Doncaster — a 5in. gauge Gresley A1/A3 'Pacific'

by: DON YOUNG

Part 7 – Mainframes, Bogie completion and Cylinders revisited

Just before we start the main business of this session, I can report that Gresley A1 or A3 'Pacifics' are already under construction in New Zealand, South Africa and the USA as well as the UK, with names such as ENTERPRISE, BLINK BONNY and SPION KOP already having been selected. The first tender has been complete for some months now, it meets with Bill Holland's knowledgeable approval, and the first boiler is complete and tested. Several sets of frames are erected, we shall come on to these in a moment, and according to my current stock the next big call will be for the cylinder castings.

I guess the appearance of DONCASTER's frames will cause a buzz of excitement among readers, it is ever the case as this single component brought forth the same reaction when I saw them emerging from large steel flats at Doncaster, yet if analysied the frames are perhaps the dullest of all the bits that make up a steam locomotive, certainly not in the same league as the boiler or cylinders which I have already described. Basically the frames exist to support the boiler, hold the wheels and cylinders in place and a lot more besides, but they do not move; on their own they are quite inanimate. As I was able to illustrate with MARIE E, in many cases a length of steel bar will do the job, that too brought forth excitement though for a different reason!; a multiplicity of steel bars could provide the frames for any steam locomotive. However, no way am I going to spoil builders enjoyment in cutting out such shapely frames and we must thank designers for adhering to plate frames in the UK which allows us in turn to create beauty in 5 in. gauge.

There is very little that can be said about the manufacture of frames even as large as those for DONCASTER, the main rule being to treat each hole and dimension with exactly the same care, be it vitally important or not, that way you will end up with a sound chassis. I see that Reeves do not list the 5 in. x ⅛ in. (or 3mm) flat we require, but as a note says that the wider sections they do have may well be sheared from cold-rolled pickled sheet, a material quality that will suit us fine, then maybe they can be persuaded to meet our need. The other problem is that the length of frames at around 45 in. is beyond the normal postal limit, which is as good an excuse as any to call in at their Alladin's Cave – at last I have come up with a description for Reeves Marston Green HQ! Talking of length, the calculation for the little bit extra to cater for the double set in the frames works out as at a puny .006 in., which means in my book that this can be ignored; nobody is going to run a tape measure over the finished product and even if they did, the 'discrepancy' would be undetectable. So first file the top edge as datum on both pieces, then carefully mark out on a single piece, clamp together and drill about eight holes at 3/32 in. diameter and spaced along the whole frame length, fitting aluminium rivets and hammering them well down to cause minimum interference. Carry on and drill all the holes to drawing, then saw and file the profile. The lightening holes really depend on the year in which you are building your A1 or A3, my notes covering the mainframes for DONCASTER only, each engine having its own history in this respect. In miniature they are of some use in oiling around between the frames and thus worthy of consideration; unlike full size they will not cause an unacceptable weakening of the frames. Lastly and most important we come to the horn gaps, huge affairs that if the fitted bolts holding the horns in place ever came loose, as they did, would lead to serious frame cracking, something that really had to be seen to be believed.

Just before we move on, a letter arrived from builder Keith Ashford at this point in preparing my notes and saying that my buffer position was incorrect relative to the front buffer beam and could he do something about it on his engine? I must be ever vigilant about such errors creeping in and must admit that this one had slipped completely through the net, so thank you Keith for bringing it to my attention and with such perfect timing that I could correct the drawings prior to their publication in LLAS. The error started when I chose 3¾ in. as the height of buffers and couplingx above rail level, something that would have been called Group Standard on the LNER, whereas 3 11/16 in. is closer to scale. Then to land the buffer spring housing fixings well inside the edge of the mainframes at the cut-out for the front bogie wheels, another 1/16 in. crept in and hey presto, the buffers were in the centre of the beam heightwise. Once pointed out, my error is a glaring one, but how to get over it? First step was to lower the centre of the buffers to 3 11/16 in. above rail level and as I had to be careful about the buffer spring housing fixings, I have reduced the depth of beam from 1⅝ in. to 1 9/16 in., the exact scale dimension being 1 19/32 in. It has achieved the desired end result and early builders who have cut and drilled their frames will simply bring up the redimensioned beams and drill through the relevant components to suit, so no harm is done, other than to my ego!

Back to the horn gaps and for the first time ever I must admit that I would use a vertical milling machine in preference to my 'old faithful' ML7, when it becomes a piece of cake with the frames bolted firmly to the table. The alternative is to bolt a piece of ½ in. thick steel plate, size 7 in. x 4 in., to the vertical slide table, preferably the plate being counterbored to accept the tee bolt heads, when the frames can be firmly clamped to same in four positions. This latter way the majority of the metal should first be sawn away and in both cases the final cuts should be with a ¼ in. end mill and measurements by vernier calipers. Incidentally, when I checked this set-up on my ML7 it was to find a pane of glass would have to be removed! The set in the mainframes towards their rear end is a very simple one to achieve, so grip in the bench vice 4½ in. behind the trailing coupled axle and use a wooden mallet to get somewhere near the right result, setting back at 2⅛ in. from the rear end. Check the 5/16 in. offset on a flat surface, correcting as found necessary, then deal with the second frame to be identical.

Doubler Plates

The doubler plates are 6⅛ in. lengths from 4 in. x ⅛ in. (or 3mm) steel flat; mark off, saw roughly to line and then produce the set to match the mainframes. Clamp in place, finish profile from the mainframes where possible, then deal with the rest of the profile before clamping in place again, drilling through and securing with snap head soft iron rivets where indicated.

Coupled Wheels Spring Arrangement

I am rather pleased at the way the coupled wheels spring arrangement worked out, it really looks the part even if the wedge bolts and adjusting screws are dummies, for no way will I fit working wedges after experience of them full size –

all of it bad! Let us make further progress with the largest of the components, the main horns, the castings for which have brought favourable comment.

Horns

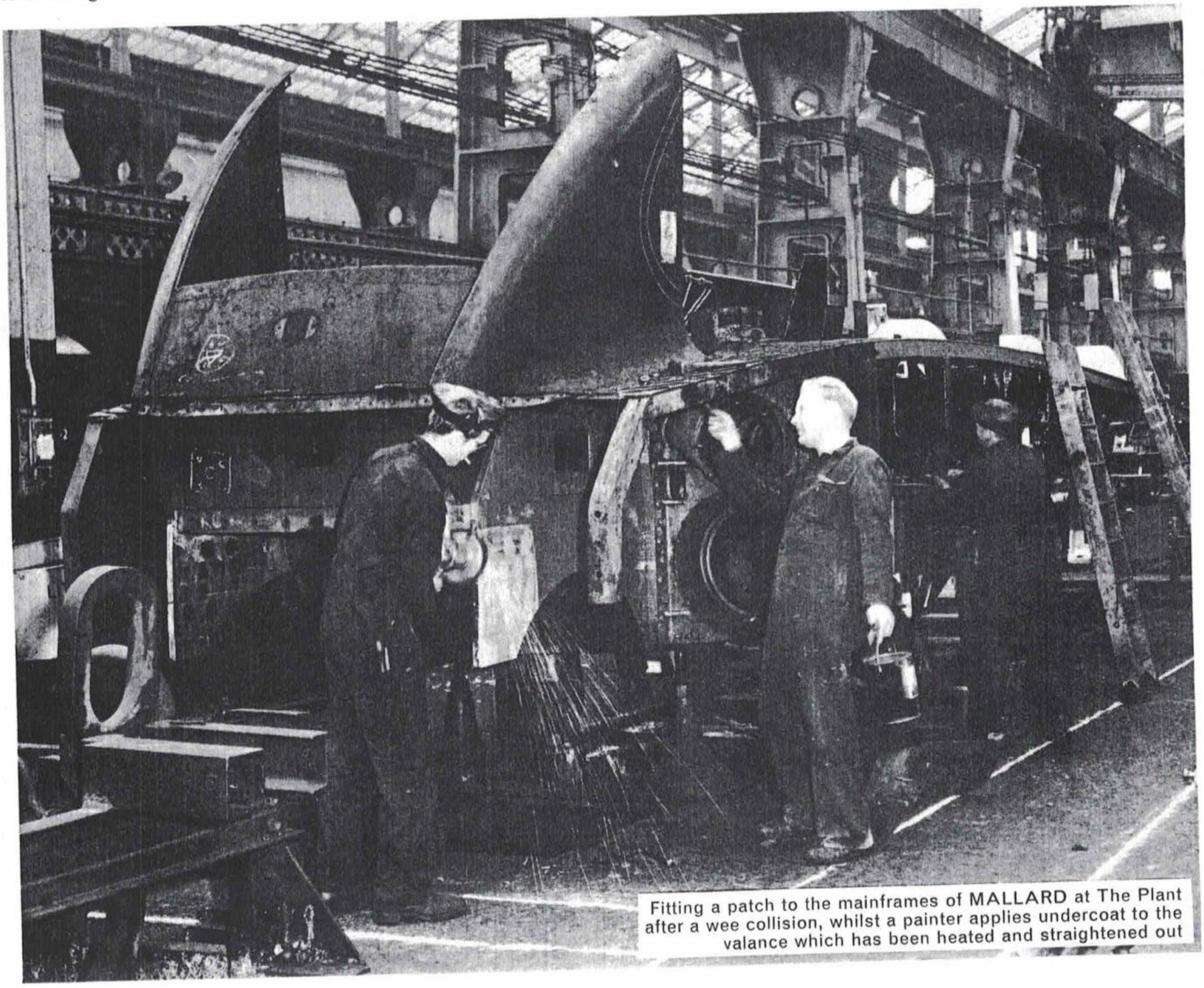
Mark off the castings so that everything is nice and central then file the inner face flat; that is the one away from the frames. Sit said flat face on the vertical slide table and bolt in two positions through the centre slot, using $1\frac{3}{4}$ in. long strongbacks from $\frac{3}{4}$ in. x $\frac{1}{4}$ in. BMS bar and drilled centrally at $\frac{1}{4}$ in. diameter to suit the tee bolts. Check a $\frac{3}{8}$ in. end mill will cover the whole surface to be machined, in fact use it to tidy up the frame fitting flange edges as a first step, altering the setting until you can machine to line. Next deal with the frame fitting face, moving on to the spigots to be a tight fit in the frames, a job for your vernier calipers. Still with the $\frac{3}{8}$ in. end mill, start milling the axlebox slot, keeping it central to the frame gap spigots and moving the tee bolts/strongbacks as you come to them, but without disturbing the setting. Those horn gap spigots have now to be reduced to $\frac{1}{8}$ in. height and 7/64 in. thickness, the latter to allow the axlebox to slide in the recess formed, so mill these also. Turn the horns over and mill the inner face to line, noting the 3/32 in. cut-back at the top, and also dealing with all the little raised bosses to be about 1/32 in. proud of the face. Cut into individual horns, grip in the machine vice on the vertical slide and mill the feet to drawing.

I should have mentioned the hornstay 'grippers' in the mainframes when dealing with the horn gaps and they are interrelated, though it is problematical whether to machine the frames first and make the hornstays to suit, or vice versa. What is absolutely essential is that the hornstays be a good fit both over the horns and into the frames; we will try to meet said requirement as the next step in the procedure and before completing the horns.

Hornstays

First cut six 3 in. lengths from 1 in. x $\frac{5}{16}$ in. BMS bar and reduce the width to $\frac{7}{8}$ in. Next grip in the machine vice, on the vertical slide and mill away 5/32 in. over $2\frac{5}{8}$ in. length to be a good fit over the bottom of the horns, then relieve the ends by 1/32 in. to arrive at the drawing dimension. Drill a couple of $\frac{1}{2}$ in. holes to start forming the centre slot, then mill to line and file the corners square before marking off and drilling the three specified holes. Turn the bar over to mill the two $\frac{1}{8}$ in. deep recesses to fit the frames, then offer up to same, mark off and mill the end flanges to be a good fit in the frame slots, then radius the corners as shown. To complete, turn the bar over again to mill the 3/64 in. recesses in the bottom face with an $\frac{1}{8}$ in. end mill.

Offer the hornstays up to their respective horns, clamp in place, to first drill and ream through the $\frac{1}{8}$ in. holes, making fitted bolts from $\frac{3}{16}$ in. A/F hexagon steel bar to suit. Spot



Fitting a patch to the mainframes of MALLARD at The Plant after a wee collision, whilst a painter applies undercoat to the valance which has been heated and straightened out through the dummy wedge adjusting bolt hole, drill and tap the horn 8BA to ¼ in. depth, then complete with a thin headed bolt and nut as shown. Next drill and tap the boss provided for the dummy wedge bolt, only what you see is the shank of the bolt secured with thin nut and locknut, so screw a 5/16 in. length of 8BA studding into the tapped hole and complete with the pair of thin nuts. To complete this stage, on the top face there is another boss for oil supply to horn and axlebox; for the moment simply drill and tap it through at 5/32 x 40T.

I make it a practice to specify as many holes as possible in the mainframe detail, this to give builders a good idea as to what is involved, and looking at the Frame Plan above you can deduce the purpose of the vast majority of them. Now there is license to drill all the holes in the frames initially, or in such cases as the horns with their wee raised bosses, to transfer the hole positions to the horns themselves initially so they are central in the bosses, then drill back through the frames; the choice is yours. This was a big problem area full size during refits when the horn had worked loose in the frames; the frame gap edges had first to be built up with weld and then ground and filed to both trammels and the horns to keep the correct coupling rod centres. Often then most of the holes had to be plugged and redrilled, it was indeed fortunate that the horns were steel castings to allow this, when we marked off and drilled back from the horn bosses. Whichever way you choose, offer the horn and stay assembly up to the frames, get them fitting and located correctly, then clamp firmly in place to drill and ream through the fixing holes, countersinking the outside of the frames.

The fitted bolts used at Doncaster were unique in my experience and worthy of description in miniature; it is a pity though that we do not have an automatic machine to make them for us whilst we get on with better things; the day will come if Walter Bossons has anything to do with it! Chuck a length of 3/16 in. A/F hexagon steel bar, face and turn down over a full ⅛ in. length to .110 in. diameter and screw 6BA. Reduce the next 7/32 in. to ⅛ in. diameter, a drive fit in the holes, then set the tool over 45 deg. to turn on the countersunk head; this is where a 4 tool turret will come in handy. Change to a parting off tool and begin parting off to leave the correct head to suit your frames, only stop when you reach about 3/32 in. diameter, move on to leave 3/32 in. of hexagon, then part right off. The hexagon head can now take punishment when you hammer the bolt home and after fitting the nut, take a small chisel and cut the 3/32 in. pintle, filing flush with the head/frames to complete. The alternative of course is ⅛ in. snap head soft iron rivets, heads inside, and this in my book is a better engineering solution, but no way would it be genuine Gresley 'Pacific'.

Axleboxes

Axleboxes next, the castings being common with E. S. COX and many other locomotives, being available in either iron or gunmetal to builders choice; I have no preference in this. First task is to produce the 1 17/32 in. x 1 3/64 in. section, by either turning or milling, then machine the ends of the casting square. Grip in the machine vice, on the vertical slide no less!, and mill a 7/64 in. deep slot with a ½ in. end mill, gradually widening to 25/32 in. to achieve the correct flange dimensions. Make a note of the vertical slide micrometer collar readings when the final cuts were taken, then rotate the bar through 180 deg. and repeat, only instead of going straight to 7/64 in. depth, do so gradually and check against the relevant horn until it just enters. Saw into individual boxes, lightly mill the bottom faces just to clean them up for the moment, then mark off and mill the 15/16 in. wide slot for the keeps, our next item.

Keeps

I have always fabricated my keeps from odd bits of brass, those on my K1/1 'Mogul' are virtually identical to DONCASTER's, simply cutting them out, clamping together to silver solder the joints, then rubbing a file over them to fit the axleboxes. Most builders though seem to prefer to machine them from brass bar, and although they don't quite come out of 1 in. square section, all you have to do is silver solder on a couple of wee pieces at the spring swivel, when the rest is fairly easy.

First cut and square off six 1 3/64 in. lengths from the bar, then mill two faces to 15/16 in. overall, a nice tight fit in the axlebox slot. Mark off on the axlebox and drill the three holes right through, the swivel pin being reamed at 5/32 in. diameter and the keep pin holes drilled at No. 52; make up all three pins for each box. To balance the cored journal hole in the axlebox, use the side teeth of a ⅝ in. end mill to scallop the keep, when we can begin to think about boring out in pairs, for which we require a jig.

Cut two 2¾ in. lengths from 1¾ in. x 3/16 in. BMS flat, mill a full ¼ in. slot for 2¼ in. down the centre of each piece, slip over a pair of axleboxes back-to-back, then drill for two ¼ in. bolts at each end to clamp the boxes firmly together with their top faces coinciding. Fit a wooden dowel into the bore of one box, mark out its centre and scribe a ⅞ in. circle, then chuck the whole assembly in the 4 jaw, fit a scriber under the toolpost and set up so that the scriber point traces the circle accurately; bore out to suit the axle steel. Turn on the 1/64 in. raised face, reverse in the chuck and repeat for the raised face on the second box; mark the boxes as a pair and also the relevant pair of horns.

