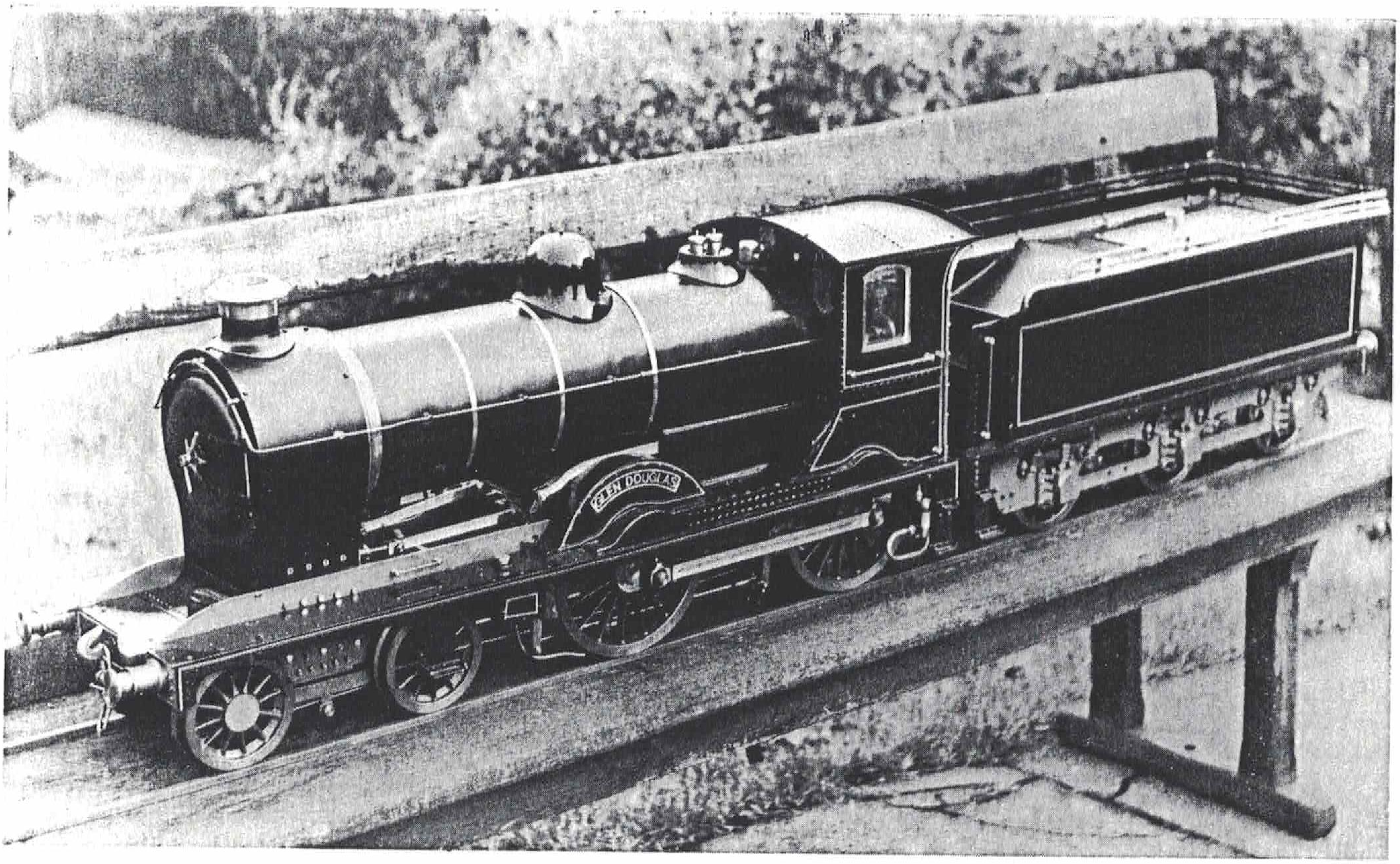
Plain turned items like dome plug, stay ends and the steam pipe should cause no problem now, and everyone uncertain about Boiler Fittings I would very much recommend Gordon Chiverton's little masterpieces as being a worthwhile investment.

Staying the Firebox

We had better stay the firebox next after that bit of light relief, and those most proficient in 'copper bashing' will undoubtably have used $\frac{1}{8}$ in. diameter snap head copper rivets as stays and brazed them in with Easyflo No. 2. Alec Farmer told



62484 GLEN LYON in store towards the end of a long an honourable career. Photograph courtesy of Real Photographs Co. Ltd.



Another view of GLEN DOUGLAS as built by Abram Reid, taken by Marshall Dickson

me some years back that screwed stays were much preferable for the amateur boilermaker, in fact, this discussion took place between HUNSLET and GLEN being drawn up, hence the alternative specification for staying. I would add that the 4BA screwed copper rod which Reeves supply in foot lengths will be ideal for GLEN, and will save builders a lot of time and effort.

The only problem in tapping soft copper is that the threads do have a tendency to tear, so a sound investment to greatly reduce this risk is a new set of 4BA carbon steel taps. Many years back I had problems screwing monel metal stays, and said so in my humble writings. There was an immediate response from John Robinson, not THE J.R.! who sent me a pot of 'goo'. At the time I had solved the problem with a greeny coloured cutting oil, and rather dismissed John's kind assistance, but later I dipped a tap in said 'Trefolex' when I was getting nowhere fast, and have been doing so ever since; its great! That takes care of the preparations, all we have to do now is knuckle down and fit the stays.

First mark off the stay positions to drawing and lightly centre pop; not too heavily or you will depress the flat copper. Starting at the upper row of side stays, drill a first hole at No. 34 right through into the firebox, sighting square with the outer wrapper. Poke another No. 34 drill in this hole and sight from this to drill the remainder of the row. Take the 4BA taper tap, dip it in 'Trefolex' or similar tapping compound, and sighting from the drill yet again, tap the outer wrapper. Remove the tap, clean off the swarf, dip it again and then tap right through into the firebox, following up with 2nd and plug taps; complete the top row. Screw in the stay, using a tap wrench located at the outer end of the length of screwed rod, and then fit a 4BA commercial brass full nut on the firebox end. Adjust so that about 2 threads project through the nut when it is tightened onto the firebox shell, then crop the stay off at the outside to leave about $\frac{1}{16}$ in. projecting.

Carry on like this until all the stays have been fitted, including those in backhead and throatplate. At this stage I used to specify in exactly the same manner as the late maestro LBSC that the inner end of each stay be supported on a piece of bar held horizontally in the bench vice and the outside rivetted over, after which each stay nut had to be tightened again, but now I feel that this rather nerve wracking exercise can be dispensed with. For the threads are not going to be sealed with soft solder, but with SX2 or 'Comsol' having a melting point of around 305°C, products obtainable from Messrs. Reeves, together with the relevant flux. Fit the neck burner to the propane torch, flux all the stays, then tackle them one by one. Wash the boiler in hot soapy water, rinse, dry and polish, then just file over the tops of the stays to make them look more presentable, but still protruding about 1/32 in.; not finished flush.

The Regulator

The next major item is the regulator, a gunmetal casting being available for the body; clean this up with files and then mark off. Chuck in the 4 jaw with the pop mark to indicate the vertical passage running true, face off, centre and drill 11/32 in. diameter to 1 15/16 in. point depth. Turn the casting over, centre for the steam pipe, drill 29/64 in. diameter to break into the vertical passage, a blunt drill will help to stop 'snatching' when the drill breaks into the other hole, then tap the outer 9/16 in. or so at $\frac{1}{2}$ x 26T. Next grip with the port face running true, centre and drill No. 40, then face off. Lightly countersink the entrance to the No. 40 hole, then tap 5BA; the pivot bolt wants to be as long as possible without fouling the dome, so you can best measure this to place when erected. Next file the 'notch' to clear the dome bush and radius the seating to fit neatly to the inside of the barrel. To complete the body, drill for the little boss to support the end of the regulator rod, turn this and the top plug, press in and sweat to seal.

Glen

by: DON YOUNG

Part 6 – Engine Concluded

The valve is a machined disc $1\frac{1}{4}$ in. diameter and 5/32 in. thick from bronze or gunmetal and drilled centrally at No. 30. Mark off and drill the two 9/32 in. ports at 23/32 in. centres, remove any burrs, then bolt to the port face and drill on through into the vertical passage in the body, again removing all burrs. To complete the valve, mark off, drill and tap the two 6BA holes for the special screws, these latter being made from $\frac{1}{4}$ in. or 6mm bronze rod, and with threads a tight fit in valve the 'Loctite' instruction can be ignored. Fit an $\frac{1}{8}$ in. bore bronze spring between the pivot bolt head and valve, this to hold the valve on its seat, and we can next deal with the operating arm. This is from $\frac{3}{8}$ in. x 3/32 in. or 2.5mm brass strip, drillled and tapped 6BA at 1 in. centres, and with a 9/64 in. square hole at the centre. For this latter I recommend you drill No. 30 and then use a swiss file to form the square; complete by profiling as shown. The links are from $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass strip, drilled No. 21 at $1\frac{3}{16}$ in. centres, and then shaped as shown. Make sure these links do not tend to pull the valve from its face, and ease a hole further to form a slot if necessary; much better this than a leaky regulator.

The regulator flange on the backhead is plain turning and is secured in place with four 6BA bronze screws, plus the two gland studs as detailed. The regulator rod starts life as an 11 in. length of $\frac{3}{16}$ in. stainless steel rod. First turn on the $\frac{1}{8}$ in. spigot to suit the boss in the body, then file or mill on the square to suit the operating arm. Turn up the brass collar and drill No. 12 or 13 to be a tight fit on the rod; we can now begin erecting the pieces.

Enter the steam pipe a couple of threads into its flange at the smokebox tubeplate, feed the regulator into the dome opening and engage it on the end of the steam pipe; screw home the latter. Mark off for the two 6BA regulator body fixing screws ahead of the dome, drill the shell No. 34 and continue into the body at No. 44, dealing with one hole at a time. Countersink the shell, then tap 6BA and secure with a bronze screw, sweating over the heads on final assembly. Feed the regulator rod in from the backhead and engage the operating arm, leaving the backhead. Remove the flange, followed by the rod, then ease the collar a further 1/32 in. or so along the rod to give a working clearance. Braze in place, then chuck in the 3 jaw and remove any excess spelter, also cleaning up the face adjacent to the regulator flange. The outer end of the regulator rod requires no description, save to say that it should wait until the boiler fittings are in place; the gland is fairly straightforward and the regulator handle only made from stainless steel to enhance its appearance, mild steel being perfectly satisfactory.

Longitudinal and Blower Stays

Whilst in this area we may as well fit the longitudinal and blower stays, in that order. Both rod and tube stays want to be 18 in. long initially and screwed 40T for about $\frac{3}{8}$ in. at one end. Screw into the front fitting about 2 turns and insert into the boiler. Scribe where the stay projects from the backhead, cut off to length and screw this end also. Repeat the procedure as before, only this time apply a drop of liquid jointing compound to the threads. Screw the front fittings in by hand, followed by the back end fitting and blower valve respectively, engaging first on the stay end and then the backhead; tighten all end fittings in turn. The steam pipe is dealt with in like manner, so we can move straight on to the superheater, and with a teeny bit of luck, complete the engine before space runs out.

Superheater Flange

The superheater flange is a finished $\frac{1}{2}$ in. length of $1\frac{1}{8}$ in. diameter gunmetal or brass bar, 'D' bitted centrally at $\frac{3}{8}$ in. diameter to $\frac{3}{8}$ in. depth. Mark off and drill $\frac{1}{4}$ in. holes at 90 deg. into the bore for the steam ways, following up with a 11/32 in. drill to provide for the spigot on the $\frac{7}{16}$ x 26T union connectors; braze up. Drill the four No. 30 holes clear of the steam ways, offer up to the steampipe end, spot through, drill and tap 5BA. Make up studs from $\frac{1}{8}$ in. stainless steel rod and secure with 5BA brass nuts; alternatively use home made bronze cheese head screws as per drawing.

Superheater

The coaxial superheater elements have much to commend them, chiefly because the smooth surfaces allow for proper cleaning, to maintain the essential gas flow over same. The only disadvantage over the twin spearhead element is a loss of heating surface, which I have compensated for by poking the elements into the firebox. For this reason a stainless steel outer sheath is called for, preferably with the end cap welded in; the central return tube can be either copper or stainless steel to choice. Some builders are concerned that the central core will not remain so over its length, and I have been shown some really ingenious schemes to ensure concentricity; my own recommendation is to wind on a wire spiral 'retarder' as I described in 'What makes a Steam Locomotive tick?' Each element can be completed to drawing, leaving the outlet overlong at the moment, to be coupled up once the boiler is erected, together with the smokebox. We had better make a start on the latter at this point, as there are some more boiler fittings on Sheet No. 7 to be made and fitted before the hydraulic test.

The Smokebox

For the moment it is back to Sheet No. 5 as it appeared in LLAS No. 4, sorry about all the confusion of numbers hereabouts, but now that we have regained our bearings there is a nice steady session ahead in making the single most important feature in any Stephensonian Locomotive.

Let us start with the front plate, marking off on $\frac{3}{8}$ in. steel plate. Saw out roughly and then file to line, including the bottom edge. Next chuck in the 4 jaw and lightly face across the back, just to clean up, then reverse and set to run true. Centre and drill through to your largest available size, then continue boring out to 4 in. diameter, by which time your pile of swarf will have grown somewhat! Add more swarf by facing right across the front to around $\frac{5}{16}$ in. overall thickness, then turn to leave that $\frac{1}{16}$ in. raised face to $4\frac{3}{4}$ in. diameter; remove all burrs. Bolt directly to the vertical slide with a strong-back, set the bottom edge horizontal, which simply means winding it down to contact with the lathe bed, then mill the $\frac{7}{8}$ in. wide step to $\frac{1}{16}$ in. depth as shown. Leave the specified holes for the moment, though you may fit those two wee brackets to support the dart if you wish.

The smokebox back plate is flanged up from 2.5mm thick copper, and as I have specified pre-flanged plates for the boiler I had better explain the procedure for this one. First requirement is a former, which can either be from the ⅜ in. steel plate just used, or ½ in. thick hardwood; the latter will be satisfactory for this 'once only' job. Mark on the outline, deducting 7/64 in. for the thickness of flange all around except at the bottom; yes, the flange itself gets thicker than the plate from which it is made as it is beaten, not thinner as one might think. Saw out the former and add a $\frac{1}{16}$ in. flanging radius. Lay on a sheet of copper and scribe around, then add ⅜ in. all round, except for the bottom of course, and scribe a further profile; cut out to this latter line. Heat the copper to a bright red and either allow to cool naturally, or quench, when you can begin to form the flange. Grip the former and plate in the bench vice, with a soft clam to stop the soft plate being marked by the vice jaw, and with a wooden mallet, work all around the flange, not trying to knock it right over, but about 30 deg. at a time. Should the copper harden and become springy, anneal again, and again if necessary, until the flange is beaten hard down on the former. Still attached to the former, in fact the latter is sometimes not so easy to remove, trim the edge of the flange, then offer up to the front plate and file down so that the two match in outer profile, to ensure the shell will fit snugly. Next scribe a circle to represent the joint ring spigot, chuck in the 4 jaw, still with the former in place and bore out to 5⅛ in. diameter. At last you can remove the former, but do take care, as the back plate is rather fragile with that big hole in it.

The boiler joint ring is plain turning from the gunmetal casting available, but do leave the bore a tight fit over the barrel, as it will distort when brazing up, when if you are not careful the tight fit becomes a sloppy one, that will let air in and destroy the vital smokebox vacuum.

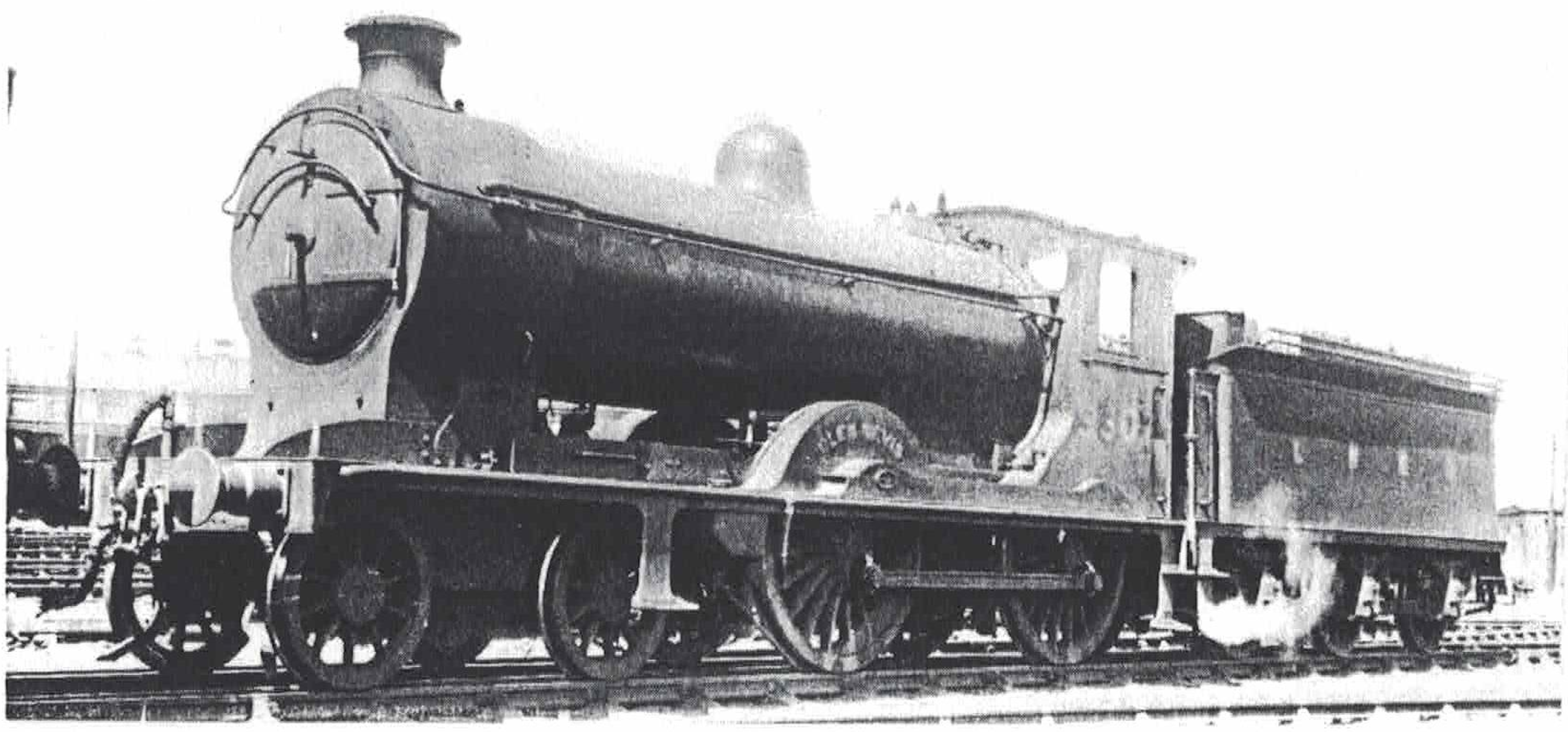
The smokebox shell is an 18 in length of 3¾ in. x 16 s.w.g. steel strip, and if you have a set of bending rolls, these will come in very handy. Those of us less fortunate can go back to the boiler barrel and pull round this by hand, the natural springiness of the material leaving us close to the correct diameter. The reverse bends you can start the same way, and then tighten a bit further by hand, to get the required fit. Secure to the front and back plates with some 8BA steel or brass round head screws, just like for the other fabrications, check the fit and squareness in the frames and over the steamchest, and when satisfied, braze up with Easyflo No. 2. File off the heads of the screws, then try over the boiler barrel, easing the joint ring with a file if required.