At the top of each box we now have to mill out the oil reservoir to 7/32 in. depth and drill the three No. 57 holes, two of them to lubricate the slides and the other the journal; at last I have positioned the latter correctly away from the crown of the bore, though I should have mentioned on the drawing that this hole hands the boxes, all journal oil holes being to the rear of the crown. For several years I studied tribology, advising on lubrication problems in industry, yet never have I said anything about this important subject with respect to our miniature locomotives. Unique to my own designs, for DONCASTER there will be mechanical lubrication to the axleboxes and slide bars, for which Myford lathe oil as available from Reeves will be ideal. When we ran trials from Doncaster, if an engine developed a hot box, then the driver would remove the worsted trimming and inject a shot of cylinder oil directly to the bearing concerned, its higher viscosity meant the oil film did not break down and the heating completely disappeared, for such only arises from metal to metal contact. So when I go to the track, a laugh that!, my oil can only contains cylinder oil which I use universally. Light machine oils such as '3 in 1' are alright in their place, but not on a hard working steam locomotive where the oil has to stay put once applied.

Turning our attention finally to the bottom of the box, I found on my K1/1 that it was feasible to produce the 3/16 in. radius over a mandrel with an end mill, if the majority of the metal had first been removed by sawing and filing, when it was simply a matter of tidying up with a file.

Before we move on to fit the axleboxes to their respective horns, the keeps have to be completed, so first mill the ⅝ in. slot right through to accept the spring swivel, removing just enough metal so that the latter will fit. Turn the keep over and mill the reservoir to accept a felt pad, one which you should soak in lathe oil right from the very outset as this is a safety feature to prevent the journal ever running dry. All you have to do now is complete the lower profile to match the axlebox.

Fitting the Axleboxes

More than 25 years ago now I was given some 'polishing sticks', pieces of batten to which fine grade emery paper had been glued to make what were in fact very smooth files. Their original use was to remove machining marks from the coupling rods on my FISHBOURNE which had given the donor offence, but I rapidly discovered they were multi-purpose. Whether such objects are available today I have not the slightest idea, though they would be easy enough to make, and they are the ideal medium for polishing the horn and axlebox slides to a mirror finish, gaining the correct fit in the process, otherwise it is a job for your smoothest file. Once the axleboxes have been entered and slide freely from top to bottom in the horns, relieve the side flanges so that when axle steel is inserted, or of course the complete wheel and axle assemblies, each box can be lifted independently of its partner by about 5/32 in.; there is no point in going to my 'standard' $\frac{3}{16}$ in. dimension on DONCASTER as the coupled wheels would then foul the frames. All this of course assumes the frames are assembled with all the cross stays in place, something that will not happen in this session, but in the same vein we can at least complete the coupled wheels springing.

Spring Hanger Brackets

These super castings require a very minimum of machining, so first file or mill a pair to thickness then saw along the line provided into individual brackets, facing off and drilling the No. 18 hole square to the face. Shock absorbers we already have from the tender, so scallop the bottom face to accept same. Incidentally, it was a shock (pun intentional!) to find on FLYING SCOTSMAN that the shock absorbers were rectangular as against oval as I **thought** I remembered them, though the main dimensions remain; those in pursuit of absolute accuracy please note. Offer up to the frames, drill through and secure with 7BA fitted bolts, or preferably 3/32 in. snap head iron rivets in this instance.

Brake Shaft Trunnions

These were a real swine both to draw and cast correctly, but the end result leaves little problem for the builder. Rub a file over the pair, including the back face, then grip in the machine vice on the vertical slide and mill the $\frac{1}{16}$ in. step to fit the frames. Saw into individual trunnions, offer one up to the frames, drill through the twelve No. 41 holes, then clamp back-to-back to its partner and drill through; bolt together. Mark off the trunnion bore on one casting, either grip in the 4 jaw or dog to the face plate for the bore to run true, then centre and drill right through the pair at 11/32 in. diameter. The three little lugs for the fixings actually locate the holes, no point in having them anything but central in same, so mark off and drill them at No. 44. Turn up the bearing from $\frac{3}{4}$ in. diameter brass or bronze bar, rub a file over the trunnion face so that the bearing flange sits comfortably, then drill through at No. 44, secure with 8BA bolts and complete the bearing flange to match the trunnion. Mark off and drill the No. 18 hole for the spring pin then file the groove to accept the shock absorbers; rivet the trunnions to the frames.

Spring Swivels

For some obscure reason, I was so concerned the swivels would fall apart on my K1/1 that I machined them from the solid; 20 years on I know better than that! First chuck a length of $\frac{1}{4}$ in. steel rod, face, centre and drill No. 22 to about $\frac{3}{4}$ in. depth before parting off a $\frac{5}{8}$ in. slice to fit the keep; repeat another five times. Next take a length of $\frac{1}{2}$ in. x 5/32 in. BMS flat, you will almost certainly have to machine it to arrive at this section, and at $\frac{3}{16}$ in. from one end, cross drill at No. 22 then radius the end over a mandrel with an end mill. Saw off at $\frac{1}{2}$ in. from the centre of the hole then scallop to suit the sleeve and to arrive at the $\frac{1}{2}$ in. dimension. Silver solder together and complete the profile to drawing.

Full size an 18 s.w.g. open box dropped over the upper end of the spring buckle to keep the pin in place, but I recommend said pin be a press fit in 5 in. gauge, as broken springs are not so common in miniature, indeed as far as I am concerned they are unheard of.

Spring Buckle and Leaves

For the spring buckle, first produce a length from BMS bar to $\frac{9}{16}$ in. x $\frac{3}{8}$ in. section. Drill the No. 23 hole, radius the end over a mandrel with an end mill, then mill away to form the fork end to suit the swivel. Drill a $\frac{3}{8}$ in. hole to start forming the actual buckle, mill out as far as possible, then complete with files to the actual spring material as gauge. Saw the buckle from the bar, face off to length, centre, drill No. 44 and tap 6BA for a cup point socket grub screw.

We already know how to silver solder 'grippers' to top spring leaves, so do this which will also anneal the spring material in the area we require, so centre pop and gradually open out the hole to No. 21, completing with a swiss file if necessary. Cut the remaining leaves to specification, feed them into the buckle and secure with the grub screw. Turn up the spring pins to drawing, those we need first are simply $\frac{3}{8}$ in. lengths of 5/32 in. steel rod, and fit the springs to their swivels.

Spring Washers

Just the spring washers to complete this part of the assembly, but they require a careful description to arrive at the correct end result. First chuck a 1 in. length of $\frac{3}{8}$ in. steel rod in the 3 jaw, face, centre and drill right through at No. 21. Over to the machine vice on the vertical slide and if you remove the top, swivelling, jaw on the Myford vice you will then be able to hold the rod securely in the scallop, when you can mill a $\frac{1}{4}$ in. wide slot to suit the spring pin head to about 3/64 in. depth. Rechuck the rod in the 3 jaw and turn to drawing, then part off an almost complete washer. Grip a length of 5/32 in. rod in the bench vice with a bare $\frac{1}{8}$ in. projecting above the jaws and drop the washer over this spigot, when with a swiss round file you will be able to file the scallop to suit the top spring leaf 'gripper'; only another 11 to go!

Assemble to drawing and you will have to wait until DONCASTER is complete to find out if the springs will perform satisfactorily as specified; someday someone will tell me if I got it right, more likely if I got it wrong!

Rear Stay

Only one other detail in this area on Sheet No. 7 and you will see by my notes that the rear stay is very much a 'make to place' item, as it has to fit between the tapering frames and support the foundation ring at the back of the boiler. By all means cut it out, bend the web as shown and braze on the flanges, ready to fit later on.

COMPLETING THE, SWING LINK, BOGIE

Bogie Frames

If there was little I could find to say about the mainframes, the only sensible comment I can make on the pair for the bogie is that they have an elegant profile; arrive at same, drill all the holes and mill out the slots to be a nice fit to the axlebox flanges already made.

Bogie Centre

The top face of the casting used as a check was reasonably flat, albeit with four bosses sticking up, so pack off the face, $\frac{3}{16}$ in. is sufficient, from the vertical slide table and bolt through the slot using strongbacks. Now you can mill the bottom edge of the side flanges to arrive at the $1\frac{5}{16}$ in. dimension, then move on to their faces to reduce the overall width to 4 in., taking care to keep the flanges of equal thickness.

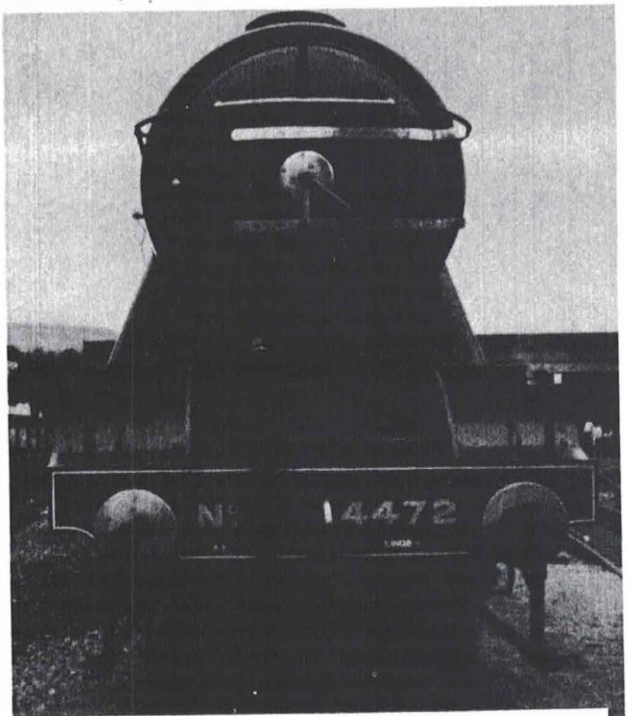
Removing one bolt at a time, use a $\frac{1}{4}$ in. end mill to arrive at a $\frac{13}{16}$ in. depth of centre slot, then tackle the latter with a larger and more resilient end mill to 1 5/32 in. width, completing in the corners with a file.
For the swing link pin holes, change from the vertical slide to an angle plate and bolt the bogie centre to same; mark off and drill right through at about No. 30 initially. The drill is likely to wander when it enters the second boss, so open out the first hole to 5/32 in. diameter and using a long 'D' bit or end mill, correct the second hole before opening out further to No. 14 and completing with a $\frac{3}{16}$ in. reamer.
The axleboxes by their fit in the frame gaps automatically align the horns, so clamp all three pieces firmly in place, drill through and rivet the horns to the frames. Now you can fit the wheel and axle assemblies, bring up the bogie centre and check for squareness, etc., final approval being when the axles turn sweetly. Spot through the frame holes, drill and tap the bogie centre at 6BA and secure with countersunk screws, though as the detail suggests, seven of the holes at each side can be opened out to clearance size in the centre if you so wish.

Stays

The rear stay is bent up from 12mm x 2mm steel strip, ends faced to 4 in. overall, offered up, drilled through at No. 51 and then shaped as shown. I would rivet this, and the front stay which is from $\frac{1}{8}$ in. or 3mm strip, to the bogie frames and this means delaying said operation until the bogie is complete.

Shock Absorbers and Spring Yoke

The shock absorbers are plain turning, even down to the rubbers, which leaves just the spring yokes to complete springing the axles. For the K1/1, I made up a jig for same from a 3 in. length of $\frac{1}{2}$ in. x $\frac{1}{4}$ in. bar, drilling two No. 30 holes at 2 in. centres and another at No. 34 midway between them; fit $\frac{1}{2}$ in. lengths of $\frac{1}{8}$ in. steel rod into the outer pair of holes. Next chuck a length of $\frac{1}{4}$ in. steel rod, centre and drill No. 30 to $\frac{5}{8}$ in. depth, parting off two $\frac{3}{16}$ in. slices; drop them over the $\frac{1}{8}$ in. pins. Rechuck the $\frac{1}{4}$ in. rod, face, centre, drill No. 43 to $\frac{1}{4}$ in. depth and tap 6BA; part off at 13/32 in.



This imposing head on view of FLYING SCOTSMAN was taken at Carnforth by DONCASTER builder Roger Early.

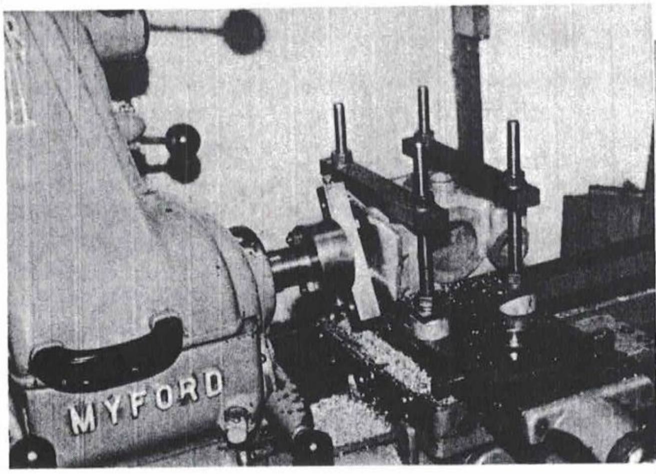
overall and bolt to the centre of the jig. To fill in between these pillars, take a length of $\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat and scallop the ends to fit between the pillars, then shape the top profile to drawing. Do the same at the other side, coat the jig very liberally with marking off fluid so that the spelter will not adhere and silver solder together. Wash off, scrub away any excess flux, dry and then zinc spray to avoid rust; you can now assemble to drawing.

Bogie Bolster and Yoke

The bogie bolster was the last pattern organised for me by Norman Lowe before his promotion within BREL made great inroads into his lesiure time; I have a lot to be grateful to Norman for. Builders of sprung side control bogies will have to modify this casting and reposition it relative to the mainframes; the rest of you follow me.
Mark off and then chuck in the 4 jaw with the centre boss running true, turn same to drawing before taking a skim across the bottom face of the bolster itself just to clean it up away from the cast ribs; it is slightly raised for this purpose. Centre and drill right through at No. 9, turn the casting over to face across the top, then drill down and 'D' bit at $\frac{1}{2}$ in. diameter to within $\frac{3}{16}$ in. of the bottom of the casting. If this latter operation worries you at all, increase the thickness slightly and make the pivot pin longer to suit. The casting is so clean that we are only left with the side flanges to complete, so pack off the vertical slide table with 2 in. lengths of 1 in. square steel bar and secure with strongbacks. Now reduce the overall width to $4\frac{1}{4}$ in. and cut the $\frac{1}{16}$ in. recess to arrive at $4\frac{1}{8}$ in. overall, a vernier caliper dimension to suit the frames.
Ten 6BA bolts may seem rather sparse to fix the bolster to the frames, especially as the flange is deep enough for a second row, but I foresaw sufficient problems in specifying them to leave them off the drawing, that way I won't get into trouble with builders! By all means fit them if you have the courage, but don't blame me if you get into trouble.
Just the yoke to complete my part of this session, a lovely little casting, though minus the slides as an economy measure, they would have trebled the price! Rub a file over the flat surfaces where the slides will fit and cut them $1\frac{1}{4}$ in. x $\frac{3}{4}$ in. from 5mm brass plate; clamp in place and silver solder together. Pickle and clean, then chuck by the spigot provided in either the 3 or 4 jaw, face off at the bottom, drill through at 7/32 in. diameter and bore out at the bottom to $\frac{7}{8}$ in. diameter to suit the bolster. Grip in the machine vice, over the slides, and mill the swing link pin bosses to $\frac{1}{2}$ in. overall thickness, then grip by the latter, introducing packing to keep the centre boss clear of the jaws, to mill the slides to an easy fit in the bogie centre; too tight a fit here and you will be in big trouble on the track. Next grip by the bottom of the casting in the 4 jaw, set the chucking spigot to run true, then part it off and drill the top flange to $\frac{3}{8}$ in. diameter, lightly facing off. Back to the machine vice and vertical slide to drill and ream the swing link pin holes, when the bogie can be assembled to the mainframes, the swing link version anyhow.