We now know how to cut large holes in thin sheet, so can tackle that for the petticoat pipe to about 1 11/32 in. diameter; this allows some adjustment. I have established a series of standard petticoat pipes to cover a variety of Locomotives, and the one we need for GLEN has been previously employed, albeit in slightly different form, on my 5 in. gauge JERSEY LILY design, the lovely Robinson G.C.R. 'Atlantic', the necessary casting being available from Messrs. Reeves. Chuck by the bore in the 3 jaw and turn down the outside, then part off to length. Grip next by the parallel shank and bore out to 1 in. diameter, the choke size, before you set the top slide over 2 deg. and continue boring until this taper comes within ¾ in. of the bottom edge of the skirt. You can turn this latter if you like, though I find a round file is quickest, with the lathe run at top speed (DO FIT A HANDLE TO THE FILE) and then polish up with emery cloth. Cut the flange 1¾ in. square from 1.6 mm brass, find the centre by the 'X' method, chuck to run true and bore out to suit the petticoat pipe. Bend to suit the inside of the smokebox shell, easing the hole again to a tight fit over the petticoat pipe, then braze up.

Chimney

The chimney comes next and I suggest you first grip it by the chucking piece in the bench vice and file the bottom to suit the smokebox shell; very little work will be required here. Next chuck in the 4 jaw and set to run true, then exercise your skill to the full in getting the cap as per drawing; a template cut from stiff plastic is very useful. You will not be able to turn much below the cap, so this will have to be attended to with files and emery cloth once the bore is completed. First bore out to $1\frac{1}{16}$ in. diameter and then follow up to $1\frac{5}{16}$ in. diameter to accept the projection on the petticoat pipe; this wants to be a tight push fit, when it is the only fixing required, and to a full $\frac{3}{16}$ in. depth. Set the top slide over 2 deg. once more and open out until, when you fit the petticoat pipe over the end, the two bores blend perfectly; your finger will tell you when this is so. When you have tidied up the base, chuck once more to part off the spigot, to leave what I reckon is one of the most attractive chimneys possible; its great!

If you have an odd 3 in. length of 1⅛ in. diameter bar available, it can be useful as to perfect blastpipe alignment, so chuck in the 3 jaw and with the same 2 deg. setting as before, turn a taper over about a 1½ in. length; centre and drill through at 11/32 in. diameter. Erect the smokebox over the cylinders, fit chimney and petticoat pipe, followed by the alignment gauge just made. We left the exhaust box minus stub pipe, so get a length of 11/32 in. silver steel rod and turn a point at one end. Set the chimney square on the smokebox, the smallest discrepancy you should be able to detect by eye, drop the rod through and centre pop the exhaust box; now you can drill for, fit and braze in the stub pipe.



GLEN NEVIS appears to have acquired a taller dome cover in L.N.E.R. days

Blast Nozzle/Blower

The blast nozzle is plain turning, the blower 'belt' being formed from an odd end of superheater flue tube, and after the union connection has been turned up, the whole can be silver soldered together. Lightly centre pop for the No. 70 blower jets, and I prefer to drill these by hand using my 34p Woolworths hand drill; it has earned its keep over the last 20 odd years! Erect the blast nozzle, then check alignment with the silver steel rod, before drilling through shell and petticoat pipe flange at No. 41 in four positions, countersinking the shell and securing with 7BA screws, nutted inside.

Steam Connections

Steam connections are easy, in fact my smokebox 'plumbing' is gradually improving over the years, so coupling up should cause GLEN builders no problems, though this will have to await boiler erection.

Smokebox Door

We can now turn our attention to the door, and a first step is to drill those three holes specified in the front plate, plus the couple in the shell for the handrail stanchions. The door itself is a gunmetal casting, complete with chucking spigot, and can be quickly turned to drawing, taking care to get a nice flat joint surface, to mate with the smokebox front plate.

Hinge Blocks and Pin

For the hinge blocks, chuck a length of $\frac{3}{16}$ in. square stainless steel rod in the 4 jaw, face and turn down to 0.11 in. diameter for $\frac{7}{16}$ in. length before screwing 6BA. Next mark off and drill the No. 41 hinge pin hole, then saw off to length and fashion this end with a file. The hinge pin is plain turning, though it is best made in two parts, with the head brazed to a length of 3/32 in. stainless steel rod and then finish profiled.

Crossbar, Dart and Handles

Back to Sheet No. 6, where the crossbar is next in line for attention. Cut this $4\frac{5}{8}$ in. long from $\frac{3}{8}$ in. x $\frac{1}{4}$ in. BMS bar, drill four No. 25 holes to start the slot to accept the dart and file out to line; the outline can best be achieved by filing also.

For the dart, chuck a length of $\frac{3}{8}$ in. steel rod, face off, turn down to 0.11 in. diameter for $\frac{5}{16}$ in. length and screw 6BA. Turn down the next 1 5/32 in. to 9/64 in. diameter, file on the 7/64 in. square and part off to leave a $\frac{3}{16}$ in. collar at the original $\frac{3}{8}$ in. diameter; fashion this latter as per drawing to an easy fit in the crossbar.

Turn up collars as bosses for the handles, drilling each centrally at No. 43. Turn up the handles themselves with $\frac{1}{16}$ in. spigots on their ends to suit No. 52 holes in the bosses, the tapered length being best dealt with by file and emery cloth; braze up. Tap the outer handle 6BA, open the inner one out to No. 33 and file in the square to suit the dart; or vice versa if you prefer.

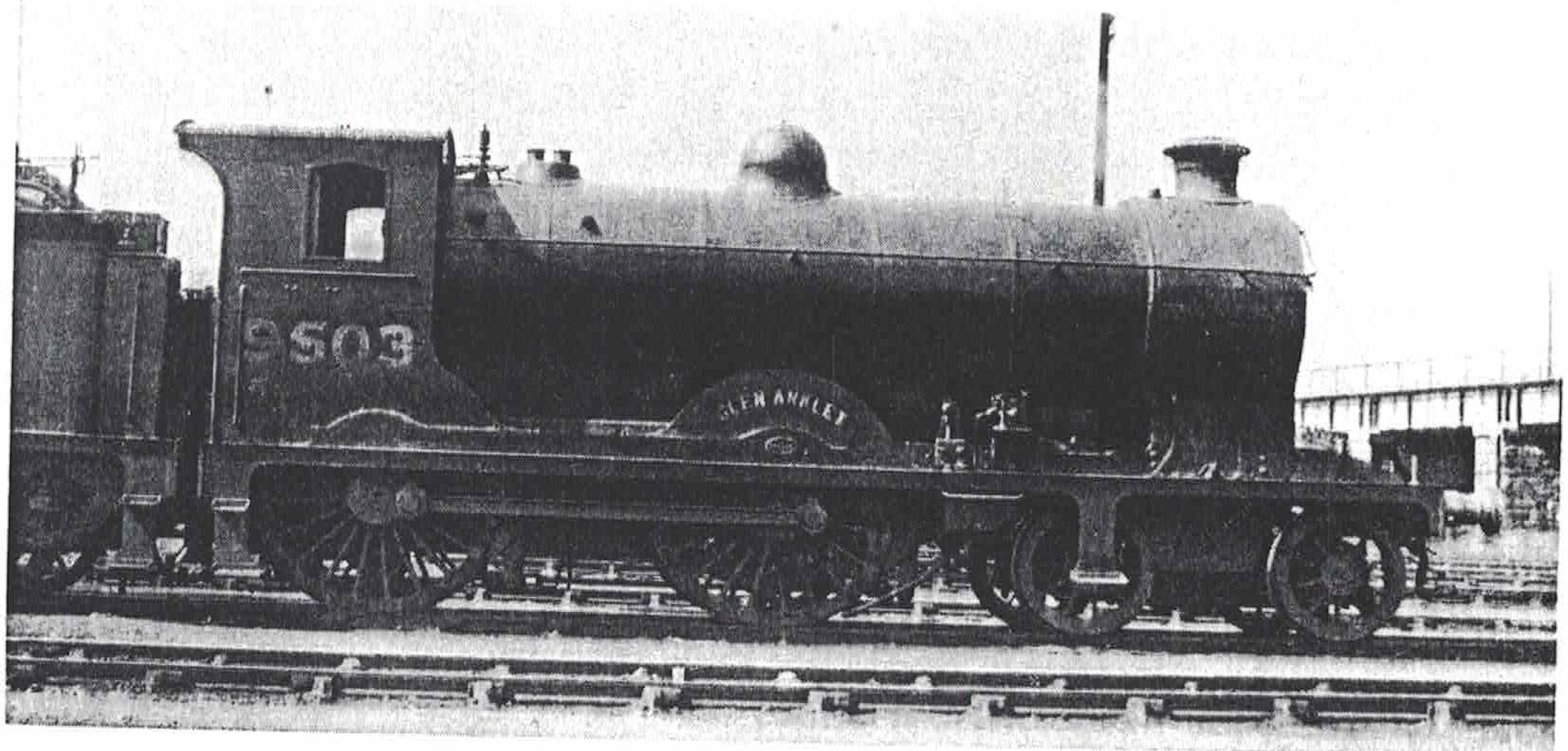
Erect the hinge blocks to the smokebox, fit dart and handles to the door, drop the crossbar into its brackets and erect the door, checking by eye and rule that it is central on the front plate. Take lengths of $\frac{3}{16}$ in. square stainless steel or brass rod for the hinges, cross drill at one end No. 41 for the hinge pin, and then fashion with files, bending to place to sit neatly on the door surface. Drill through at $\frac{1}{16}$ in. diameter in three positions in each and secure the hinges with copper rivets; that virtually completes the smokebox.

Firehole Door

I was lucky enough to hit on a solution for the firehole door to suit my 'work horse' designs some 15 years ago now, which has stood the test of time, and this is depicted again for GLEN. It came about through a, mistaken, belief that authentic sliding doors were not practical on SMALL LOCOMOTIVES, for the reason of coal fouling the lower guides, and was originally tried with success on my Adams 02 Class 0-4-4T before I changed to the correct sliding pattern; my scrap box shows there were other and less successful schemes which were tried and found wanting.

Mark out the door on 3mm brass sheet, saw and file roughly to line, then drill the No. 30 central hole, plus the three air holes. Chuck an odd length of $\frac{1}{2}$ in. rod, face, centre, drill and tap 5BA, then bolt the door to same to turn the periphery to size; the baffle is dealt with in like manner. Make the spacer from $\frac{1}{4}$ in. brass rod, when you can assemble these three pieces with an $\frac{1}{8}$ in. copper rivet.

For the hinge block, start by producing a squared $\frac{1}{2}$ in. length from $\frac{3}{8}$ in. x $\frac{1}{8}$ in. brass flat. The end pieces are shaped as a pair from 3/32 in. or 2.5mm brass, and may be spaced $\frac{1}{2}$ in. apart with a bush, using a 7BA bolt to hold things together, this for brazing to the base; drill the two No. 41 fixing holes to complete. Turn up 5/32 in. thick collars from 7/32 in. brass rod, lay on lengths of 5/32 in. x $\frac{1}{16}$ in. brass strip, and braze up to form the hinges. Trim these off to length, erect to the firehole door, and rivet in place after checking the fit of the hinge block; complete this part of the assembly with the hinge pin. Hold against the boiler backhead, check that the



GLEN ARKLET proudly displays her mechanical lubricator; one that is most accessible even in 5 in. gauge!

door swings freely and that the baffle does not foul the firehole ring, then spot through from the hinge block, drill the backhead No. 48, tap 7BA and secure with home made bronze cheese head screws.
The catch is bent up from $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass strip and in turn rivetted to the door, when we come to the single most important part, the catch spring. From some unknown source I managed to acquire a piece of 0.015 in. thick hard phosphor bronze, and this is just perfect for the spring, though I have checked that spring steel is also very suitable. Cut out with tin snips, tidy up with a file, then bend in the bench vice to the shape shown. Lay on a block of lead to centre pop the two holes, then drill these to size. Position is very important, so hold against the backhead and close the door until the catch just engages its spring at the outer end; spot through the spring before drilling and tapping the backhead, again using home made bronze screws to secure. You should now be able to close the door against the spring pressure quite easily. To open the door, a short length of chain is fitted to the wee unspecified hole in the catch, or you can use the bent pricker from your fire-irons kit. You then fire and close the door with your shovel, just to the outer end of the catch spring at first, to allow for a bit more 'top air', this to keep a clear chimney. Once the fresh coal is alight, then you simply close the door with the shovel and wait until the next firing turn.

Hydraulic Test

Although really the official hydraulic test ought to await the last 'puncturing' of the boiler shell, which in the case of GLEN means the fitting of the boiler support/expansion brackets, this is the logical point in the series to describe the test. Remove the dome plug and completely fill the boiler with water, removing any trapped air by tilting. All fittings should be left in place, though the safety valves will either have to be 'gagged', or removed and plugged. Couple the master pressure gauge, preferably at the dome, and the tender hand pump to one of the feed check valves. Pump up the boiler, in increments of 40 p.s.i.g., inspecting at each stage, until you reach twice the chosen working pressure; hold this for at least 20 minutes, or to your boiler inspector's satisfaction, then release, empty the boiler, when we can further adorn it.

Lagging and Cleading

Again I am working ahead of actual events, but little remains to complete description of the items depicted on Sheet No. 6, so I will tidy up before moving on to Sheet No. 7.
For lagging I was lucky to gain a stock of 4 in. wide asbestos tape, in two thicknesses, which I find to be ideal in this application, being held in place by 15A fuse wire. Reeves carry asbestos lagging $\frac{1}{16}$ in. thick in $\frac{1}{4}$M squares, and this will be my next source of supply when present stocks are exhausted. Cut one piece to fit the barrel only and then a second piece to cover the whole area to be lagged, leaving a full $\frac{1}{8}$ in. clearance ahead of the spectacle plate to allow for boiler expansion.
The best cleading material I have found to be 0.015 in. thick brass shimstock, which is very hard and springy. Measure around the barrel, after the lagging is in place, and cut a piece to give roughly a 1 in. overlap. The joint will be on the bottom of the barrel, so next cut a hole to clear the dome flange. Wrap around the lagging and tie with two pieces of string, just to gain some control over the springy material, then insert a rod through each loop and begin winding; this simple device is called a 'Spanish windlass' and is capable of exerting tremendous pressure. Ease the joint together, then soft solder the seam, using an iron ahead of feeding in the solder, so that it immediately 'gels' and stops any gap from reopening.

Boiler bands are from $\frac{3}{16}$ in. wide brass strip, so wrap around the cleading and cut with about an $\frac{1}{8}$ in. overlap. File each end to a radius and then drill No. 44 before bending through 90 deg. to form a tab. Fit around the barrel again, then insert a $\frac{1}{2}$ in. long 8BA bolt and tighten up. For the firebox area, cut another piece from the brass shimstock and slide the front end under the rear boiler band on the barrel. To hold the rear edge in place we shall fit a piece of $\frac{3}{16}$ in. brass angle to the spectacle plate, fitting to place against the cleading, which latter must stop short of the cab by about $\frac{1}{16}$ in. to allow for expansion. The sides of this piece of cleading will tuck down inside the splashers, which leaves just the one boiler band in way of the firebox. This should be made in two pieces, the bottom end either being fixed directly to the frames with an 8BA hexagon screw, or bent at 90 deg. and fastened to the splasher. On the top centre, between the safety valves, bend up as for the other bands and put an 8BA bolt through to tighten.

Dome

The dome is a gunmetal casting, complete with chucking piece, though we shall use this latter in the first instance to grip in the bench vice so we can file the bottom face to sit snugly onto the cleading. Next chuck in the 4 jaw and set to run as true as possible, then turn the top profile. Centre and drill about $\frac{3}{8}$ in. deep at No. 43 for the 8BA retaining bolt, then back to the bench vice and files to complete the outer profile. Finally saw or part off the chucking piece, before blending in with a file to the rest of the profile.

Sheet No. 7

Very little remains to complete the GLEN Locomotive, before we move on to the Tender, as will be seen by a glance at Sheet No. 7. Manifold, Steam Brake Valve and Whistle, Don Young Designs can supply; for Bye Pass and Injector Steam Valves we will supply our later, and far neater, globe valve versions, and in fact no tapping is required in the backhead for this pipe mounted globe valve.

Safety Valve Casing

This is another gunmetal casting dealt with very similarly to the dome, the last operation being to drill two $\frac{9}{16}$ in. holes to clear the safety valve stems.

Cylinder Drain Cocks

There is one job remaining on the chassis, the cylinder drain cocks. The 'cocks' themselves are our ball type, developed originally to overcome the same sort of restricted area on L.B.S.C's MAID OF KENT, since when they have been found to be almost universally useful. The guide plates on the cocks now have closed slots, so remember to remove the front ones and slip over the pull rods before brazing on the blocks. Twist the ends of the pull rods so that the operating lever slips neatly between them; the route of this latter to either the left or right hand side of the cab, alongside the seat box, can best be worked out to place; if I produced a drawing for this then builders would be sure to report a 'foul'!

Boiler Erection

We can now bring the two major assemblies of chassis and boiler together by erecting the letter. I have already covered the smokebox end, so the next thing is to set the boiler level in the frames, packing up to the barrel from either the horizontal or boiler stay.
The expansion brackets are bent up from odd ends of 2.5mm copper remaining from the boiler, shaped as shown, and first drilled in five places at roughly 7/32 in. diameter, this to clear the stay ends. Next mark off at four positions between these

holes and drill No. 34 Offer up to the outer wrapper, check that the expansion bracket is in fair contact, then spot through, drill the wrapper at No. 44 and tap 6BA. Make up home made cheese head bronze screws with threads a tight fit in the boiler, smear them with liquid jointing compound and screw home.

Ashpan and Dumping Pin

Mark out the ashpan on a sheet of $\frac{1}{16}$ in. thick steel; cut out and bend up to be an easy fit over the firebox extension. Hold in place, spot through from the No. 11 hole in the frames for the dumping pin and drill these through. The pin guide can best be a length of copper tube, faced off to a tight fit inside the ashpan, when this, and the corners, can be brazed up. The dumping pin is a length of $\frac{3}{16}$ in. steel rod, to which an end piece can be screwed, pressed or brazed to choice. Slot the other end of the pin with a hacksaw and splay out so that the pin will not come out of its own accord when running.

Grate

I have had consistently good results with mild steel fire-bars, except when burning anthracite; this stuff is lethal!, hence I have specified stainless steel to cover this eventuality. As the required section is available from both Messrs. Reeves and Whiston, this specification should not cause me correspondence, always a good reason for trying to adhere to items that builders can easily obtain. Cut eight bars 5 in. long, drill one of them No. 30 at 1 in. from each end, and use as a drill jig to tackle the remainder. Spacers are from $\frac{3}{8}$ in. rod, drilled No. 30 and parted off in 7/32 in. slices, this is except for the 4 in No. 3/32 in. spacers in way of the support arms, these latter being bent up from the firebar section. Erect in the ashpan, clamping in place, then erect to the firebox and set the top of the bars no lower than the top of the foundation ring; when satisfied, rivet the grate to the ashpan.