MERLIN'S MAGIC

Having set Merlin Biddlecombe the exacting task of machining the first cylinder blocks for DONCASTER, over the Christmas/New Year period I rather upstaged him by sneaking into my own workshop, with results that you read about in LLAS No. 23. It was perhaps as well that I did this, for Merlin's notes did not arrive until 24 hours before we put the May issue together, so no way could they be included. I must say though that just as Merlin helped me sort things out over the telephone, so his notes will be invaluable to all DONCASTER builders, for they do show how a professional approaches this job; somewhat more effectively than my amateurish approach with the very limited time at my disposal, 2



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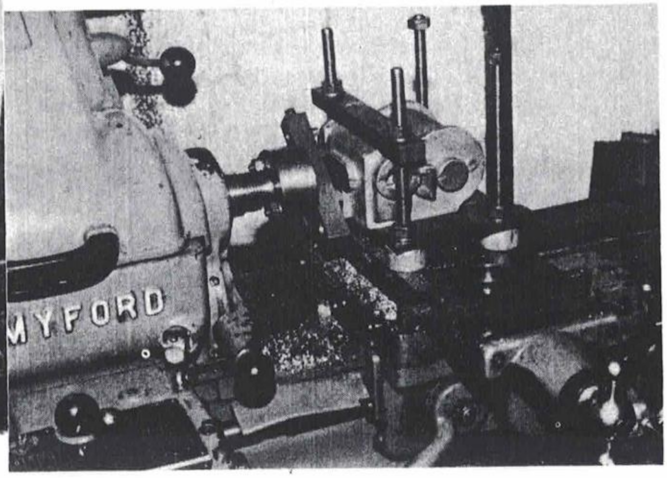

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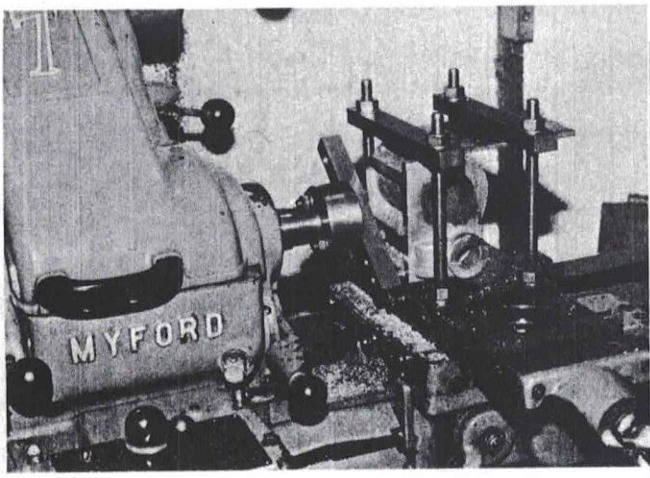

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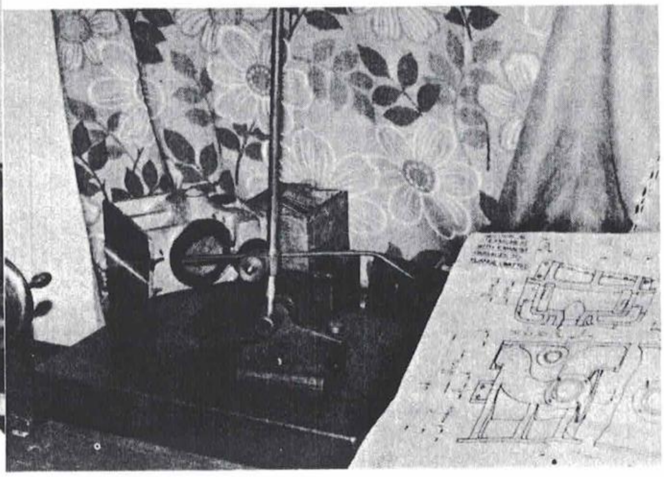

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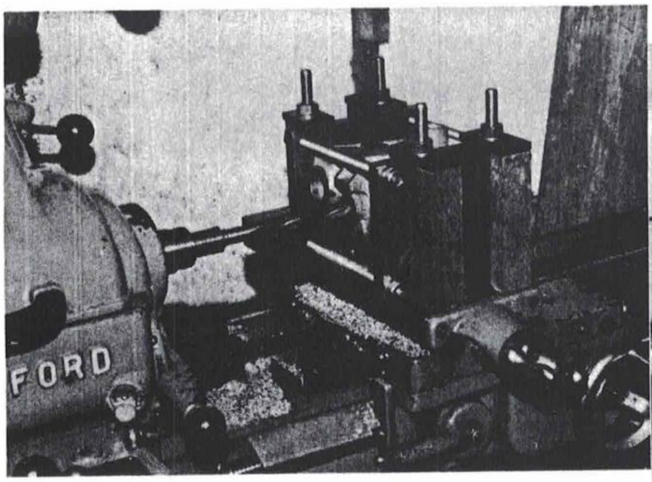

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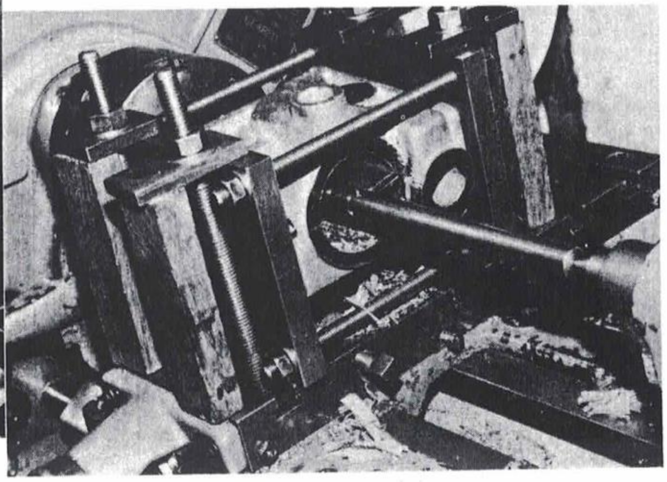


Merlin's Workshop: Views **1-3** are exercises in flycutting, being the inside cylinder bolting flange, top boss on outside cylinder and bolting face respectively. **4** Marking out the inside cylinder with a height gauge after machining the bolting faces. **5** Drilling and reaming the piston rod boss **6** Boring out the cylinder between centres.

and the very excellent photographs which he took as he progressed are worth thousands of words. Merlin has asked that I edit his basic notes into a form suitable for LLAS, though in truth there is little for me to do, and I reckon that with just a little training I could hand over this spot to him and sit back, or rather retire into the workshop and start my own DONCASTER!

Centre Cylinder

First file the base of the casting to be roughly square with the side flanges, but more importantly to be flat, then mark out with a scribing block or vernier height gauge to balance and centre the casting, remembering that the bore is $\frac{1}{16}$ in. offset from the centre line of the casting. Set up on the lathe saddle with suitable packing and clamping in place with strongbacks. In the days before the clock gauge, the old-timer turners used to do wonders with a piece of chalk, and although I don't claim to go back that far!, I do on occasion employ a good old-fashioned setting up technique which I call a 'sticky pin'. This consists of a length of $\frac{1}{16}$ in. rod ground to a very fine point and attached to the chuck face or mandrel nose with a lump of plasticine. It is of course a very sensitive means of lining up a face if a clock gauge is not available, when I was able to flycut the first side flange, taking it down to the scribed line. The casting was then reversed and aligned by clock gauge, though you can use accurate measurement or whatever else takes your fancy. If you have the luxury of a 4 – 5 in. micrometer, or 6 in. vernier calipers like Don, the final check is when the first cut has been taken on the second flange. The two side flanges having been machined to size, the cylinder can now be properly marked out, boxing in all the bores, holes, etc.

Whilst Don simply packed up his cylinder block direct from the boring table, another way is to sandwich the block between two plates and this is what I did for the prototype, when I was able to treat the whole as an assembly and set it to the required height on the surface plate. The plates I used were $\frac{1}{2}$ in. thick, size 6 in. x 4 in., drilled 11/32 in. diameter at 13/32 in. in from each edge and secured with four $\frac{5}{16}$ in. bolts which were 6 in. long. Once bolted to the cylinder block and the whole transferred to the surface plate, I set my height gauge, and it does not have to be the vernier variety, to the centre height of the lathe mandrel from the saddle or boring table; on my Myford Super 7 the dimension happened to be 2.082 in.; transfer to the surface plate and set the block from either end, tighten the bolts then transfer the jig and block assembly to the saddle, with gland end towards the chuck. I found the jig assembly just fitted between the first and third tee bolt slots on the Super 7, using $\frac{3}{8}$ in. bolts, 1 in. x $\frac{1}{4}$ in. plate clamps and outrigger spacers which were 4 in. high; the photographs which I took at the time should amplify my notes.

Using a clock gauge, check the inner edge of the $\frac{1}{2}$ in. plate by traversing the saddle, and when satisfied, tighten hard down. At this stage the boxing in of the holes becomes very useful. Lodge a 'sticky pin' in the chuck or mandrel nose and align the cross slide by rotating the mandrel, splitting the error on each revolution by adjustment of both sticky pin and cross slide until all error has been eliminated; set the micrometer collar to zero and lock the slide. Check again that all is well, it is an expensive casting!, then centre, drill and ream the gland housing to $\frac{1}{2}$ in. diameter; we are ready to tackle the main bore. For this I used a $\frac{1}{2}$ in. diameter boring bar that was 11 in. between centres, fitted with a $1\frac{1}{4}$ in. diameter x 1 in. long collar at about 5 in. from one end, this latter to house the boring tool. Actually machining the main bore requires little explanation, save that being a 'blind' one then some form of stop is in order; a clock gauge clamped to the ways and traversing to a zero at each pass is perfectly satisfactory. Do not forget though that if the boring tool is mounted at an angle within the collar, as mine was, that each time a cut is put on then a wee calculation is required to cover for its advancement, otherwise you could have a nasty crunch! Like Don, I found it extremely easy to arrive at a good finish for the main bore, this despite the apparent slenderness of the boring bar, which of course was saved by the restraint provided at the gland housing, indeed several builders who saw this cylinder at the Model Engineer Exhibition were encouraged by my result. Once the main bore is to the required size and finish, the next step is to machine the chamfer at the mouth, grinding a tool specially to the required angle.

Although I had no problem here with tool chatter, a floating steady about $\frac{1}{2}$ in. long, with outside diameter to suit the main bore and reamed centrally to suit the boring bar, entered into the bore just ahead of the tool would be sensible.

Don was a bit concerned about cleaning up the back end face of the bore and whilst we chatted on the phone, all sorts of ideas were dreamt up, none of which seemed to be either simple, or right. However, several days later it occurred to me to try a knife tool and fly cut it. I suppose the large area to be dealt with was off-putting, but it turned out to be an easy operation with not the slightest tool chatter. With my jigged assembly of course, it was easy to reverse the whole on the saddle and fly cut the front cover face, though I went to Don's favourite vertical slide. Bolted to the bottom slot of the table is a piece of steel size 4 in. x 4 in. x $\frac{3}{4}$ in. to act as an angle plate, I sat the cylinder block on this with the valve chest closest to me and used strongbacks over the top of the cylinder and the bottom of the plate to bolt firmly in place, when it was a simple matter to fly cut the cover face; again the photographs I took should be useful here to augment my notes. Do take care though not to break into the steamchest and here I estimated the .025 in. metal I left was just about adequate.

To machine the slide bar bracket, I stayed with the vertical slide, set the block on same with steamchest downwards and bracket towards the front, when an $\frac{1}{8}$ in. end mill chucked in the 3 jaw quickly produced the required result to scribed line. I guess I am gaining Don's approval by repeated use of the vertical slide, for by hanging the cylinder block from the top of the slide I was able to drill and tap the steam inlet; a glance at the photograph will reveal my set-up for this. At the same setting, I was able to deal with the exhaust spigot, this was machined with a left hand knife tool held in the 4 jaw chuck, two opposite jaws being used to vary the cut and arrive at the finished $\frac{7}{8}$ in. diameter. Then it was a case of borrowing a $\frac{7}{8}$ x 26T die to screw the spigot.

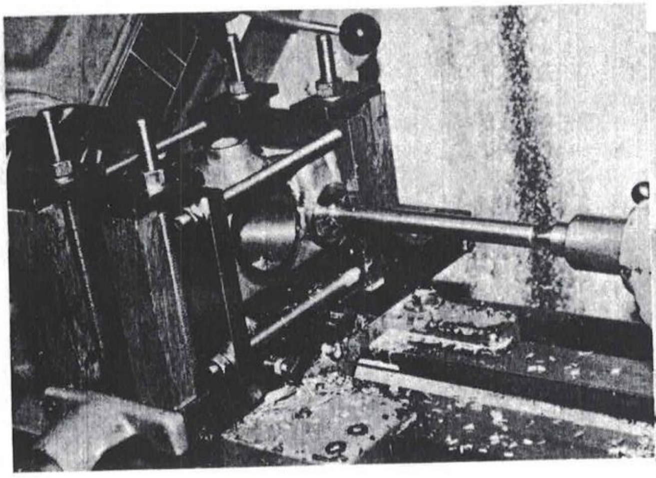
I have rather deliberately got the machining of the steamchest out of strict sequence because just like Don, he can be a real Jonah at times!, my original tooling proved inadequate and I too had to break down to make a $\frac{5}{8}$ in. boring bar, one that was 11 in. long, cross drilled $\frac{1}{4}$ in. diameter for the tool and tapped 4BA at 90 deg. to same for a grub screw. Setting up again on the saddle took an age, but I was rewarded when a uniform $\frac{7}{8}$ in. bore through the steamchest resulted in double quick time. To face the ends, I made a knife edged tool from $\frac{1}{4}$ in. silver steel rod as I will describe. Chuck the boring bar in the 3 jaw with the $\frac{1}{4}$ in. rod in place and face to give a flat at 90 deg. to the boring bar. File, mill, or simply rotate the tool in the boring bar, to machine again and to give a few degrees of top clearance; harden and temper to arrive at a tool which will face the ends of the steamchest. As I was still cautious after my earlier disaster with too flexible a boring bar, I turned up a floating bearing that was $\frac{7}{8}$ in. o.d. x $\frac{5}{8}$ in. bore and 1 in. long, I was taking no chances!, which was slipped into the steamchest bore close to the end that was being faced, that way I arrived at the desired end result. All I had to do now was open out the ends of the steamchest to

$\frac{15}{16}$ in. diameter, for which I made another and shorter knife edged tool. This tool I set against a cover face just machined, set a clock gauge on the lathe bed with spigot against the saddle, when I could traverse the carriage by exactly 15/32 in. to arrive at the correct depth for the valve liner spigot; in the end it was all very civilised.

Unless Don can find otherwise, we only have two machining operations to go, and here I must mention that I do not regard such things as drilling and tapping cover holes, those for cylinder drain cocks, etc. as machining operations. One operation which I almost overlooked is the chamfer on the inside of the gland housing to give clearance for the piston, and for this a tool was fashioned from a scrapped silver steel axle for a SPRINGBOX, though another way is to make and fit a wee tool to the $\frac{1}{2}$ in. boring bar after dealing with the main bore. The final and very important operation is to cut the passage between the front end of the main bore to the annulus in the steamchest which has been cast in, and thank goodness the patternmaker saved us having to cut that which Don specified at the rear end! For this operation I went back again to the vertical slide and turned the block to an angle which cleared everything, when it was a simple matter to centre and drill some $\frac{1}{8}$ in. holes, ones which could then be opened out into a slot with an end mill, or in my case an $\frac{1}{8}$ in. slot drill inserted into a extension holder.

The object of the exercise which Don set me was to machine the cylinders on my Myford Super 7, which I not only achieved successfully, but gained a lot of satisfaction in the process. As both my notes and photographs show, after machining what I call the centre cylinder, my confidence was such that I did not complete machining the matching outside pair, though I did square them up and then marked them out to check that all was well, when it would have been a simple matter to have repeated the operation used on the middle cylinder, though without the bother of that 7 deg. angle between main bore and steamchest. I would have liked to have completed what I had set out to achieve, but Don had loaded other and more urgent work upon my plate, and as he has broad shoulders, I can blame him for the fact that my notes peter out!