Front Running Board

The front running board is bent up from $\frac{1}{16}$ in. steel sheet to fit neatly between the frames, when we can turn our attention to the main platework, our last major task on the engine.

Superstructure

There is no doubt that brass is the kindest metal to work when making the superstructure and I recommend its use wherever possible, especially as in GLEN we have a couple of quite major fabrications to be dealt with. Steel is of course a suitable substitute, and much preferable to no GLEN at all if brass be beyond your pocket. For both metals I recommend zinc coating from an aerosol can after fabrication; for steel to prevent rapid rusting and for brass to form a 'key' for the subsequent painting.

Side Running Boards and Valances

For the side running boards, start with two lengths of 2 in. x $\frac{1}{16}$ in. strip and mark out to drawing, checking the overall length to give $\frac{1}{16}$ in. to 3/32 in. overhang over both beams. Saw and file to outline, then bend up the $\frac{5}{16}$ in. flange, gripping the outer edge in the bench vice and hammering down over the jaws, a little at a time.
The valances are not detailed and can be lifted from Sheet No. 1. The main piece of structure is a 29$\frac{3}{4}$ in. length of $\frac{3}{8}$ in. x $\frac{3}{8}$ in. x $\frac{1}{16}$ in. brass angle, to fit snugly between the beams. To this are brazed pieces of brass sheet as backing for the cab steps, another piece in line with the rear bogie wheel, and a third piece at the front to form the fancy end. For all three pieces it is best to braze on plain pieces of plate, size well in excess of requirement, laying the pieces on a flat surface so that a clean joint is made. To complete, mark out the profile and saw and file to line. The steps themselves are folded up from 1.2mm brass and fitted in place with a few snap head copper rivets. The side running board is rather flimsy, so clamp the valance to same, with the edge of the running board protruding by about 3/32 in., then sweat together before cutting away the top flange of the valance to suit the already profiled running board.

Splasher/Cab Side/Seat Box

This combined fabrication is really something to behold, and is certainly worth spending a lot of time over, for it will make or mar your finished engine. Start by marking out the outer side plate for the coupling rod splasher, deducting $\frac{1}{16}$ in. from the dimensions given as it is best if the top plate comes right to the outer edge. Clamp another piece of plate to that marked out, to saw and file to line. The top plate is from 1$\frac{3}{8}$ in. x $\frac{1}{16}$ in. strip and is fashioned to fit the outer plates. If you sit the two outer plates on a surface plate, spaced about 1$\frac{1}{4}$ in. apart and clamped together, then you will be able to form both top plates to place and to be a good fit. Next concentrate on the front splasher and cut the outer plate to suit the coupling rod splasher, again deducting $\frac{1}{16}$ in. for metal thickness around the upper profile and making a pair. Clamp these in place also and fashion the top of the splasher from 15/16 in. x $\frac{1}{16}$ in. strip to suit, bevelling off at the rear edge to blend into the coupling rod splasher, although you can cut this latter away for much of it will have to disappear eventually. The little step can best be bent up from 1.2mm strip and shaped to place.
Moving back to the cab, we can again cut out the side sheets as a pair, and use to form the small piece of splasher top plate; this time it is 1$\frac{3}{8}$ in. wide. The seat box is made up from pieces of 1$\frac{5}{16}$ in. x $\frac{1}{16}$ in. strip, rivetted or screwed in place with lengths of $\frac{1}{4}$ in. x $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass angle. The piece shown dotted at the front end of the seat box can only protrude down between splasher and boiler, otherwise it will foul the wheels, in fact you can continue the splasher top plate upwards if you like and forget this little separate piece. It now needs an inner plate to completely close in and stiffen the whole assembly, made to place with the bottom profile matching that of the frames. Use small pieces of brass angle to secure in place, then clamp the whole assembly to a very stout base, like a length of 2 in. steel angle, and sweat up all the joints. Offer up to the running board and attach with the specified screws.

Cab Sides

Cut the cab sides to drawing, to match up with the splasher, then bend up the $\frac{3}{16}$ in. half round beading to suit the back edge profile and sweat in place. Cut the doubler strip from $\frac{1}{2}$ in. x $\frac{1}{16}$ in. brass and rivet in place, then offer up to the lower portion, spot through, drill and tap. This cab is very distinctive, with its single window to offer maximum protection to crews when working on the West Highland Railway. The window frame is from wood, with a perspex or mica 'window' glued in. It can be mounted in runners, pieces of $\frac{1}{8}$ in. brass angle sweated to the cab side, or simply glued in place.

Spectacle Plate

I would now recommend cutting a spectacle plate from stiff card and checking this to place, before committing to steel or brass sheet. The 'pukka' plate is made in two halves for ease of assembly, with a doubler strip as for the cab sides for bolting together. Use pieces of $\frac{1}{4}$ in. brass angle to attach to the cab sides, cutting away in way of the windows. For these latter, cut pieces from $\frac{1}{16}$ in. mica or perspex to a tight fit in the spectacle plate, cut out the surrounds, and fix these latter in place with 1/32 in. countersunk copper rivets.

Glen

by: DON YOUNG

Part 7 – Conclusion

Cab Roof

To complete the cab, roll up the roof from $\frac{1}{16}$ in. sheet, cut to size and rivet or sweat in the angle stiffeners. Whether the cab roof requires to be made portable is for you as driver to decide, though my own opinion is that this is only necessary for ground level tracks. What it does mean is that the specially shaped angle to join cab sides to roof will either be rivetted or screwed to both; only to the roof if the latter is to be portable.

Sandboxes

That leaves just the sandboxes to complete the engine, which can either be solid chunks of metal, or fabrications. Even if your choice be fabrication, it is easiest to machine up a chunk of metal to act as a former for all the pieces, as this makes life a lot easier. Fold up the wrapper first, trimming to shape, then add the front and back plates. Filler and outlet boss should be made a push fit, then remove from the former, clamp together and silver or soft solder the seams. Clean up, and you can radius all the sharp corners to better represent a casting, before fixing to the main frames. Bend the length of copper tube sweated to the outlet as shown on Sheet No. 1 and next time we can move on to the Tender.

The Tender

After the engine, the tender is much more straightforward, and can be quickly dispensed with, at least on paper! The photographs of the tenders built by David Grant and Abram Reid will also be of assistance, so let us proceed on the ultimate session.

Frames

The frames come nicely within Reeves standard 2 ft. stock length, though unfortunately the closest width is 3 in. Check one edge of each piece on the lathe bed or surface plate; mark out the profile, cut-outs and holes on one piece, drill in about 4 positions and rivet to the second frame. Profile with saw and files, drill all the holes, then separate and remove all burrs.

Beams

Metrication has helped in one direction, for 32mm x 32mm x 4mm is a standard section in steel angle and perfect for the end beams. Deal with these as on the engine, clamp to the frames, and lay the whole assembly on the lathe bed to check for flatness. Check for squareness also across the frames, then drill and tap the attachment holes. Complete the front beam by attaching the bottom drawbar lug.

Frame Stays

Frame stays are fabricated from 3mm strip, though if you have any odd ends of 4mm material left over from the beams, use these for the ends to provide a better machining allowance to arrive at $6\frac{1}{8}$ in. overall; bolt these to the frames with top edges flush.

Running Gear

This comprises Axleboxes, Horns, Hornstays, Wheels and Axles, so let me deal with them in that order.

The axleboxes start life as a length of 1 in. square drawn gunmetal bar; first reduce the width to 29/32 in. Grip in the machine vice, on the vertical slide, and mill a slot 41/64 in. wide and 3/32 in. deep to leave a 7/64 in. flange at the bottom; turn through 180 deg. and repeat the process, to leave the slot a good fit in the frames. Saw into individual pieces, chuck each in turn in the 4 jaw and face off to $1\frac{1}{8}$ in. overall. For the finishing cut, clamp the carriage to the lathe bed so that all boxes are completed to identical length. Mark a pair of boxes, chuck them back-to-back in the 4 jaw with the marked on axle centre running true, then centre and drill right through at $\frac{7}{16}$ in. diameter; this is an easier form of construction to that detailed. Alternatively the boxes can be made from 1 in. square BMS bar and bronze bushed for the axle.

We now have to fit the outer face to each axlebox, fashioned from 1 in. x $\frac{1}{4}$ in. BMS or brass flat. First reduce to 7/32 in. thickness, then file on the top shape at each end of the bar. Saw off to length, mill the ends square, and repeat the process until you have all six 'covers'; braze or screw in position to choice.

Castings will be available for the horns, requiring a minimum of machining. Grip in the machine vice and mill the frame fixing face, then rotate through 90 deg. and repeat for the axlebox sliding face. Turn through 180 deg. and mill the outer edge to $\frac{1}{2}$ in. overall, then do the same for the frame fixing flange. Saw into individual pieces and face off to $1\frac{3}{8}$ in. finished length.

Fix an axlebox into its frame slot, locate a pair of horns with bottom faces flush with the bottom edge of the frames and clamp firmly in place. Drill back from the frames at $\frac{1}{8}$ in. diameter in the 4 positions and fit snap head rivets, hammering down into countersinks in the inside face of the frames. You will now almost certainly have to ease the axlebox to be an easy sliding fit, and this is important for the tender to ride safely. To complete each axlebox, centre, drill and 'D' bit to accept the spring buckle, then drill from this flat bottomed hole at No. 51 into the bore as oil supply.

The hornstays are plain $1\frac{13}{16}$ in. lengths of $\frac{5}{8}$ in. x $\frac{1}{8}$ in. BMS flat; drill those No. 44 holes carefully so that they align with the horns, to drill and tap the latter 8BA for hexagon headed screws.

The subject of wheels and axles has already been well covered for the engine, though I am indebted to our good friend and advertiser, Mr. Jackson of Arrand Engineering, for his cautionary tale on 'Loctite' No. 636, which has been duly noted. This is one of my problems in having been divorced from everyday engineering for over 5 years now, so one has to place reliance on suppliers literature. I cannot understand the Loctite people's love of the "numbers game", for they seem to delight in change. Even more baffling is that in Retaining Compound No. 35, used with Primer 'T', they had a product which never required additional mechanical fixing; marvellous stuff. I have seen it transmit 900 H.P. to a propeller in the worst sea conditions, and Gordon Chiverton will verify that No. 35 defied all his efforts to remove the starter gear on his "horseless carriage"; perhaps it was too good? Our tender can now be wheeled and checked for free running.

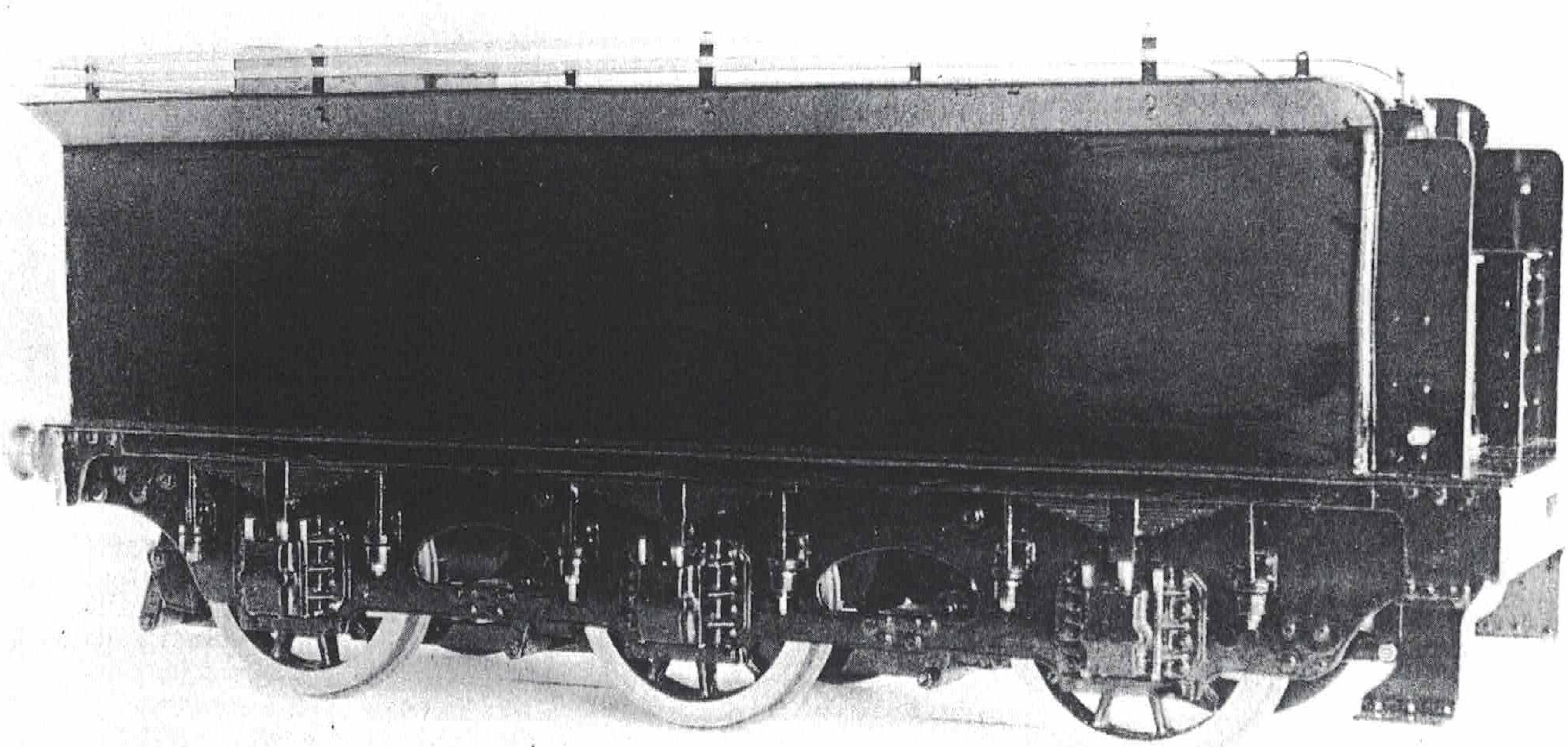
Tender Springing

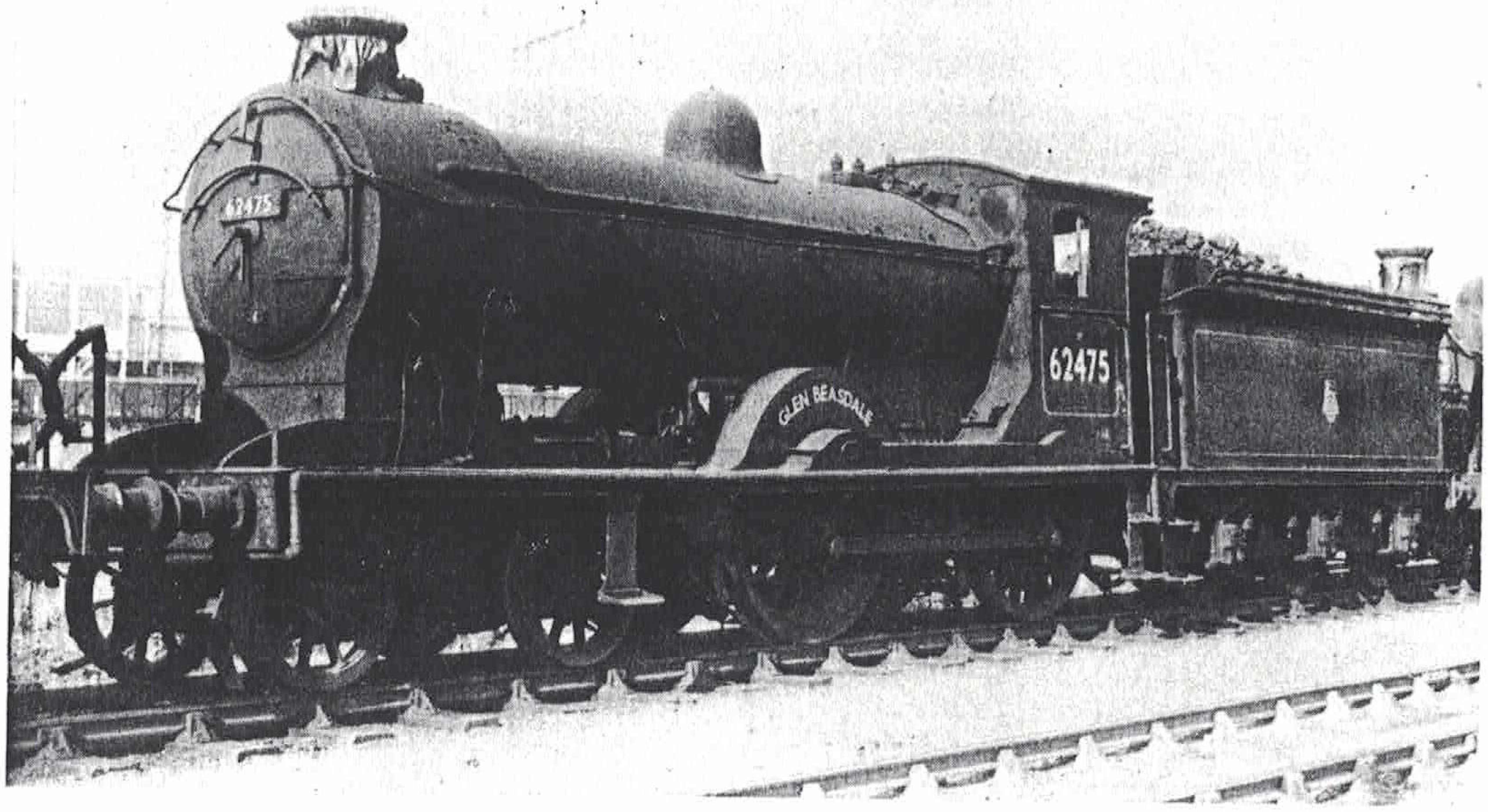
Working leaf springs add a touch of realism, and those on GLEN's tender are clearly visible, and relatively easy to make. For the spring hanger, chuck a length of $\frac{3}{4}$ in. diameter steel bar in the 3 jaw and turn on the outer profile. Centre and drill No. 23 to $\frac{1}{4}$ in. depth and part off a 13/64 in. slice. Complete all twelve bosses, and as the brake hanger brackets are very similar, deal with these at the same time. Cut $\frac{9}{16}$ in. lengths from 5/32 in. steel rod and press these into the spring hanger bosses to leave the $\frac{1}{8}$ in. spigot shown; these pins may be brazed in for additional security. Offer up to the frames, drill the $\frac{1}{16}$ in. holes and secure with snap head iron rivets. The spring links are going to be a bit monotonous, but to reduce the time spent on them, and to ensure they are all identical, first make a 'master', drilling first and then carefully profiling until you are satisfied with the result. Now case-harden this master link to give a glassy surface, really give it the treatment! and use first as a drill jig for the No. 22 and No. 31 holes in 12 pieces of 10mm x 2mm steel strip; the master can be of any thickness. Poke drills through the No. 22 and No. 31 holes and file down to profile, which you will find very easy, as the master makes a fine filing jig.
For the spring buckles, chuck a length of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. BMS bar truly in the 4 jaw and turn down to 7/32 in. diameter over a $\frac{5}{16}$ in. length; centre, drill No. 43 to about $\frac{5}{8}$ in. depth and tap 6BA. To form the buckle I would drill a 23/64 in. diameter hole and file out to $\frac{3}{8}$ in. square using a piece of spring material as gauge, this I call the "fitters way". Gordon Chiverton prefers the "machine method", which is to mill out a $\frac{3}{8}$ in. slot and then close it by brazing on a 3/32 in. thick top plate. The top spring has rather fancy ends and the best way I find to produce these is first take a length of $\frac{3}{8}$ in. square steel bar and cross drill at No. 30. Grip a block of steel in the machine vice, into which a length of $\frac{1}{8}$ in. silver steel rod has been pressed as a fulcrum, slip the $\frac{3}{8}$ in. square bar over this, chuck a $\frac{3}{8}$ in. end mill in the 3 jaw and radius the end to the shape shown; saw off to complete. Poke the top spring leaf through a large potato, fit the ends and braze in place; the potato will prevent the spring loosing its temper, though the end will be sufficiently softened for you to use a slitting saw or file to produce the slot to accept the spring link. Cut the remaining spring leaves, as specified, assemble in the buckle and secure with a hardened steel 6BA grub screw. To complete, cut twelve $\frac{3}{8}$ in. lengths from $\frac{1}{8}$ in. steel rod, press in to locate the spring links, fit these in turn to the spring hangers and add the 3/64 in. split pins.