What I would say though is that neither I, and I am sure this applies equally to Don, would claim that the methods that we have described are the best ones available to builders of DONCASTER. I am equally sure though that after reading our notes and looking at the photographs, other and better ways can be found to achieve the same end result, especially if milling machines and boring heads are available to the builder; it will be easier too when Don changes his requirement that everything he describes has to be within the capability of the Myford ML7 or Super 7; roll on the 254S! To conclude, if one builder or reader finds just one of my ideas of use, then the time spent will have been very worthwhile, now back to Don.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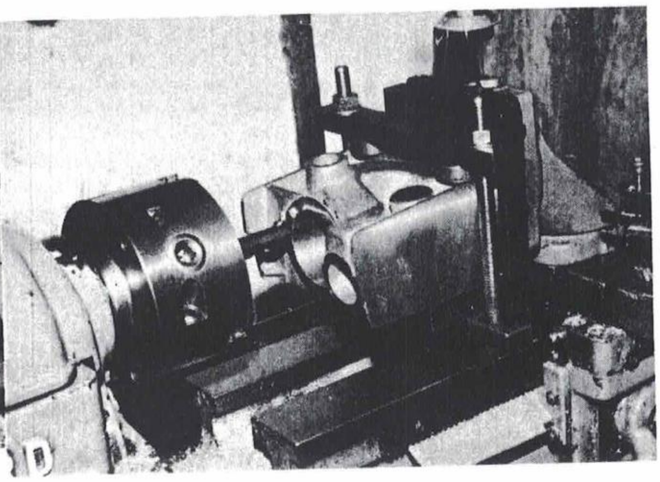
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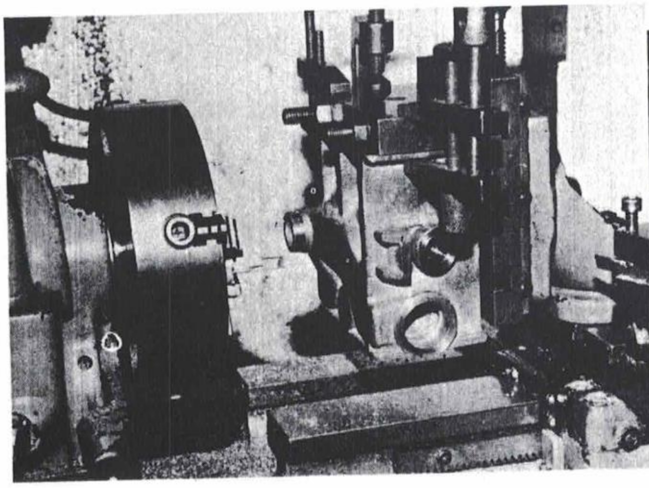
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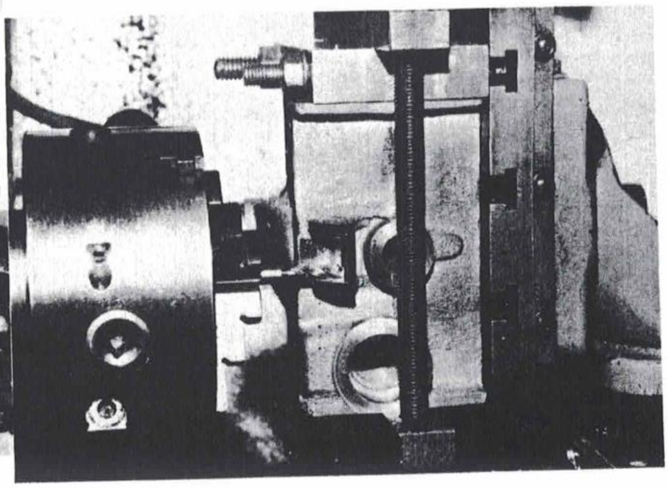
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7 Boring out the steamchest, again between centres. **8** Machining the end of the main bore with a knife tool. **9** Cutting the exhaust boss on the inside cylinder; that on the smokebox saddle can be dealt with similarly. **10** End milling the slide bar housing on the inside cylinder, the easiest of the three! All photographs by Merlin Biddlecombe.

Doncaster — a 5in. gauge Gresley A1/A3 'Pacific'

by: DON YOUNG

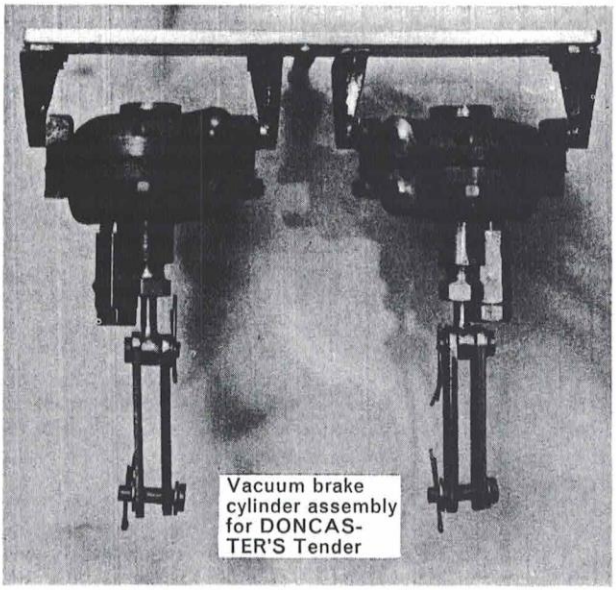
Part 8 – Erecting the Frames

By the time this session is complete, our frames will be erected and we can try the boiler in place. Bill Holland has already got that far and reports that all is well, which is all the encouragement I need to press on!

Front Buffer Beam Assembly

Although the beam assembly complete with buffers is a rather complex one, it does at least kick off on a simple theme with the beam itself, so square off a $9\frac{1}{8}$ in. length of $\frac{1}{8}$ in. or 3mm thick material that has been reduced to $1\frac{9}{16}$ in. width, scallop the ends as shown, drill all the holes as specified and rivet on $2\frac{1}{4}$ in. lengths of $\frac{1}{4}$ in. x $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass angle. Next bend up two pairs of gussets from 1.6mm steel, silver solder the corners for the extra strength this provides and mill the flanges if necessary to be square. Each side of the coupling hook are two pairs each of three holes and the gussets are rivetted to the beams by way of said holes, with faces $4\frac{1}{8}$ in. apart. Beam edge stiffeners use more $\frac{1}{4}$ in. brass angle, so cut 90 deg. notches in one face and bend up to the dimensions shown. If you have any problem in arriving at the $4\frac{1}{8}$ in. dimension when dealing with the the second end, make up in two pieces, silver soldering the joint between them is then optional, when you can rivet them to the beam; already the assembly is becoming impressive, though I think you will agree that use of channel section for the beam itself full size would have been both stronger and cost effective?

Stiffening the beam outside the mainframes are the pair of massive buffer spring housings, castings in full size, but ours will have to be fabricated on a question of expense. Although on the drawing I state they be made from 2.5mm thick material, I suggest now that I come to describe them that you first take a $5\frac{1}{2}$ in. length of 1 in. x $\frac{1}{8}$ in. flanging quality strip, bright steel will crack, and bend it up to form the sides of the 'box'. Make it 1/32 in. bigger all over, then when you machine to drawing the rounded corners will disappear.



Vacuum brake cylinder assembly for DONCASTER'S Tender

Although you won't be able to machine just yet, offer up to the beam and cut the scallop to suit the bottom corner; now you can bend up the top and bottom plates to be a tight fit, when only a little packing will be required to hold them firmly in their correct positions. There are a couple of wee $\frac{1}{16}$ in. ribs top and bottom to complete the structure, then drill through on the back face at No. 27 and bolt a $\frac{3}{8}$ in. diameter x $\frac{1}{16}$ in. thick steel washer in place to represent the boss, or alternatively turn up a stepped one and press it home; braze up. Wash off in warm soapy water, clean all the excess flux away with an old toothbrush, dry and zinc plate from an aerosol can to prevent rusting; machine to drawing. In structural engineering a much stronger high strength friction grip bolted joint can be obtained if the mating metal surfaces are zinc coated and the same practice has much to commend it in miniature.

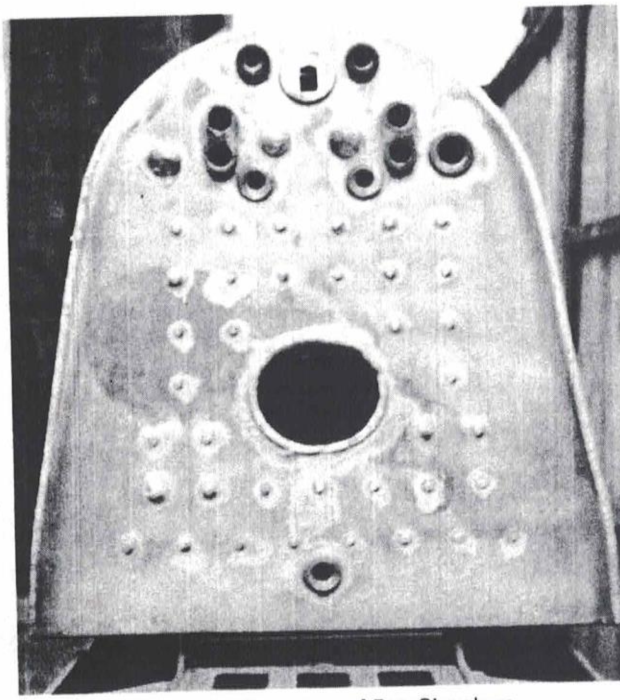
Offer the buffer spring housings up to the frames and beam to drill all the fixing holes and we can turn our attention, literally!, to the buffers. I know my good friend Ron Kibbey is going to chide me for the lack of a sub assembly of the buffers, but for once something is going to be easier for me to describe than draw, so let us make the piece parts as a first step.

Material for the buffer stocks is either $1\frac{1}{4}$ in. square or $1\frac{5}{8}$ in. diameter steel bar, so chuck in the 4 or 3 jaw as appropriate and face the end before centering and drilling 13/32 in. diameter to about $1\frac{1}{4}$ in. depth. Open up to $\frac{13}{16}$ in. diameter to $\frac{3}{8}$ in. depth, you will probably have to complete this by boring, then match the two bores with a 55 deg. chamfer as indicated. Lightly scribe the bolting circle at $1\frac{1}{4}$ in. diameter then part off at a full 1 in. overall. Reverse in the chuck, gripping by the $\frac{13}{16}$ in. bore, to turn down the outside to the detail dimensions, then bolt to the vertical slide table to mill the flange to 1 5/32 in. square. Mark off and drill the four No. 44 holes and radius the corners of the fiange to complete the stock. The back plate is from 2mm plate; clamp to the stock, drill through the No. 44 holes, fit bolts and profile the backplate to match the stock, then complete with a 9/32 in. hole through the centre. The stem is plain turning from $\frac{7}{8}$ in. diameter free cutting steel bar, to a nice sliding fit in the stock.

It is very tempting to turn the shank of the buffer head from $\frac{5}{16}$ in. steel rod and then either weld or braze the head to same, the latter a $\frac{1}{4}$ in. slice from $1\frac{3}{8}$ in. diameter bar, then grip in the 3 jaw by the 17/54 in. diameter shank to turn the head to size, though machinists may prefer to start with a $3\frac{1}{2}$ in. length of said $1\frac{3}{8}$ in. diameter bar and fill the swarf bin!

There are an awful lot of spring plates and probably the easiest way to deal with them is to part them off from round bar of the appropriate size, rather than cutting from sheet and then turning to size in multiples. Some kind person is going to tell me the source of rubber buffer springs to save my embarrassment, just as for the shock absorbers earlier on, but I do know the humble tap washer is from too hard a grade of rubber; something a little more flexible is required here. Full size the buffer springs and plates were bonded together, indeed the rubber was specially moulded and we knew them as 'Spencer Springs', but such is purely optional in 5 in. gauge.

To assemble, first insert the buffer stem from the rear of the stock, followed by a, large, buffer spring, a plate, and spring and another plate, then finally a spring; temporarily bolt the



An impressive backhead courtesy of Reg Chambers

backplate in place. Slide in the buffer head, enter it in the spring housing through the beam and feed on springs and plates to fill the space to the back plate of the housing. Bolt stock and backplate to the beam, tapping the latter 8BA, then feed the buffer head through the rear of the housing and secure with a couple of 4BA thin nuts. The 7/64 in. diameter spigot at the very end of the buffer head is to accept a 3/64 in. split pin– drill this to place.

The action of the buffer is that the spring in the housing acts first, then as extra loading is added the buffer head comes into contact with the stem and brings the housing spring into play. Although it was rather sophisticated, when 500 tons of train and 160 tons of engine/tender ran into anything, like the buffer stops at Kings X, engine buffers were rather a waste of time.

2:1 Gear Stay

Moving aft, very quickly we arrive at the 2:1 gear stay which is another fabrication, and quite a sturdy one. I suggest you make the end plates from 5/32 in. (4mm) thick steel to provide a machining allowance after fabrication, so cut these plates out first and you can produce the cut-out at this stage if you like to match the frames, then it will position the two diaphragms. Before cutting out the latter, cut the front plate $3\frac{7}{8}$ in. long from $1\frac{3}{8}$ in. x $\frac{1}{8}$ in. flat, and the back stiffener from 1 in. x $\frac{1}{8}$ in. flat, blending the ends as shown; now deal with the diaphragms to sit neatly between. Drill $\frac{7}{16}$ in. holes for the fulcrum bushes and turn them up to be a press fit, drilling centrally at 5.5mm; cut the three slots in each diaphragm. At the top there is an $\frac{1}{8}$ in. square stiffener bar right across and to complete the structure there are two wee webs to give support to the fulcrum bushes. To hold the bits together for brazing, I would use 8BA round head screws, tapping into the ends of the plates, when the whole can be silver soldered together, cleaned and then zinc coated. Ream the bushes as the first step in machining, then mark back to the end plates and machine in turn to $4\frac{1}{8}$ in. overall, keeping the fulcrum in its correct position. I would recommend this stay be one of the last to be erected to the frames; get the main stays into place first.

Motion Plates

I came up with a round turn at this point, for when I picked up the sample castings it was to find they differed somewhat from the drawing detail, so obviously I had not kept the patternmaker up to date with my drawing alterations. No harm has been done as the pattern can be readily modified, as it has been between the time of penning my rough notes and typing them up, plus the castings already produced will suit A4's, though I will have to amend my description as well, for instead of being cast in pairs they are now singles.

Pack up in the machine vice to be level, mill the frame fixing face, then use the side teeth of, say, a $\frac{5}{8}$ in. end mill to deal with the slide bar foot. Use the side teeth again just to clean up the edges of the frame fixing flange, then reverse in the machine vice and deal with the wee step to accept the valance. Mark off and drill the slide bar feet and personally I would leave the frame fixing bolts until the cylinders and slide bars have been erected, then there will be no need to worry about shims. All you have to do now is tidy up with files and judging by the earlier castings there will be very little to do here.

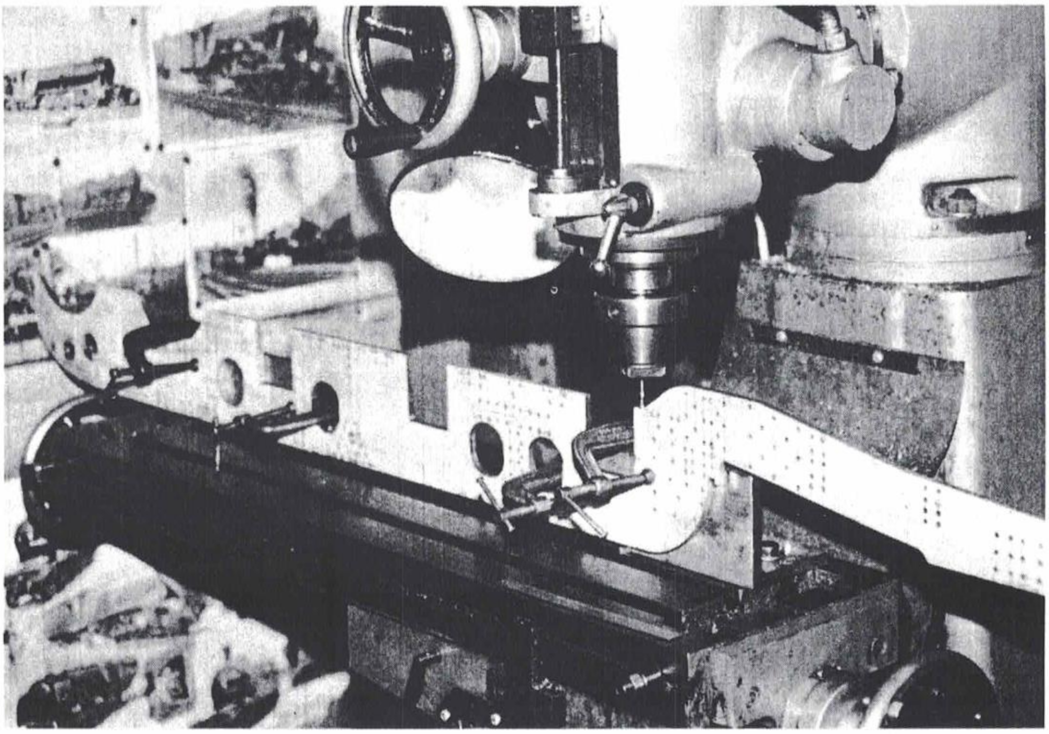
The inside motion plate did check out to drawing, although it took me a couple of weeks to pluck up courage to go on. The pair of lightening holes allow us to bolt this motion plate directly to the vertical slide table, though packing out from same to avoid damaging the machined surfaces, when the end flanges can be milled to $4\frac{1}{8}$ in. overall. Actually there are more dimensions on this detail than machining operations!, for all you have to do now is grip in the machine vice, set to the cast face for the slide bar and just skim it; all frame holes can be dealt with on erection.

Frame Stay

The frame stay is cut out and bent up from 2.5mm steel sheet and then if you are building a very early A1 version reduced to $\frac{11}{16}$ in. width over the central portion. Grip in the machine vice to mill the end flanges to $4\frac{1}{8}$ in. overall when again the fixing holes can wait until later on in the proceedings. At this juncture the '1 or 2 off' will remain a mystery, but I can tell you it is tied up with the need for additional stiffening of the mainframes in that area, plus a change to higher capacity sand boxes to allow for the non-stop runs between Kings X and Edinburgh in inclement weather.