Brake Gear

The most prominent feature of the whole tender to me are those massive brake blocks, shoes is hardly the right word, reminder perhaps of the days when wood was the chosen material, or that the West Highland Railway was not the place for poor brakes!
For brake hangers I envisaged that 10mm x 4mm would become a standard metric section, no such luck to date, so use $\frac{3}{8}$ in. x $\frac{1}{8}$ in. or $\frac{3}{16}$ in. BMS flat and mill the slot in the brake blocks to match. I also thought originally in terms of a cast ring for the blocks, but so little can be gained from this apart from boring out to fit the wheels that I now recommend $1\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS flat. Our tender brakes won't be as vital as those on the full size GLEN's, but will simply be used when stationary, as a safety precaution, so get into the full size habit and apply the handbrake every time you leave the footplate.
Mill the BMS bar first to reduce the width to $1\frac{5}{8}$ in. then mark on the profile of the block and drill the No. 30 hole. Saw and file out the back profile, then saw from the bar to as close as you can get to $1\frac{15}{16}$ in. radius, completing with files, including a chamfer on the inside edge so that the block does not bite into the root radius on the wheel. Turn up the brake hanger pins and erect the hangers, then mill the slot in the blocks, or saw and file same, so that when fitted and in the 'off' position, the block cannot tilt so that its top edge digs into the wheel tread, the potential cause of a nasty accident. Brake block pins are similar to those for the brake hanger, and I should have mentioned earlier about rivetting the hanger brackets to the inside of the frames.
The brake beams are plain lengths of $\frac{3}{16}$ in. steel rod, to which collars are pressed or brazed. Assemble these, clamp the brake blocks hard against the wheels, measure the lengths for the pull rods and make these latter to suit from $\frac{3}{8}$ in. x 3/32 in. BMS strip. Radius the ends over a $\frac{3}{16}$ in. rod fulcrum,

David Grant's GLEN Tender—Note the excellent running gear





No. 62475 'Glen Beasdale' in storage; what a pity the superb chimney is hidden from view

then mill or file down the centre position to $\frac{1}{4}$ in. width. On assembly you will observe the meaning of the note about spacers to locate the pull rods correctly; measure and make said spacers to place.

Having had a brake shaft seize in its trunnions, due to water spillage, I use brass for the latter nowadays, but turn up trunnions from material of your choice. Turn the brake shaft an easy fit between the frames, and in the trunnions, when we can attend to its arms. That to accommodate the handbrake is from $\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat; drill the holes, radius the ends and complete with files. The shorter arms to receive the leading pull rods should be drilled together, when they can be individually fashioned, or in pairs. Assemble to the shaft, with a length of $\frac{3}{16}$ in. rod through the No. 11 holes to align all the shorter arms, then braze up. Erect to the frames, drill and tap the trunnions, and secure with round or hexagon headed screws.

Handbrake

That leaves the handbrake to complete the brake gear, and for part of the description we must assume the tender body is made and in place.

For the brake column, take a length of $\frac{1}{2}$ in. square bar and face off to $1\frac{7}{8}$ in. overall; braze on two fixing lugs and an $\frac{1}{8}$ in. capping plate; all three pieces should be oversize at this stage. Chuck truly in the 4 jaw, centre and drill right through at No. 21, following up with a $\frac{5}{16}$ in. 'D' bit to $\frac{1}{8}$ in. depth in the top flange. Fashion and drill the two lugs, then lay aside for the moment.

The brake spindle is a $3\frac{3}{4}$ in. length of 5/32 in. steel rod, screwed 32T for $1\frac{1}{4}$ in. at one end, with a $\frac{5}{16}$ in. collar pressed on and brazed in the position shown. Chuck in the 3 jaw and face off any excess spelter, so that the collar becomes an easy fit in the recess provided in the column, at the same time reducing the upper portion to $\frac{1}{8}$ in. diameter. For the brake column cover, cut an $\frac{11}{16}$ in. square from $\frac{3}{16}$ in. brass and file to the profile shown. Grip carefully in the 4 jaw to run true, then turn on the spigot to leave a 3/32 in. thick flange; centre and drill through at No. 30. Take a knife edged tool and scribe a circle, very lightly, at $\frac{5}{8}$ in. diameter, mark on the centres of the four fixing holes and drill these No. 44. Fit the spindle to the column, slip on the flange, spot through the No. 44 holes, drill and tap the column 8BA for hexagon headed screws. Now you can complete profiling the top of the column to match the cover.

For the brake handle, cross drill a piece of $\frac{1}{4}$ in. steel rod to accept the handle which is bent up from wire, 12 s.w.g. being ideal, but use what you have available; braze up. Chuck the $\frac{1}{4}$ in. rod in the 3 jaw, centre and drill No. 31 to about $\frac{1}{2}$ in. depth. Face off so that the boss is flush with the handle, as shown, then part off to give the required $\frac{1}{4}$ in. thickness. Press onto the spindle, with the cover in situ, and we only have to couple from the handbrake to the brake shaft, two components being required, the brake rod and nut; the latter needs no description.

For the hand brake rod and starting at the lower end, drill a No. 31 hole in a piece of $\frac{5}{16}$ in. square steel bar. Radius the end then saw and file the $\frac{1}{8}$ in. slot to $\frac{5}{8}$ in. depth before sawing off at $\frac{7}{8}$ in. overall and radiussing this end also. The centre portion is an approximate 3 in. length of 5/32 in. rod, which brings us to the upper fork. The fitter in me from apprenticeship days reckons this should be bent up from $\frac{3}{8}$ in. x $\frac{1}{16}$ in. strip, you can bend flanging quality steel of this section round an $\frac{1}{8}$ in. rod by hand to arrive at the correct size. Clamp a 5/32 in. packing piece in the slot, to drill through the $\frac{1}{4}$ in. hole for the brake nut, then braze the three pieces together to form the complete rod. Radius the upper fork over a mandrel then complete the flanks with a file; you can now erect the brake gear and test same.

Buffers

The chassis can now be quickly completed, and we can also add another finishing touch to the engine, in the shape of the buffers, for which the total requirement is a 12 in. length of 1 in. diameter free-cutting steel. I stress the 'free-cutting' so that the buffer heads can be burnished bright, though manufacture will commence with the stocks.

Chuck the 1 in. bar in the 3 jaw and turn down for 5/32 in. length to $\frac{5}{16}$ in. diameter; screw 40T. Centre and drill No. 34 to around $\frac{3}{4}$ in. depth, following up at 11/64 in. diameter, preferably with a flat-bottomed drill, to $\frac{1}{4}$ in. depth; part off at a full 1 in. overall. Repeat for the other stocks then chuck a length of, say, $\frac{5}{8}$ in. rod; face centre, drill through at 9/32 in. diameter and tap $\frac{5}{16}$ x 40T. Screw an embryo stock into this adaptor and complete the outer profile; the line in the centre of the flange means these were in two pieces full size; a knife edged tool will simulate this. To complete the stock, bore out to $\frac{5}{8}$ in. diameter for a full $\frac{5}{8}$ in. depth; I find a $\frac{5}{8}$ in. end mill will give the required size, and finish.

For the heads, chuck the 1 in. bar again and turn down to $\frac{5}{8}$ in. diameter, an easy sliding fit in the stock, over a 27/32 in. length. Use a round nosed tool and produce the blending radius between shank and head at this stage. Centre, drill $\frac{7}{16}$ in. diameter to $\frac{5}{8}$ in. point depth and complete with a 'D' bit, then centre again, drill No. 43 to about 5/32 in. depth an tap 6BA. Part off at a full $\frac{15}{16}$ in. overall, reverse in the chuck, set the top slide over 6 deg. and machine the face of the head, blending into the periphery with a file, FITTED WITH HANDLE, the lathe running at top speed. This is a very unusual buffer head, for normal practice is for the working face to be radiussed and the taper to be on the back, but I have checked out this detail, so GLEN builders can claim this feature to be authentic.

The retaining bolt is 6BA x $1\frac{1}{4}$ in. long and as the 8BA head is rather essential to leave the spigot on the stock sufficiently robust, you will probably have to make the bolt. The acid test of a buffer is that it is just possible to fully depress it using all your strength; ones that can be pushed in with one finger are a waste of time if you do happen to run into an obstruction. So let this be your yardstick in selecting the buffer spring, clamp the whole together in the branch vice, fit the 6BA bolt and release; fit the buffers to their beams.

Passenger Hauling Coupling

I recommend the fitting a passenger hauling coupling to the tender rear beam, made in one piece from $\frac{3}{8}$ in. square steel. Chuck truly in the 4 jaw and turn down in stages over a $1\frac{3}{8}$ in. length to $\frac{3}{16}$ in. diameter; screw the outer $\frac{1}{2}$ in. at 2BA. Reduce the next $\frac{3}{8}$ in. to 9/32 in. diameter and file on the 7/32 in. square to fit the beam, cross drill No. 11 and part off. Saw and file the slot, then complete the radius over a mandrel. Again a strong spring is required, for you will be surprised at the drawbar pull that GLEN can exert, so 16 s.w.g. (1.6mm) is the spring wire required, and pre-tension the spring with the 2BA securing nuts.