Vacuum Cylinder Stay and Bracket

Moving slightly forwards on the engine and to the bottom L.H. corner of Sheet 8, we come to the vacuum cylinder stay; one we can actually hang something on when complete! Start with a bare $3\frac{7}{8}$ in. length of $\frac{7}{8}$ in. x $\frac{1}{8}$ in. BMS strip and cut two identical lengths from $\frac{1}{4}$ in. x $\frac{1}{4}$ in. x $\frac{1}{16}$ in. brass angle to sit on same as a stiffener. End plates are fashioned from the same $\frac{3}{4}$ in. x $\frac{1}{8}$ in. flat and clamped in place, when we can give attention to the centre stirrup. Take a length of $\frac{3}{8}$ in. x $\frac{1}{16}$ in. steel strip and bend it around a piece of 5/32 in. rod, trimming off to the $1\frac{5}{16}$ in. dimension, then cut stiffening webs as shown, clamp in place and braze up; wash off, clean and zinc spray. The only machining is the end plates, when we can move on to the cylinder brackets. Turn up the bearings from $\frac{1}{4}$ in. rod, you can use brass or bronze here if you prefer, then cut and shape the backplate to drawing; braze up. Offer up to the mainframes, drill and tap the holes, when we can try the vacuum cylinders in place. Engage one of the fulcrum on each in the centre stirrup, feed on the cylinder brackets and lift the whole up between the frames. Once the cylinder brackets have been attached the position of the cylinder stay becomes obvious, and although it should not be attached to the mainframes just yet, you now know what to do when the time comes; it will not be long delayed.



As with Merlin Biddlecombe's photographs showing machining of the middle cylinder in LLAS No. 24, this shot of mainframes receiving attention in Bill Holland's workshop is worth 1,000 words

Expansion Link Bracket and Weighshaft Bearing

For absolute authenticity, these two details apply to GREAT NORTHERN only as built, they must have been found wanting very early on, which is very strange when it is realised that both Gresley, and later Thompson designs, reverted to same. Basically the alteration was to extend the inside bearing plate on the expansion link bush back to the weighshaft and make the latter bearing integral; this will become clear when we reach the later detail on Sheet 9. Most of the description is common to both types, so there will not be too much repetitive description; I can deal with the major portion here.

There is much satisfaction in creating such a lovely fabrication as this, plus although it does look complex it does break down into fairly simple piece parts, the first thing being to decide the critical features and method of construction. A very substantial building base is required, a 5 in. length of 2 in. x $\frac{1}{2}$ in. BMS flat. Scribe a line along a 2 in. face at $\frac{5}{8}$ in. from one edge, then at about $\frac{3}{4}$ in. from one end and on this line, centre, drill and ream through to $\frac{5}{16}$ in. diameter. Do this in the machine vice on the vertical slide, or alternatively bolt directly to the vertical slide table, when you will be able to move on exactly 2.844 in. on the cross slide to drill and ream a second hole to $\frac{1}{2}$ in. diameter; fit 3 in. lengths of steel rod in each hole. One of the beauties of fabrication work is that done properly, very little machining is required afterwards, in fact the only slightly different pair that I made for my LNER Class K1/1 'Mogul' required none at all, which is what I am proposing again here, when the base can be cut from $\frac{1}{8}$ in. or 3mm steel sheet to the drawing dimensions. Offer up to the frames, get the weighshaft centre lines to coincide, then deal with the fixing holes before drilling back and reaming for the weighshaft bearing. Sit over the $\frac{1}{2}$ in. rod on the building jig, then drill and tap a couple of 6BA holes so the plate will not move. Next turn up the expansion link bearing housings to be $\frac{9}{16}$ in. o.d. and $\frac{3}{16}$ in. thick, bores being reamed to $\frac{5}{16}$ in. diameter. We now have to space the housings correctly on the $\frac{5}{16}$ in. rod, for which I suggest $\frac{3}{8}$ in. o.d. x 22 s.w.g. copper tube be employed, one piece obviously being 17/32 in. long and the other I calculate at 1 13/32 in.; thread these on.

The rest of the pieces are simply there to hold the bearing housings in their correct position, so let us hurry on.

Cut the top plate $3\frac{5}{8}$ in. x $2\frac{1}{8}$ in. from $\frac{1}{8}$ in. or 3mm plate initially and use odd scraps of angle to clamp it in place ready to accept the bearing brackets. These latter have beaded edges which can be added separately, though I have found it much easier to have them integral, in which case we need two pieces of 4mm thick plate, size $2\frac{1}{2}$ in. x $1\frac{1}{2}$ in. At 1 1/32 in. from one of the longer edges and about $\frac{3}{8}$ in. from one end, centre pop, clamp together as a pair and drill a $\frac{9}{16}$ in. hole right through; this is the bearing datum. Offer up to bearing and top plate to mark out the profile, which can best be sawn and filed to line, then mark off the lightening hole in the centre, drill around the profile, break out and again file to line. Grip in the machine vice, using a wedge shaped piece of packing to support the 15 deg. edge, and with a $\frac{1}{4}$ in. end mill, preferably one with the corner of the teeth honed to a slight radius, carefully mill by eye to reveal the $\frac{1}{16}$ in. beading. Now you can cut the top plate to drawing, but with a $\frac{3}{16}$ in. wide strip extending to include the wee rear bracket; surplus material we can cut away after brazing.

Two more pieces to make, the first a $1\frac{5}{16}$ in. square from 2.5mm sheet and bent to $3\frac{11}{16}$ in. radius to match the front edge of the frame fixing flange. To complete we need a triangular piece which is then scalloped to $\frac{11}{16}$ in radius as shown, this to stiffen the piece we have just added back to the frame fixing flange.

Coat the jig with marking off fluid so that any stray spelter will not adhere, cramp all the pieces firmly in place, mix flux to a stiff paste and seal all the joints to prevent oxidation, then heat rapidly and apply Easyflo No. 2. Wash, clean off all excess flux, then saw away the surplus metal before zinc spraying. Check the assembly by erecting on the jig once more, correcting any wee error by judicious tapping with a wooden mallet, when no further machining should be necessary. The weighshaft bearing is plain turning, with three wee ribs brazed on, when a little later on you will be able to erect and try a length of $\frac{5}{16}$ in. silver steel rod for alignment before completing all the fixing holes.

Star Stay

We now come to the major fabrication which is the kingpin of all Gresley and indeed all the LNER 'Pacifics', the massive star stay. Cut the upright member first a bare $3\frac{7}{8}$ in. long from 3 in. x $\frac{1}{8}$ in. steel flat, with ends perfectly square and including the lightening holes. Next cut the end flanges to drawing from 4mm or $\frac{3}{16}$ in. plate. On the centre line of the brake hanger pin, and do remember to cut the relief in the vertical member for same, drill four No. 44 holes at approximately $\frac{15}{16}$ in. pitch, offer up to the vertical member, spot through, drill and tap 8BA for round head screws. At top and bottom we need a strip 25/32 in. wide and 2.5mm thick, which has to be waisted down to $\frac{7}{16}$ in. over the centre portion; if this is made a tight fit between the end flanges then no other fixing will be necessary. Next cut the pair of horizontal members, the scallop being roughly 2 21/32 in. radius, though you can best check this to place to get a decent joint with the $\frac{3}{16}$ in. x 3/32 in. edge beading to complete; braze up, clean and zinc spray.

The end flanges have to be machined to $4\frac{1}{8}$ in. overall and I would dog the fabrication to the faceplate, lightly centre the flange at the outer end and support with the tailstock to face off; reverse and repeat.

Boiler Stay

Immediately below the star stay detail is that for the boiler stay, a right little pig! Start with a $6\frac{11}{16}$ in. squared length of $\frac{3}{4}$ in. x $\frac{3}{4}$ in. x $\frac{1}{8}$ in. steel angle and reduce the section to $\frac{5}{8}$ in. x 9/32 in., which means a lot of metal has to be removed. Cut slots in the 9/32 in. face to accept either 5/32 in. or $\frac{3}{16}$ in. end flanges, just like the standard LBSC buffer beam construction, then deal with the horizontal member from $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. flat, to include the five lightening holes. All we have to do now is complete the 'star' section with lengths of $\frac{1}{4}$ in. and $\frac{1}{2}$ in. x $\frac{1}{8}$ in. strip to arrive at the shape shown, when we can braze up, clean and zinc spray. Now we have to machine the end plates and slots to accept the double thickness of the frames, for which it is easiest to bolt the stay directly to the vertical slide table, through the lightening holes, and use a large end mill for the majority of the flanges, changing to a $\frac{3}{16}$ in. long series one at the cut-outs. Snape the ends of the angle as shown when we can make a start on the outriggers.

Outrigger

Cut out the main shape from 1.6mm steel sheet, drill this and the boiler stay $\frac{1}{16}$ in. diameter in six positions as shown and then use 10BA bolts to assemble temporarily. Although you can cut the little facings to accept the valance, delay brazing same in place until the valance is made and ready to erect; you will have to check the whole assembly against the boiler too, as the latter may well have 'grown' during manufacture.

Drag Box

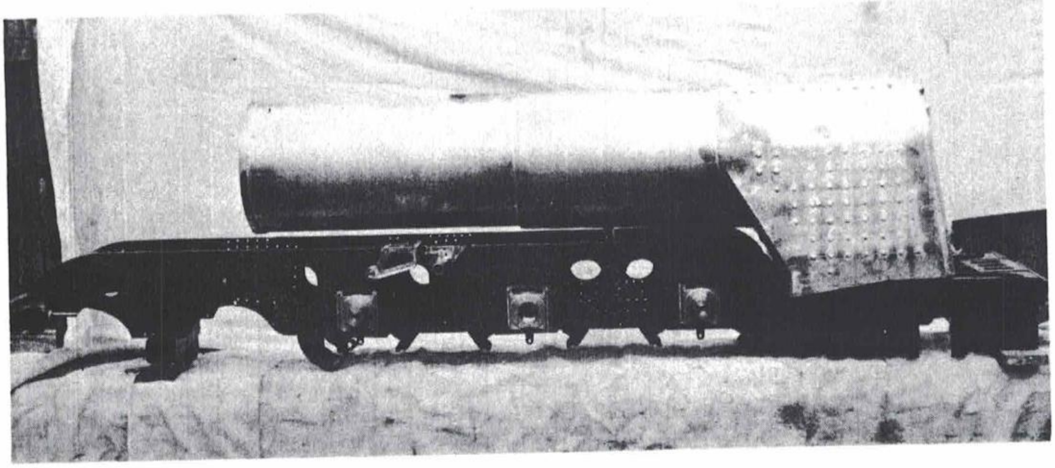
To gain maximum enjoyment from any project, one has to be in sympathy with the designer and to date builders approve of the mixture of steel fabrications, with use of castings confined to where they make a useful contribution. Of course, something that helps any cause enormously is the quality of the drawings, all due to tracer Helen; we have worked together in industry and in the cause of my designs for almost 30 years now and it is a great feeling to have my very ordinary pencil originals turned into works of art. Helen has not been too well during the DONCASTER project, but such has not shown in her work, other than the time taken to complete tracing the complete set. But I think you will agree that all good things are well worth waiting for, though I must in return thank builders for their patience.

On with the drag box, our last major fabrication in this session, and a most interesting one. Start with the pair of intermediate horizontal members, dealing first with the profile, then the lightening holes and finishing up with the $\frac{7}{16}$ in. hole for the drawbar pin housing. Turn the latter up from $\frac{1}{2}$ in. rod in two pieces to be a press fit in the plates, but before pressing home, cut the front plate of the box and slide into place. Deal with the backplate next and secure to the horizontal members with 8BA round head screws for brazing, then add top and bottom plates, with matching lightening holes, again screwing into place, then make the side flanges to sit between. At the front end we need a length of $\frac{7}{16}$ in. x 3/32 in. steel strip to fill between the intermediate horizontal members, so bend to suit the drawbar pin housing and then cut to suit the front plate of the box. There are webs between the housing and front plate, also a pair inside the box, so cut and fit these in place. There are also wee gussets at the very front of the housings, hardly big enough to worry about but included for authenticity, when the whole lot can be brazed up, cleaned and zinc sprayed.

Chuck in the 4 jaw and take a very light skim across the back of the box, then deal with the side flanges to be $3\frac{1}{2}$ in. overall. The rubbing plate is from $\frac{1}{8}$ in. or 3mm steel flat and screws to the back of the drag box, round heads being used to represent rivet heads, so fill the slots with plastic metal or similar.

Frame Erection

Although personal preference would be to wait until the crossheads and slide bars have been fitted to the cylinders, so that the motion plates can be aligned, the crosshead detail is on Sheet 9 and it is past time the frames were assembled, so that we can see what DONCASTER really looks like. We shall need a lot of clamps to hold the pieces in place, which I make up as required from $\frac{3}{8}$ in. x $\frac{1}{8}$ in. steel flat, bending into a horseshoe shape and tapping one leg 2BA for



Reg Chambers boiler married to Bill Holland's chassis – I guess the caption must read IT FITS! !

a bolt; you simply make them up to suit the job, something commercial ones seldom do, though I do have a pair of Record ones from way back that come in extremely useful at times. Anyhow, assemble as per Sheet 7, check for squareness and flatness in as many positions as possible, the ultimate check being the coupled wheel and axle assemblies, plus a length of $\frac{5}{16}$ in. silver steel rod to represent the weighshaft. Once satisfied, you have literally hundreds of holes to spot through, drill and tap as specified, plus a host of special bolts to make for absolute authenticity; for a change I can create weeks of work with just a single sentence!

Intermediate Boiler Stay

As the boiler has already been completed, try it in place before proceeding too far with the frame erection, checking its fit particularly to the boiler stay, also the rear one, when we can tackle the intermediate 'stool' to suit the block brazed to the bottom of the boiler barrel.

The intermediate boiler stay is basically an 'I' beam with end plates and I recommend you make it $\frac{7}{8}$ in. deep initially with top and bottom flanges $\frac{1}{8}$ in. or 3mm thick. The end plates similarly should be from 5/32 in. or $\frac{3}{16}$ in. plate; add the stiffening webs if you like and then braze up, clean and zinc spray. All machining work can be carried out in the 4 jaw, or use machine vice and vertical slide to mill the faces, getting the depth of beam so that it properly supports the boiler without the need for shims; fasten to the frames.

Trailing Frames

Regrettably I only managed to squeeze about half the details for the trailing frames onto Sheet 8, the remainder will appear next time, so we can only go part way to complete this assembly.

For the frames themselves we need two 11 in. lengths of $3\frac{1}{2}$ in. x 1 in. steel flat, same quality as the mainframes. Get the top edge nice and flat, then square the front edge to it before adding the bending lines. Achieve the $1\frac{1}{16}$ in. set as the next step, sitting on the lathe bed and using vernier calipers to check same, then mark out to drawing. The front part of the frames at least have to be marked out individually, so pack them up so that you can use a scribing block to deal with the sloping portion to match the ashpan; be prepared to adjust here later on, including chamfering the edge if required, as the fit will be a very tight one. Profile the front of the frames, when you can decide for the main portion whether to deal with them individually, or as a pair; whatever your decision it is a question of profiling and drilling holes. Reference the latter for the Cartazzi horns, because the castings have wee bosses cast integral as for the main ones, you may prefer to drill the frames back from the horns, especially as the end result is well and truly exposed.

Stiffeners and Drag Beam Ends

Stiffeners next and I would bend up the main portion from a length of $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. steel flat to be $1\frac{7}{16}$ in. overall, add the webs and then braze up. Now it is a question of machining the three main faces to arrive at $1\frac{3}{8}$ in. width, when most if not all of the radius at the corners will disappear. Separate the mainframes, something we shall be doing quite often yet awhile!, to drill back the nine No. 34 fixing holes, then deal with the group of holes similarly at the front end of the trailing frames. Re-erect, bring up the trailing frames, drill and fasten to the stiffeners.

The drag beam ends, $2\frac{15}{16}$ in. finished lengths from $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. BMS flat, now fit flush with the drag box backplate, when after snaping and drilling to drawing, it too can be attached.

Trailing Frame Stay and odd details

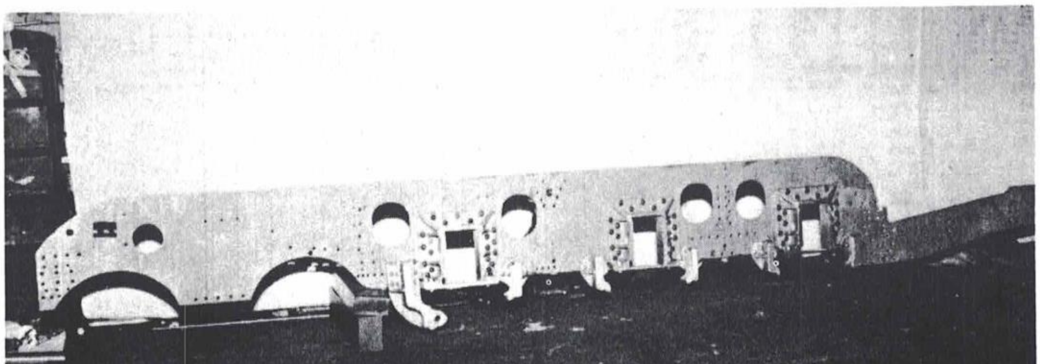
Bend the trailing frame stay up from 1 in. x $\frac{1}{8}$ in. steel flat to a little over $6\frac{1}{2}$ in. overall and either mill or turn the ends to be a good fit between the frames, when it too can be attached. If you were attentive then you would have made the spring buckles, hanger brackets and shock absorbers for the trailing axle at the same time as the identical tender details, otherwise you will have to set up again now.