Valance

For the valances, start with a length of $\frac{3}{8}$ in. x $\frac{3}{8}$ in. x $\frac{1}{16}$ in. brass angle and fashion to be a close fit between the beams. Cut pieces oversize to represent the ends, plus lengths from $\frac{5}{16}$ in. x $\frac{1}{16}$ in. strip for the beam bolting flanges. Clamp together, braze up, then mark off and fashion to drawing. The steps are bent up from 1.2mm brass or steel and fastened in place with 3/64 in. copper rivets, when the complete valance can be erected and screwed to the beams with 8BA countersunk steel screws; the chassis is complete.

Tender Body

After the struggle with some of the engine platework, the tender body is relatively easy, though it will consume vast quantities of 1.6mm brass sheet, plus the best part of 20 feet of $\frac{1}{4}$ in. brass angle. Take the soleplate for instance, this is $22\frac{3}{4}$ in. long and $7\frac{3}{4}$ in. wide, the base on which to build the rest of the body. Sit the soleplate on the frames and you will find the flanges of the wheels just foul; about $\frac{1}{4}$ in. is required for clearance at the deepest point. The 'tin bashers' amongst us will simply dish the soleplate locally, without cutting metal, but those of us less skilled, including yours truly!, will have to cut metal until there is a proper clearance and then make up box splashers to fill said holes, rivetting to the soleplate with pieces of $\frac{1}{4}$ in. brass angle.

The ideal way to form the tender sides, back and front is from a single piece of brass 56 in. long and $5\frac{1}{4}$ in. wide, this latter to include the flare; bending each corner around $\frac{1}{2}$ in. diameter bar, with the joint on the back centre line and sealed with a doubler strip. Problem is that the standard sheet size is the metric equivalent of 4 ft. x 2 ft., though 6 ft. x 3 ft. sheets are still produced. The alternative is to use two 28 in. lengths, with doubler strips on front and back centres.

How to deal with the flare? The easiest way is to make a saw cut in the middle of each corner, then grip in the bench vice and fold over a little at a time along the flat surfaces. Treat the corners with a mallet, then cut 'V' shaped pieces to fill the gaps. Braze these in for preference, then tidy up with files, leaving the front sheet which is not flared outwards at the top. The secret with platework I feel is a minimum number of large parts, as against a multitude of small ones, reducing the number of troublesome joints to a minimum; plain plates cannot leak!

Cut out the coal gate $1\frac{1}{2}$ in. wide in the front sheet, then rivet lengths of $\frac{1}{4}$ in. brass angle to the bottom angle, using $\frac{1}{16}$ in. snap head copper rivets. I should have said earlier that tank dimensions, outside ones, are $20\frac{1}{4}$ in. long and $7\frac{1}{2}$ in. wide; centralise for width on the soleplate, set $\frac{1}{2}$ in. from the rear edge, then check for squareness. When satisfied, drill the soleplate No. 44, continue into the brass angle at No. 50, tap 8BA, countersink the soleplate and fit screws, this at roughly 1 in. centres; you will now have a quite rigid structure. We must now attend to the tank top.

I suggest you start with the removeable portion, the plate itself being straightforward. Part off a $\frac{5}{8}$ in. length from $1\frac{1}{2}$ in. o.d. x 16 s.w.g. copper, or brass, tube for the filler, position to drawing and braze in place before cutting the plate away to the bore of the tube. Cut two pieces from 1.6mm brass sheet for the lid, file the joint faces flush and sweat together. Now mark off, saw and file the profile as per the drawing detail. Most D.I.Y. shops stock a variety of miniature hinges, and one of these should be suitable for your needs, though it is almost as quick to make your own, like that for the firehole door. Warm the soldered joint to separate the pieces, remove any solder present and rivet the hinges to both portions of the lid. Complete by sweating the smaller portion to the filler tube, this being towards the front, so that you will be able to check the tender water level and bye-pass return easily from the driving position.

Hand Pump

The hand pump is sited so that an extension from its handle passes through the filler tube for operation; let us make said pump. Grip the body casting in the 4 jaw chuck to bore and ream for the ram, plus face across the valve box. Fit an angle plate to the vertical slide and bolt the body to same, through the bore. Deal with the suction side first, milling across the boss, then centre and drill into the bore at No. 30. Follow up with a 7/32 in. 'D' bit to $\frac{1}{4}$ in. depth and tap $\frac{1}{4}$ x 40T. File a slot in the remains of the No. 30 hole to break up the seat.

Mill the foot on the casting, then rotate through 180 deg., face, centre, drill and ream at $\frac{1}{8}$ in. diameter into the bore, again following up with the 7/32 in. 'D' bit and $\frac{1}{4}$ x 40T tap. The separate suction valve seating is reamed at $\frac{1}{8}$ in. diameter for its 5/32 in. rustless steel ball and the No. 30 hole in the outlet connection has 'V' notches filed in to prevent the ball from seating inadvertantly.

The ram is a $1\frac{3}{4}$ in. length of $\frac{1}{2}$ in. rustless steel rod, cross drilled No. 43 and then slotted $\frac{1}{8}$ in. to accept the handle. Make up the pair of $1\frac{3}{4}$ in. centres anchor links, then mill the lug on the body to accept same, using 3/32 in. snap head brass rivets as pins. To complete, turn up the end plug to a press fit in the bore, applying a drop or two of soft solder as additional security if you like.

On installation, the delivery pipe loops downwards to a bulkhead connection in the soleplate, then turns forward. As engine/tender flexible connection I employ a cycle pump connector, which has $\frac{1}{4}$ x 26T ends, though you can cut off the male end and clip directly to the 5/32 in. o.d. copper pipe.

Suction and Bye-Pass Fittings

Whilst on the subject of soleplate penetrations, three more are required. Two of them are suctions for injector and axle driven feed pump, these can follow the details given for DON HUNSLET, including the filters. Position them clear of obstructions like frame stays; ahead of the leading stay and behind the leading axle I would recommend. Take the injector pipe forward to the water cock, one of our 'standard' fittings, and after another 1 in. length of 5/32 in. (or $\frac{3}{16}$ in) o.d. copper pipe has been fitted, complete to the engine connection with plastic hose. Feed pump suction is similar, without the water cock, control being after delivery from the pump. This brings us to the last pipe, the bye-pass return, this again requires a bulkhead connection and terminates open-ended in the area of the filler tube.

Completing the Tank

We can now close in the top of the tank, so first site lengths of $\frac{1}{4}$ in. brass angle so that the removeable section of the tank top is level with the beginning of the flare. Rivet the angle to the side and back sheets, when the tank top can merely sit in place.

Immediately ahead of the removeable portion of the tank top is the coal bulkhead, shown dotted on the drawing. I recommend that this project about $1\frac{1}{2}$ in. into the tank itself, which makes it $2\frac{7}{8}$ in. deep; fix to the tank sides with $\frac{1}{4}$ in. brass angle and 8BA countersunk head screws.

The fixed tank top extends right forward, angled downwards to form the coal space, and there is a $\frac{1}{4}$ in. projection through the coal gate in the front sheet. Fix pieces of $\frac{1}{4}$ in. angle to the side and front sheets, then screw the tank top to this, again using 8BA screws at about 1 in. pitches. Remove the removeable portion of the tank top, that's logical! plug up all the holes with little wooden dowels, pour in some Bakers soldering fluid, plus some soft solder. Gradually warm up the whole tank, using a small burner with diffuse flame, playing all over the outside sheets, and when the solder melts, keep tilting the tank so that the solder reaches and penetrates all the seams. Wash thoroughly with hot soapy water, rinse and dry, then fill and check for leaks. Minor leaks can be plugged with paint, in fact I would dilute some white paint, pour into the tank, swill around and pour away the surplus; a white interior shows up any pollution.

At the front of the tender are two panels, $4\frac{3}{8}$ in. high and $1\frac{1}{2}$ in. wide. The top and front of each panel can have $\frac{3}{16}$ in. coping applied, then soft solder to the front of the tank. Make up a wooden box to form the tender footplate, a neat fit between the panels, and make the toolboxes from wood also. Glue and pin the whole wooden assembly and fasten to the panels to provide additional stiffness with small brass countersunk woodscrews, No. 2 x $\frac{3}{8}$ in. if I remember correctly.

Coal Rails

That brings me to the very last feature on the Tender, the coal rails, and I reckon you will share my loathing for them in miniature before too long, beautiful though they look when first fitted. For they are things to get clothing caught up in when driving, they bend easily and the paint tends to fall off. To partially remedy these potential disasters I recommend that they be plated in from the coal bulkhead aft; throughout if you like.

For authentic construction, first cut $1\frac{1}{4}$ in. lengths from 5/32 in. x 20 s.w.g. brass strip, boiler band material, set at roughly 2 in. intervals around the tank top, with $\frac{3}{4}$ in. sticking above the top of the flare, and securing each to the latter with 10BA countersunk screws. Now bend up each of the coal rails in turn, clamping to the uprights, drilling through at 3/64 in. diameter, countersinking each side and securing with copper rivets. When the whole assembly is complete, remove all the 10BA screws, lift out the coal rail unit and braze each joint; reassemble. Plating in the rails simply means filling in between the uprights with $\frac{3}{4}$ in. wide x 0.9mm thick brass strip.

Finale

It remains for the moment to wish GLEN builders pleasant steaming and thank you for the pleasure of your company; hopefully we shall return to this lovely Locomotive from time to time, maybe in 'Builders Corner'.

This shot of Abram Reid's GLEN on the Glenrothes Club Track shows the excellent detail work on the Tender, though I wonder how long the coal rails will remain in such pristine condition!