Weighshaft and Slide Bars

The remaining details on Sheet 8 in the top R.H. corner are what I term 'mechanical' ones against the structural ones we have been dealing with thus far in this session, and as for the trailing frames I cannot progress them all to completion.

Although detailed to be authentic, I doubt if all weighshafts will finish up exactly to drawing. The problem will be to get the 7/32 in. squared portions exactly aligned when they are about 8 in. apart; it is easy to deal with them individually, but not as a matched pair to ensure the lifting arms are exactly in line, as they must be. The alternative though is both simple and foolproof, hidden by the end nuts, though there is much satisfaction if the hidden detail is also correct, and for this reason it is worth trying to achieve it before giving up and taking the easy way out.

First square off an $8\frac{7}{8}$ in. length of $\frac{5}{16}$ in. silver steel rod, reduce to $\frac{3}{16}$ in. diameter over a 11/64 in. length at each end and screw 40T. Erect the vertical slide with table along the lathe axis, instead of across it as normal, then attach the machine vice. Grip the embryo weighshaft in the latter, it too along the lathe axis, checking this by winding the carriage along with a d.t.i. against said weighshaft, then with a $\frac{1}{4}$ in. end mill, tackle the first flat until the micrometer reading over the bar shows .266 in. Move on to the opposite flat and remove the same amount of metal, when the micrometer reading will be .219 in. if my arithmetic is correct; repeat for the other pair of flats to complete the square.



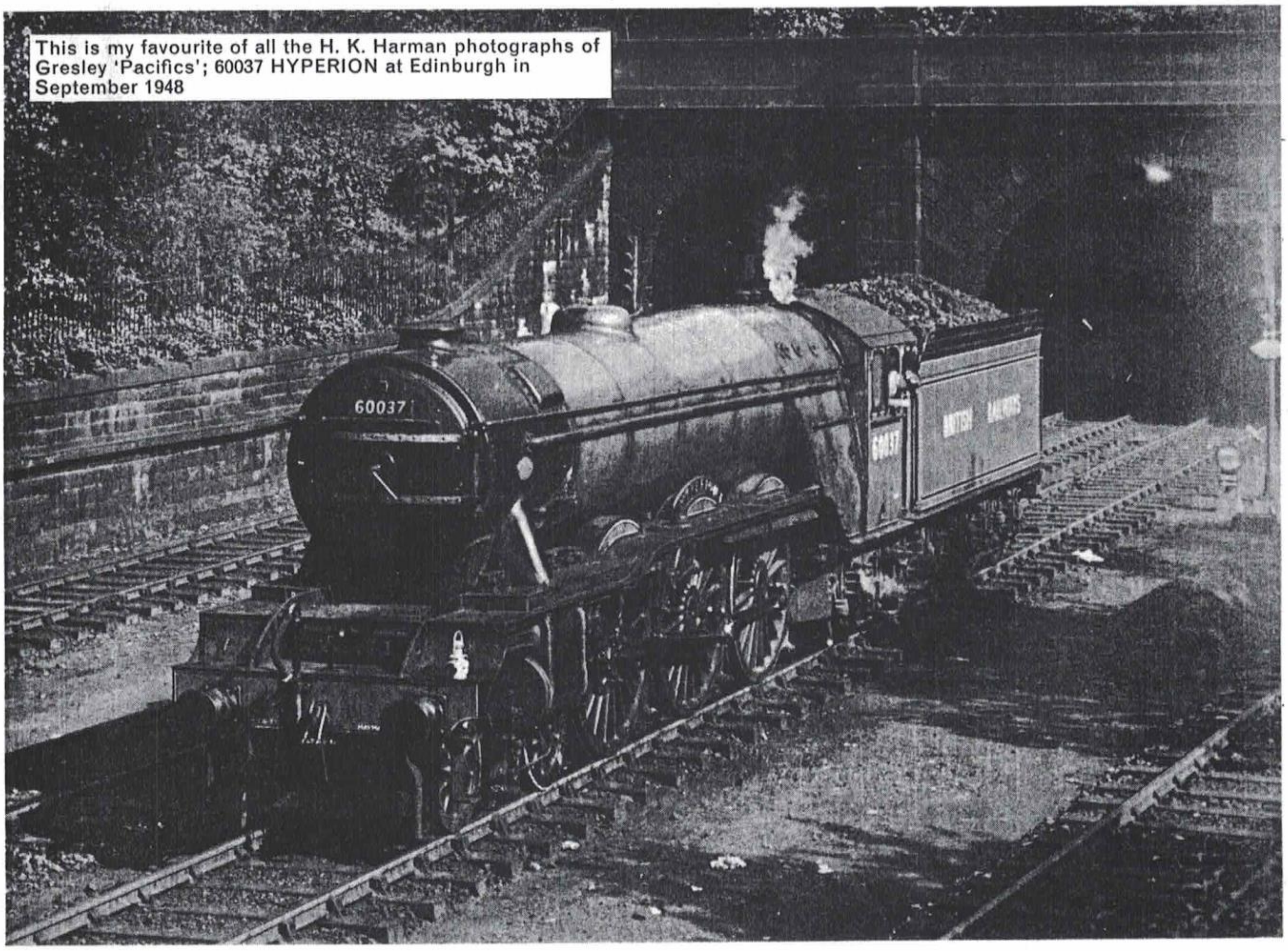
Bill Holland's frames suitably adorned with horns, spring hangers and brake-shaft trunnion

Turn the bar end for end, set it true again and use an engineers square off the lathe bed against the machined square to correctly orientate it, this is where any error will creep in, then machine the second square. If things do not work out, change my specification from 7/32 in. square to 1/4 in. diameter, the lifting arms being altered to suit, when all that is required on assembly is an 1/8 in. taper pin through the pair and then filed off flush at both sides, when nobody but you will know the difference!

A supplier who gave me satisfactory service over many years, when I was building instead of describing steam locomotives, is K. R. Whiston of New Mills, Stockport; indeed it has been my biggest disappointment that I was unable to retain their advertising in LLAS, for it would surely have paid handsome dividends by now. One of the products in which they then specialised, and I expect this continues to be so, is sections of chrome vanadium steel, known commonly as gauge plate, which I have found ideal for motion work. Because of its strength, I think of it as being 'tough', it has allowed me to design and make valve gear parts that are closer to scale without the risk of their failure, and being supplied ground all over firm datum are readily established. The slide bars on my LNER Class K1/1 'Mogul' came from this source, the top ones only requiring to be squared off to length and holes drilled in same, so I hope you are equally fortunate. All holes are I believe self-explanatory, save for the 5/32 x 40T tapping which is for oil supply from the mechanical lubricator; harden out the top slide bars to the instructions supplied with the material if you wish, though they will last a long time in the 'as supplied' condition.

For the bottom slide bars I pondered long and hard on my K1/1. I wanted the superior quality of the chrome vanadium steel, yet I could not bend it. In the end I sacrificed hardening it and brazed lumps of mild steel on at the front end, shaping this to drawing, and this has stood the test of time. To be fair to one of my main supporters over the years, the Alladin's Cave at Marston Green, Reeves of course, they do stock gauge plate in pieces 9 in. x 2 in. and various thicknesses which of course will be very suitable for our purpose, which in turn reminds me that the 'Trade News & Reviews' section of LLAS has rather fallen by the wayside of late through a lack of information from our advertisers.

The packers between top and bottom bars at their outer ends are again self-explanatory, though you may well have to ease them in the centre to gain clearance for the connecting rod, something you can check out to place. The bolts are plain turning, with lengths checked to place, especially where they pass through castings, which almost brings this session to a close. Before doing so though, when Tom Greaves first saw my drawings he pointed out the lack of shims between top and bottom slide bars, specifically at the front end. Now I believe in a minimum number of piece parts, particularly when they can work loose, so my shims are integral with the bottom slide bars, hence that wee step at the front end. By all means introduce brass shims here if you wish, they will gain Tom's full approval and want to be roughly 1/32 in. thick to look right, but experience with the K1/1 has proved that the details as drawn work best and that is why my specification is so precise in this area, including use of high tensile steel for bolts, arrived at independently, but with the full approval of that exceptional craftsman Bill Carter of GN 'Atlantic' fame, but I must stop this name dropping!



This is my favourite of all the H. K. Harman photographs of Gresley 'Pacifics'; 60037 HYPERION at Edinburgh in September 1948

Doncaster — a 5in. gauge Gresley A1/A3 'Pacific'

by: DON YOUNG

Part 9 – Bits and Pieces

In many ways this is a tidying-up exercise, adding the final bits to the chassis and covering some of the variations, though before the session ends we shall be able to progress the rods ready for the valve gear next time round. Let us make a start with the concluding items for the trailing frames before moving on to the, cartazzi, trailing axle.

Spacer and Running Board Support Brackets

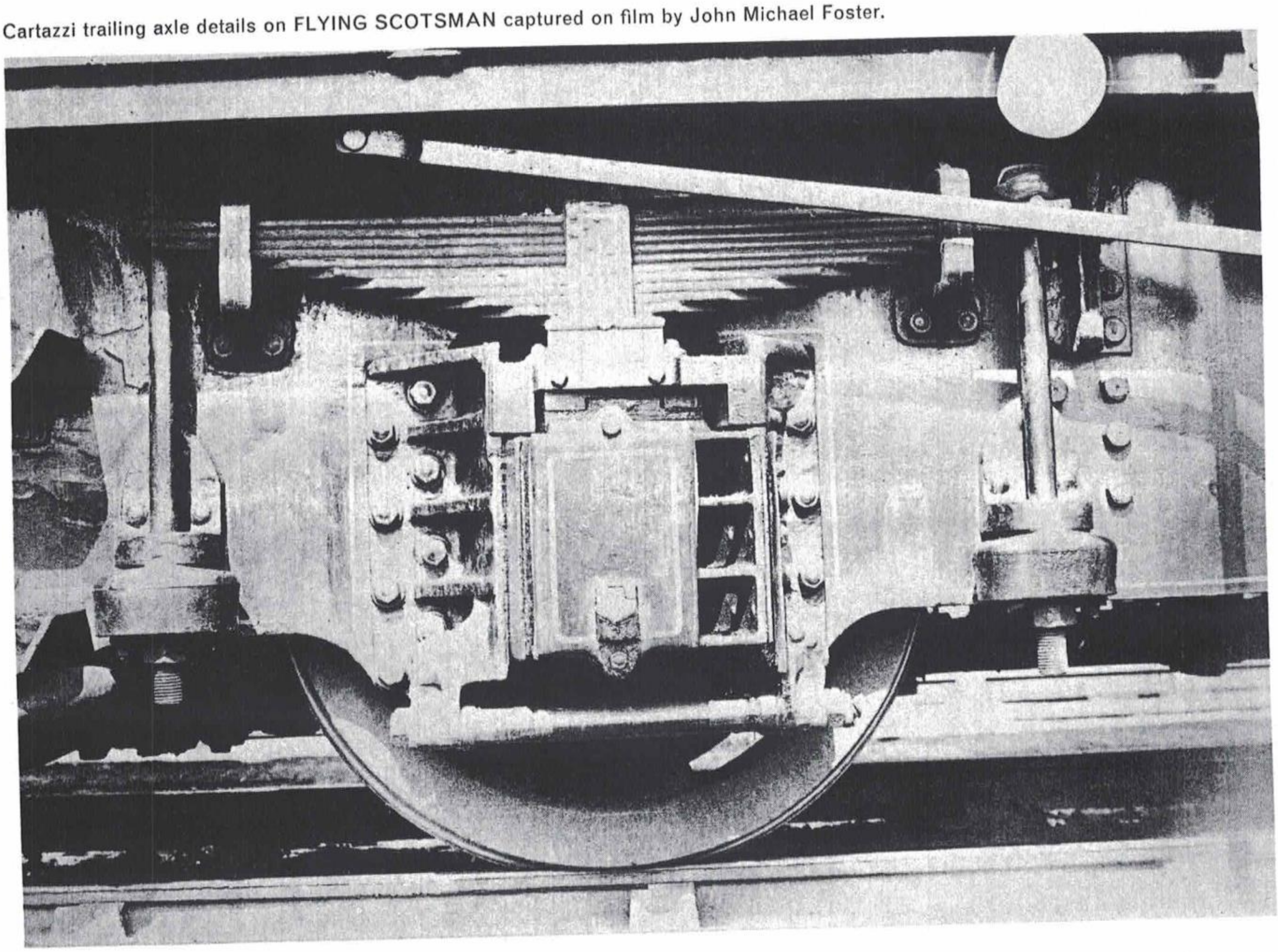
The spacer between main and trailing frames was a casting full size, but does not warrant a pattern in 5 in. gauge, being better fabricated. Start with a full 2¼ in. length of $1\frac{1}{16}$ in. x 2.5mm steel plate, then cut ⅝ in. wide side flanges to suit, angling one edge of the centre plate to 2 deg. to set the flange over to match the mainframes; clamp together. Now add all the webs to drawing, making them a tight fit between the side flanges so that no additional fastening is required ahead of brazing; do just that. Scrub, wash off, dry and zinc plate from an aerosol can, then mill across the bottom and outer side flange just to clean up, concentrating lastly on the inner flange until the spacer fits between the frames in its allotted place; drill through, and tap if this is your chosen method of fixing.

A tee bar stay, ½ in. x ¼ in. x $\frac{1}{16}$ in. section, is mentioned on Sheet 7 as being fitted underneath the spacers. You now have the latter in place, so can bring up the tee bar material, adjusting the length as necessary from the 6½ in. specified, and fixing with a dozen 8BA hexagon head bolts.

For the rear running board support brackets, start by bending up two lengths of ¼ in. x ¼ in. x $\frac{1}{16}$ in. brass angle to the shape shown, sandwich a piece of 2.5mm brass or steel plate between them and either silver solder or rivet together, finally profiling to drawing. Frame fixing holes are common with those for the spacer just made, the rest will have to await arrival of the running board.

Between the driving and rear coupled wheels is another running board support bracket of slightly different construction, this one being a casting full size. Start with a triangular piece from 2.5mm plate, fit a ⅝ in. x 2.5mm strip to two sides, including the scallop in the right angled corner, and complete the third side with 5/32 in. x $\frac{1}{16}$ in. strip before brazing up. Lightly mill the top and frame fixing faces to be flat and square, then add the lightening hole before fixing to the frames.

Cartazzi trailing axle details on FLYING SCOTSMAN captured on film by John Michael Foster.



Cab Steps

It makes a pleasant change to be able to fix steps to something as substantial as the frames, rather than to hang them on a flimsy backplate when the whole can very easily get bent in service. Fold them up to drawing, silver solder the corners if you wish for the extra strength this provides, and attach to both engine and tender. Unlike E. S. COX the Horwich 'Crab', these steps remained standard throughout the years of construction, though of course it is a different story at the front end.

CARTRAZZI, TRAILING, AXLE

Wheels and axle are plain turning; ease the end collars on the latter so that the wheels will pass easily onto their seats, when we can turn our attention to the axleboxes. Thanks to the skill of the patternmaker, these castings are very precise, indeed the cast-in lightening holes have drawn forth much favourable comment. Grip in the machine vice with one of the working surfaces hard against the back face and mill across that exposed; only a bare $\frac{1}{16}$ in. has to be removed, then reverse and arrive at the $1\frac{1}{4}$ in. dimension. Deal with the front face similarly, then reverse again, use packing to clear the wee bosses for the cover studs and deal with the back face to arrive at 1 9/32 in. overall. The box actually measures $1\frac{3}{16}$ in. deep as cast against the $1\frac{1}{8}$ in. specified on the drawing, and I make it that all the metal has to be removed at the top, though my feeling is to just clean up the top, including the wedge, because the cast boss for the cover stud makes removal of $\frac{1}{16}$ in. metal difficult to say the least. Anyone who wants to adhere rigidly to the drawing should mill said boss clean away and braze on another; it hardly seems worth the bother.

We know how to bore out the axleboxes and mill the recess for the oil tray from the tender, but this pair are not so easy to chuck in the 4 jaw. I cut the mating horns into single pieces from the cast pair and tried to use them as packing pieces under two of the chuck jaws, but it did not work out very well as there was a tendency for things to slip, so in the end I simply filed up wee wedges from $\frac{1}{2}$ in. x $\frac{1}{4}$ in. BMS bar, doing the job to place, and then sawed them from the bar and tightened the jaws onto them; this worked really well. Milling for the oil tray caused no problems, the latter we have already made for the tender and only the length varies, and the cover is so much simpler this time. Erect the whole to the axle and we can move on to the horns.

Builders will note that the wee raised bosses come almost to the edge of the casting, so rub a file over said edge to get it both flat and true, when this becomes a datum for marking out. Using a combination square; I discovered the castings reproduced the 17 deg. angle very closely, but how to set up for machining without a host of jigs and fixtures? I pondered long and hard, then took a cast pair of horns, removed two jaws from the 4 jaw chuck, when I was able to tighten the pair remaining onto the hornstay blocks at the ends of the castings, gripping the casting very securely, and used a round nose tool, followed by a d.t.i. to check the working face was set correctly, before turning to my scribed line on the frame fixing face; both front and back pairs of horns were dealt with in this way.

I next rubbed a file over the frame fixing faces, to make sure they were flat and then gripped the pair of castings in the machine vice, working faces together and frame fixing faces hard against the back of the vice, this to mill the outer edges. Wee cramps were used to hold the castings firmly together, then the machine vice was released and the frame fixing flanges turned towards the 3 jaw chuck, the latter holding a $\frac{1}{4}$ in. end mill. Now I could arrive at the $\frac{11}{16}$ in. dimension for total depth, and cut the $\frac{1}{8}$ in. recess on each casting to arrive at the frame 'gripper'. The castings were cut with a Junior hacksaw into individual horns, ends lightly milled to be square, then I gripped by the frame fixing face in the machine vice, milled the face to accept the hornstay, marked off and drilled the pair of No. 34 holes.

I had no trailing frames to complete the erection, though I was sorely tempted!, but clamp a pair of horns over an axlebox, fit to the frame opening, clamp the horns to the frames in turn and drill the No. 41 fixing holes, bolting in place. Now is as good a time as any to check that DONCASTER will negotiate the curves on your track, and even 40 feet radius is on the tight side for such a huge and magnificent machine, taking remedial action if required as per my 'important note'. Incidentally, after all the careful re-alignment of frames, etc. carried out at Doncaster Plant, after trials the engines then went to Carr Shed, where nearly all of them were turned on the very tight triangle as opposed to a turntable. To hear them groan and squeal as they negotiated such tight curves made me wonder what had happened to our careful alignment even before the mighty 'Pacifics' had re-entered service.

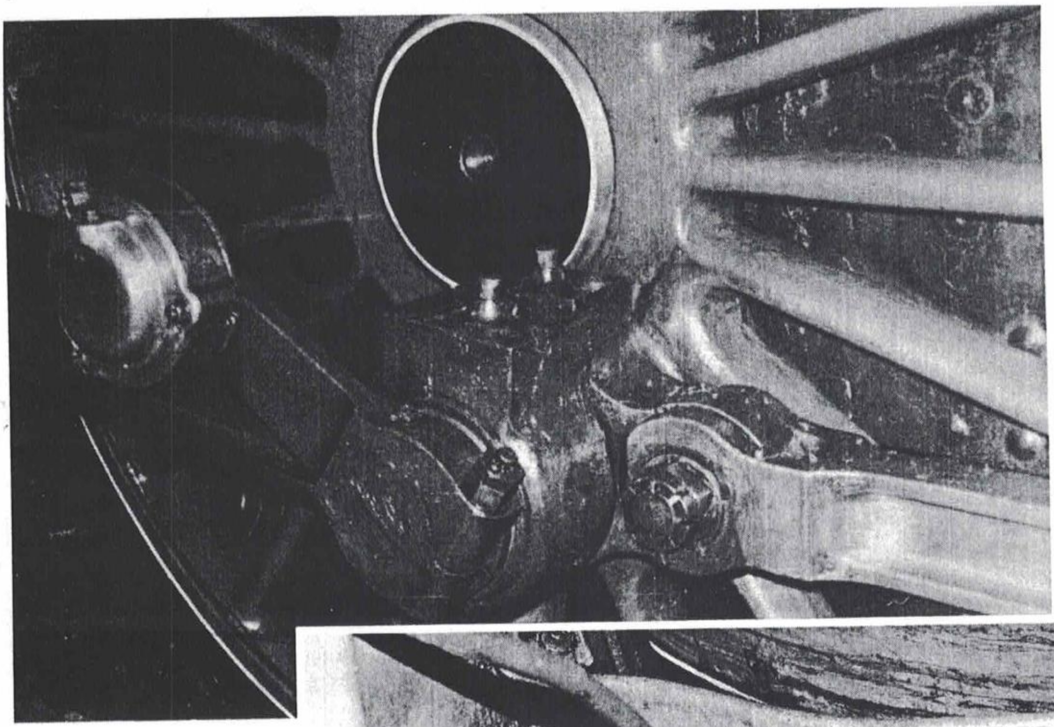
For the hornstay, start by clamping pieces of $\frac{1}{4}$ in. x 3/32 in. steel strip to the horns and drilling through the No. 34 holes, then chuck full $1\frac{1}{2}$ in. lengths of 5mm diameter steel rod in the 3 jaw, drilling right through at No. 34; from each end of course. Ease to a very tight fit between the hornstay ends, assemble with 6BA bolts and silver solder together, then ease to a proper fit between the horns before turning up the hornstay bolts. Turning long bolts from small hexagon rod can be trying, but in increments of approximately $\frac{3}{8}$ in. it does not take too long, plus the end result will be satisfying.

Axlebox end covers next and being basically flat they are so much simpler than for the tender. Material too is non-critical, so first arrive at two pieces each $1\frac{1}{2}$ in. long and $\frac{13}{16}$ in. wide. To achieve a good match with the axlebox, particularly those cast bosses for the studs, I recommend you cut a template from plastic sheet or stiff card, then transfer to the metal to complete the profile and drill the fixing holes. Tap the axlebox from same and if like me you are not happy using a 10BA tap, vary the specification to 8BA, completing with nuts and studs to suit. All you have to do now is produce the cut-out to accept the oil tray filler and we can move on to the side control and springing.

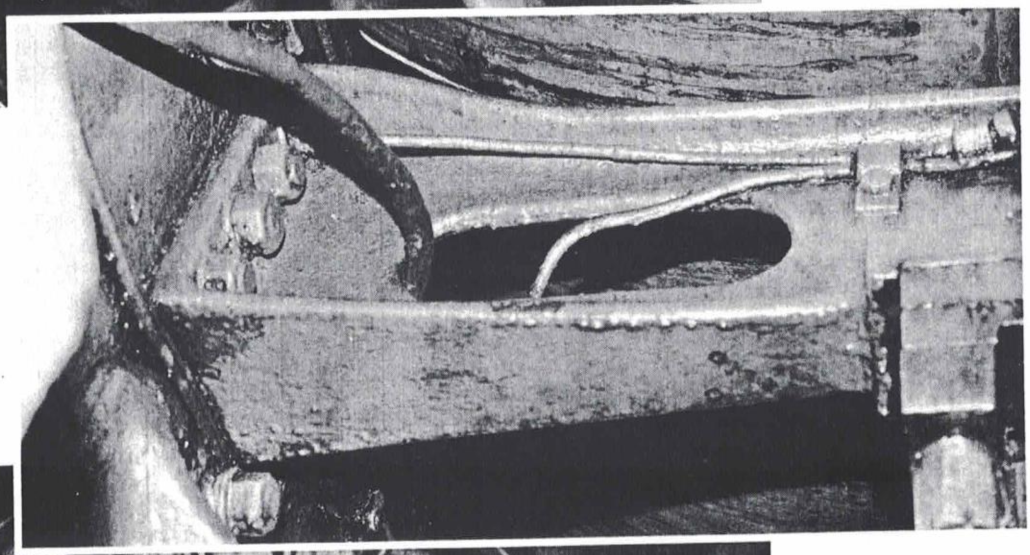
For the side control wedge, square off a $1\frac{1}{4}$ in. length of $\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS bar, chuck truly in the 4 jaw and turn on the $\frac{5}{16}$ in. diameter spigot, reducing the overall thickness by 1/64 in. in the process. Next shape the ends at 17 deg. to arrive at the profile shown, then grip in the machine vice and deal with the $\frac{3}{8}$ in. wide and tapering slot to suit the axlebox.

The spring plate is really massive and although it is feasible to turn on the spigot and bore the central hole in like manner to the side control wedge, it will be much easier to turn it up separately and braze to place, when we have a nice flat surface for all the machining operations. So take $1\frac{7}{8}$ in. length of $1\frac{1}{4}$ in. x $\frac{1}{2}$ in. BMS bar, mark off and first mill the $\frac{15}{16}$ in. wide slot to $\frac{5}{16}$ in. depth right across at 17 deg., which means a tilting vertical slide, or careful packing using a fixed one as I have; reduce the overall thickness at the two end flanges to $\frac{7}{16}$ in. Next mill to expose the seating for the oil box, then deal with the sides to include the recesses to suit the horns, only the latter will have to be completed to an easy fit with files. Drill the $\frac{5}{16}$ in. hole, turn up the spigot and braze together.

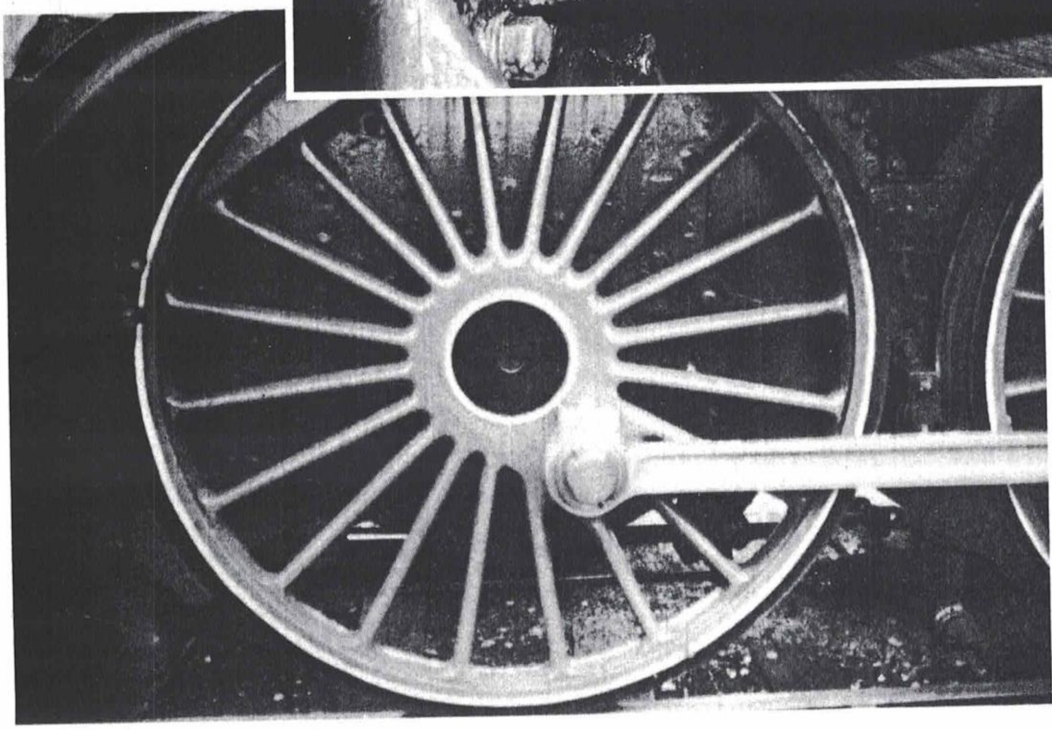
Why Doncaster had to have so much variation between spring ends and hangers I do not understand, for the style used on the tender could well be repeated on the trailing axle and save us drilling two holes in the top spring leaf into the bargain. Cut to length, file away half of a $\frac{7}{16}$ in. length of 3/32 in. steel rod, poke the spring leaf through a large potato and braze on the gripper. Centre pop the leaf though at each end ahead of brazing, filing away the pimple formed until a wee hole appears, one which you can now open out a little at a time to No. 12, changing to a $\frac{3}{16}$ in. end mill if the drill



'Long distance' rod ends and knuckle details on FLYING SCOTSMAN, this time by Roger Early



John Michael needed to be a contortionist to photograph the inside motion plate



Roger Early stayed outside the frames, sensible chap!, to show us the trailing coupled wheel and rod end. Note the orientation of the taper pin through the crank pin cap

jams when it gets to the gripper; you can now assemble the spring as per instructions, though I am certain it will require some final adjustments when you reach the track.
Whilst on the subject of final spring adjustment when the engine reaches the track, Bernard Clarke tells me the coupled wheel springs on his E. S. COX require some stiffening by substitution of spring steel leaves for the Tufnol ones I specified on the drawing, though having stripped down for painting over the winter months, he has not yet finalised the exact number.
The spring hangers are plain turning from $\frac{5}{16}$ in. steel rod, but the final item, the spring washer, is far from straightforward, being a drop forging full size and very few of us have this facility. Chuck a length of $\frac{7}{16}$ in. steel rod, centre and drill No. 12 to $\frac{5}{16}$ in. depth. Transfer to the machine vice on the vertical slide, the table of the latter being along the lathe axis, and using the side teeth of a 3/32 in. end mill, deal with the groove to suit the top spring leaf. Back to the 3 jaw to start parting off a 5/32 in. slice, but when you get to about $\frac{5}{16}$ in. diameter, transfer to the bench vice and first produce the oval profile with files before adding the 3/32 in. radius all around; part off to complete.
If I recall correctly, the side control wedge oil box was a neat brass casting and although ours could be fabricated, save for the hinge block I reckon it will be best machined from solid, $\frac{1}{4}$ in. square, brass bar. Start with a $\frac{7}{8}$ in. length and first mill $\frac{3}{16}$ in. steps at the ends to leave 3/64 in. thickness for the bolting flanges, then drill the centre portion and mill out to a $\frac{3}{8}$ in. slot with a 5/32 in. end mill; set over and mill the 10 deg. angle for the lid. Drill the No. 50 holes, shape the ends as shown and we can move on to deal with the hinges and lid.
Chuck a length of 3/32 in. brass rod in the 3 jaw, face, centre and drill No. 57 to $\frac{5}{8}$ in. depth and part off a $\frac{1}{2}$ in. slice; repeat to form a second piece only $\frac{1}{4}$ in. long. Braze the longer piece to the oil box, then mill away for 7/32 in. at the centre. Shape the lid and braze the shorter length of rod to it, then file the ends of the rod to obtain a fit, securing with a 3/64 in. pin. Erect to the spring plate, drill and tap 10BA to suit, then drill the hole indicated down to the wedge, and we can make a start on the rods and motion.

RODS AND MOTION

Crankpins and Crossheads

I said earlier on when we machined the driving and coupled wheels that to make life easier I had transferred the raised bosses at the crankpins to the latter, so there is now a bit more to turning them up than usual, though nothing too terrible.
The trailing pair are straightforward and can be secured to the wheels by medium of Loctite No. 601, unless you prefer a press fit. For the driving pair, turn the outer 7/32 in. length to 13/32 in. diameter initially, then grip in the machine vice on the vertical slide to mill the 9/32 in. square. We shall need both the return cranks and a simple jig before we can fit this pair to the driving wheels with the squared end correctly orientated.
It is now 33 years since I last worked on a Gresley A3 Class 'Pacific', so obviously memory has dimmed on some of the details, and I must admit I do not recall the leading crankpin and cap as I have drawn them, though the Works drawings are very specific on this feature and nothing I have read indicates that any design alteration was ever made. I missed the trailing crankpin cap a paragraph back, plain turning with two flats milled on for a spanner, but I clearly remember the position in which the retaining, taper, pin was fitted as it was possible to fit the spanner and give it a good clout or two to sheer the taper pin if it could not be driven out. Again the leading crankpins are plain turning, though the 9/32 in. diameter recess for the cap should be carefully 'D' bitted and the cap turned to a tight fit therein.

It is a great pity that forgings are not feasible for the crossheads, for they are not the easiest to fabricate, though we shall win – of course! I was only thinking as I wrote that last sentence how times have changed, for the fitting skill has disappeared in industry since my apprenticeship, if two pieces do not fit then there is an inquest rather than resort to a file, whilst my brother's craft as a blacksmith has evaporated in less than 25 years. Such was brought home to me in full measure when a few weeks ago I was consulted about the construction of new standard gauge Locomotives, for who could design them in the UK – only a handful perhaps, and one would have to go to the Orient to have them built; the cradle of the Industrial Revolution is empty!

Returning to the crossheads, there is no apparent reason at this stage for provision of a slot seemingly for a drop arm in the centre crosshead, until it is realised that the upper portion of said drop arm is a lubricator for the gudgeon pin; let us proceed.

For the main body of the crosshead, start with a $1\frac{1}{2}$ in. squared length of 1 in. x $\frac{3}{4}$ in. steel bar, black for preference. First reduce the overall thickness to 21/32 in. and machine the top face as your second datum, then mark off, particularly for the piston rod and gudgeon pin. Full size the gudgeon pin was tapered to fit both sides of the crosshead, something that would be difficult to emulate. Cross drill the crosshead at No. 8, following up at $\frac{1}{4}$ in. diameter to about $\frac{3}{8}$ in. depth, then use a Slocombe centre drill or 60 deg. Rosebit to countersink the inside face, remembering this hands the crossheads.
Next chuck in the 4 jaw with the piston rod centre running true; face, centre and drill 7.9mm to $\frac{7}{8}$ in. depth, then turn down the boss on the outside as far as you are able. I will try to include a photograph of a full size crosshead as its exact shape is easier to show this way than to describe. I have been putting off machining the recess for the connecting rod small end simply because what I have drawn cannot be achieved exactly, happily a mistake I did not make too often.
I have a feeling the original intention was to pin drill from the back face of the crosshead at 19/32 in. diameter, then press in an $\frac{1}{8}$ in. thick ring containing the 60 deg. countersink and braze it in place, then for some unknown reason decided against this. I now suggest you use a $\frac{5}{16}$ in. end mill both from the rear and bottom, to get the slot to width, then chuck in the 4 jaw with a parting off tool under the toolpost, pulling round by hand to approach the radius as shown, sufficient to clear the connecting rod.

Cut the drop arm support from 4mm sheet, starting with a piece about 2 in. long and $\frac{3}{4}$ in. wide. Clamp to an angle plate on the vertical slide and use the side teeth of an end mill to reduce the centre portion to $\frac{1}{16}$ in. thickness, leaving the lugs at the bottom. Next to the machine vice to mill the $\frac{5}{16}$ in. wide slot to accept your drop arm material, then mark off, drill the No. 8 hole and complete the profile to drawing. Turn up a .20 in. diameter spigot about $\frac{1}{2}$ in. long, drop it in the pickle for a few minutes, then leave outside for a few days so that it rusts and the spelter will not adhere; braze the drop arm support to the crosshead.

The slipper is from good quality bronze or gunmetal and can either be made in a single piece, or as a $\frac{5}{8}$ in. x 5/32 in. flat and a $\frac{1}{4}$ in. x 13/64 in. bar, in both cases being attached to the body with a couple of 6BA countersunk screws and then brazed up.

Fit a crosshead to its piston rod, assemble the slide bars over same and bolt in turn to the rear cover. If the top slide bar is too low, then simply add a shim to correct; if too high then machine the slide bar itself to a fit, until the crosshead slides freely. Once this is achieved, you can deal with the motion plate seatings to retain the sweetly sliding crosshead. Turn up the gudgeon pin to a good fit in the crosshead and we can move on to the rods.

Coupling Rods

The set of rods I have detailed are what I call the 'long distance' variety, having larger oil bosses/reservoirs than the original design to give sufficient capacity for a non-stop run between Kings X and Edinburgh Waverley, some 392 miles. A feature too of Gresley rods was their lightness, something very much appreciated by those who had to handle them, though it was not unknown for them to buckle in service. To help avoid repetition in 5 in. gauge, I recommend the front faces only be fluted, that is unless your first aim is to win a Championship Cup.

No matter what the finish of our coupling rods, the really important feature is that their centres coincide exactly with those of the axles, so first we have to make drill bushes to fit said axleboxes. These want to be 7/8 in. o.d. to be a good fit in the journal bores, about 3/4 in. long, one being bored out to 21/32 in. diameter and the other 15/32 in. diameter; clamp the axleboxes to the top of the horn slots.

For the leading coupling rods, take a 9 in. length of 1 1/4 in. x 3/8 in. mild or chrome vanadium steel bar and mark off the crankpin centres. Align to the drill bushes, drill through to size, then mark off and drill the knuckle pin hole. Next job is to mill to the correct section, so select a 14 in. length of, say, 1 1/2 in. x 1 1/2 in. x 3/16 in. bright steel angle that is perfectly square. In one face, drill holes to suit those in the coupling rod, in the other face 5/16 in. holes at roughly 2 1/2 in. centres right along so that you can move the angle on the vertical slide table, the cross slide traverse being much less than the 9 in. we require, plus the overhang would be far too great.

Erect and use the side teeth of a 1/2 in. or similar size end mill to first reduce the end bosses to 23/64 in. thickness, then remove 3/64 in. more metal from the centre section. Deal with the other side of the rod to arrive at 17/64 in. thickness, then mark on the profile, sawing out roughly to line. Go back to the length of angle, bolt the rod in place, and deal with the edge facing you with an end mill, adjusting until you can machine to line along half its length; the rod is slightly fish-bellied. When you have dealt with one half of the edge toward you, change to a Woodruff key cutter and deal with the opposite edge from the mid point to the far end, then reset the rod the other way and deal with the rest of the edges. Now you have to set the rod central to mill the 7/32 in. wide flute right along, again with a Woodruff key cutter. If you are able to grind a wee radius on the corners of the teeth on the cutter, this will then leave a tiny root radius in the flute which will greatly enhance the appearance of the finished rod, strengthen it too. Use the mandrel and end mill technique for the rod eyes, tidying up with files, then back to the machine vice to mill the tongue for the fork end at the knuckle. Complete the rods by drilling and tapping for the oil reservoirs.

Trailing coupling rods next, for which we need two pieces each 7 in. long and 1 in. x 1/2 in. section. Concentrate on the fork first, drilling right through at 3/16 in. diameter and then following up to about 1/4 in. depth to 1/4 in. diameter. Cross drill No. 3 at the end of the slot, saw it out roughly and then mill to the 7/32 in. dimension; radius the eye over a mandrel with an end mill. Turn up the knuckle pin to be a tight fit, then turn up and press the bush into the leading coupling rod. I deliberately make rod bushes a very heavy press fit, just easing the end so that they will enter the rod and poking the drill through again after fitting. Now you can align the driving crankpin hole in the leading coupled rod with the driving axlebox, using either a stepped pin for the purpose or the drill and its bush, then slip the requisite bush into the trailing coupled axlebox and drill through the rod; the rest is a repeat of the process for the leading pair of rods.

Alloy steel rods fitted to LNER Locomotives were all hand finished to a high standard. Corners of the flanges on the 'H' section were first chamfered by cutting with a chisel, the best possible training for any apprentice in the precise removal of metal with hammer and chisel, then filed, ground and finally emery clothed to an even and polished radius, something to be proud of.

Connecting Rods

Apart from the sheer size of the outside connecting rods, carved from 14 in. lengths of 1 1/4 in. x 1/2 in. steel bar, machining is relatively straightforward, there being no fish-belly as for the coupling rods, just a uniform taper to both top and bottom edges and the fluting. If your DONCASTER is earmarked both for hard work and appearance at Exhibitions, then you may well want to impress the judges by fluting the backs of the rods, in which case use chrome vanadium steel for the extra strength it provides.

Although uncle Frank Young opened my eyes to some of the shortcomings of the Gresley engines, I still rate his inside connecting rod and strap very highly, feeling the feature was wrongly blamed for the incidence of big end bearing failures in service. That this design for long periods cheerfully accepted a full 50% of the total driving force generated by all three cylinders was testimony to me of its basic soundness, a classic example in my view of the effective and efficient use of metal.

With careful marking out we can use 1 1/2 in. x 3/8 in. section material, otherwise it will have to be 2 in. x 3/8 in. and a lot of swarf! Start with a 10 1/2 in. length of bar and at 3/4 in. from one end on the centre line of the 1 1/2 in. face, centre and drill through to as large a size as possible. I recommend you do this in the lathe, holding the bar in the machine vice on the vertical slide, when you can either swap the drill for one of those precision boring heads, or follow Merlin Biddlecombe and I in chucking a boring tool in the 4 jaw; whichever way you choose, bore out to 15/16 in. diameter against vernier calipers. Next job is to saw almost one half of the redundant hole away, square off with an end mill, then mark off and drill the pair of No. 11 holes to at least 3/4 in. depth before milling the two shoulders, only leave a few thous for final fitting to the strap.

Mark off the centre at the small end of the rod, drill 9.0mm and begin forming the eye. The idea as you can see is to finish with a wee flat in which to drill the No. 41 oil hole, and as the dimension to said flat is the same 17/64 in. as the eye radius, you will have to take particular care not to lose the flat as you mill the radius over a mandrel. The main body of the rod is dealt with as for the outside pair, only as this one can be seen from either side of the engine, then both sides of the rod must be fluted. At the strap end you will have to change to saw and files to achieve the 2 1/4 in. radius, using a pin drill in the 3/16 in. holes to cut a recess for the retaining nuts for the strap, these being from 4BA hexagon steel bar; in other words you will have to make all four of them.

'Very good' said Norman Lowe on first sight of Sheet 9, 'you have the correct fluting shown on the inside connecting rod detail, but how can you achieve it in practice, Don?' The only answer I can give is as we did the job in full size; by hand grinding. I have done this sort of work with small grindstones held on a mandrel in the 3 jaw chuck, a length of bar as a rest clamped under the toolpost, and run the lathe at top speed, but apart from nasty abrasive grit flying about, such an operation is painfully slow. Another alternative is to hold the grindstone in an electric drill chuck, but I find the machine cumbersome to hold and control precisely in this role. The real answer is one of those small pneumatic 'windy machines' as used in many garages nowadays; if you can loan one for a few minutes then you will be able to arrive rapidly at the end result as shown.

Again for the strap, a bit of outside help would not come amiss in bending a length of 1/2 in. x 3/8 in. black steel bar into a horseshoe to achieve the correct grain flow, otherwise it will have to be 2 in. x $\frac{3}{8}$ in. black steel flat and cut out from the solid. Whichever way you start, first operation is to bore out to $\frac{15}{16}$ in. diameter, facing off to 11/32 in. thickness at this set-up, then rechuck in the 4 jaw to deal with each of the integral studs in turn. Next grip in the machine vice and mill two flats to match up with the $\frac{15}{16}$ in. half moon, dealing with the connecting rod end to achieve an exact fit, no slackness here please. Bolt the strap to the connecting rod over a $\frac{15}{16}$ in. mandrel and mill the back of the strap to 23/32 in. radius. Change to a ball nosed end mill to complete the shape at the back, then complete the profile at bottom and oil reservoir with an end mill, drilling and tapping said oil reservoir as shown.

For the inside big end brasses, I would saw a $1\frac{1}{2}$ in. length of $1\frac{1}{4}$ in. diameter cast gunmetal or bronze bar in halves, mill the joint faces and then chuck both halves in the 4 jaw to completely machine them at a single setting. First turn down to $1\frac{1}{8}$ in. diameter over a $\frac{3}{4}$ in. length, face and lightly chamfer the outside edge, then with a parting off tool that has been ground square, cut the recess to accept the strap, a tight fit therein. Centre, drill to $\frac{3}{4}$ in. depth at about $\frac{11}{16}$ in. diameter, then bore out to an odd end of crankpin material as gauge to an easy running fit. Start to part off, and remember the 1/32 in. offset to get back to centre line from the offset cylinder bore, chamfer the corner and then part right off. If there are any machining marks, I would simply remove them with a smooth flat file, rather than try to set up the halves again to face off.

Assemble one half of the brass to the strap, try it over the crankpin and lightly scrape the bore of the brass if it binds to the crankpin, then repeat with the other half in the connecting rod end. I have deliberately specified the brasses to be a tight fit in strap and rod end, but if you are worried about them turning in service and cutting off the vital oil supply. which reminds me to tell you to drill oil feed holes in all the brasses, fit a wee $\frac{1}{16}$ in. peg on the centre line of the recess in the end of the connecting rod, and mill a mating hole no more than $\frac{1}{16}$ in. deep in the mating brass. I would not recommend this course of action though, which is why there is no mention of same on the drawing detail.

BOGIE WITH SIDE CONTROL SPRINGING

The rest of this session is a tidying up process on the chassis, covering some of the alterations that were made after construction of the prototype GREAT NORTHERN. Although Edward Thompson was rightly criticised for choosing the very first Gresley 'Pacific' for his hideous transformation, purely from a practical viewpoint, GREAT NORTHERN was the correct choice, for she must have been the least standard of the whole class. Apart from the obvious reason, I avoided naming my A1/A3 FLYING SCOTSMAN because, as the third member of the class, she too has several non-standard features. It is a tragedy that FLYING SCOTSMAN is the sole A3 preserved and although rightly she was the first candidate for preservation, she is not really representative of the A3's; oh, that PAPYUS and BOOK LAW could be heard today along with my favourite HUMORIST!

I am in rather a cleft stick when it comes to proposing the alternative bogie with side control springing, for although this is the way I would build my DONCASTER as a variation on the superb Gresley swing link pony truck on my K1/1, I have so many swing link bogie centres and yokes on shelf that I hope some of you will not take my words to heart!

The late maestro LBSC used to allow his bogies to swing freely from side to side, so the leading coupled wheel flange took all the load when entering and on curves. This was just about OK for $2\frac{1}{2}$ and $3\frac{1}{2}$ in. gauge locomotives, but on his otherwise spectacular 5 in. gauge MAID OF KENT 4-4-0 it was far from satisfactory. Thus fitting side control springing to the MAID was one of my early design exercises. Now I see no harm in fitting side control springs where one end presses against the bogie frames and the other engages the yoke or buffing block, such an arrangement is self-centering and works very satisfactorily in service, although the 'proper' arrangement is the one depicted here, where the same, central, spring is compressed from one end or the other, depending on which way the bogie moves relative to its bolster/yoke. Enough of the chat, on with the details.

The modifications necessary to the bogie frames are simply the repositioning of holes to pick up the new bogie centre, and that to the bolster merely revises the fulcrum, so let us go straight to the heart of the matter with the new bogie centre, and at last I have a sample on shelf to play with!

Rub a file over the bottom face to get it nice and flat, then chuck in the 4 jaw and face across the top, raised, face to arrive at $1\frac{5}{16}$ in. overall depth. I did envisage having to machine the main portion of the top face, but there is no machining allowance for same, and in any case a couple of minutes with a file is all that is required such is the finish on the casting. It does mean though that I have chosen the wrong datum from which to mark out the holes, one should always use a machined face, so if you are not happy with the bottom face as filed flat, chuck again in the 4 jaw and give it the lightest of skims. At $\frac{11}{16}$ in. up from said bottom face, scribe a line along both side flanges, find the centre of the cast in slot, centre pop and set to run true when chucked in the 4 jaw. Centre and bring the tailstock into play to face across the flange, then drill the $\frac{1}{2}$ in. hole before reversing in the chuck and repeating to obtain the 4 in. dimension overall. Scribe that line at $\frac{11}{16}$ in. up from the bottom face again and mark off for the 11/32 in. holes, setting up in the machine vice on the vertical slide to drill them through; or you can use an angle plate in lieu of the machine vice as being a more robust set-up. To mill the slot along the centre, I would 'dog' the casting directly to the vertical slide table, bottom face towards the 3 jaw chuck, and use a $\frac{1}{4}$ in. end mill to first arrive at the 1 in. dimension, filing the corners, then open out to 1 3/32 in. width over the bottom 13/32 in. depth. Full size at the side flange they were cut away at the slot as shown on my detail; such serves no useful purpose and is included only for strict authenticity. Assemble to the bogie frames with 6BA steel countersunk screws and you can use clear instead of tapped holes in the centre where nuts can easily be fitted; very few can. The yoke is another casting; so mark it off, chuck in the 4 jaw, face across the bottom, centre, drill and bore out to $\frac{3}{4}$ in. diameter to an easy fit over the bolster fulcrum. Done this way round, rather than boring from the top, you can see the metal wall thickness around the hole and reset if necessary for it to be uniform. Now you can machine the ends for the hole to be central and face across the top to $1\frac{1}{8}$ in. overall depth. Grip in the machine vice, on the vertical slide, to mill the top face to $1\frac{5}{8}$ in. and the spigot down to 1 in. to suit the bogie centre, again an easy fit. Drill the No. 12 holes at the ends, insert in the centre, cut out the retaining plate from 3mm brass or steel sheet, drill the five holes, offer up to the yoke, spot through, drill and tap 8BA for the four retaining bolts. Actually it is a good idea to turn the pivot bolt up first, assemble the whole to the bolster, when the retaining plate is aligned automatically to the yoke.

The spring bar is very much akin to the yoke on top of the bogie axleboxes, again for springing, and is fashioned in like manner, the spring bolts and cups being plain turning. If you now look at the arrangement of the bogie side control springing, you will see we require two bare 4 in. lengths of 5/32 in. steel rod as spring rods and four spacers which are each $\frac{5}{16}$ in. o.d. x 5/32 in. bore and $\frac{3}{8}$ in. long.

The best way to erect the springs and cups to the bogie centre is to fit the cups over the spring ends, insert a length of 4BA steel studding through the cup bores, fit 4BA nuts and tighten to fully compress the spring. Cut away sufficient surplus studding so that the assembly fits between the allotted webs, then release, The bogie centre now has to be slotted to accept the spring bars, from the intermediate webs to the side flanges, so mark off, mill the slot to $\frac{3}{8}$ in. width and then open out with a square file against the actual spring bar to achieve an equal clearance top and bottom. Complete the assembly to drawing; when the spring bars are fitted to the yoke the four spacers should just press against the spring cups, so adjust if necessary.

All that is required to complete is a shield over each of the springs, bent up to place from 1mm or similar steel sheet and held in place with 10BA steel screws, twenty eight of them to be authentic, though a few less if like me a 10BA tap is torture!

Mudguard

I wondered as I bolted a mudguard to the frames on the full size DONCASTER back in 1952 what it was supposed to protect? Normally the mudguards stayed in place during refits, so I guess this one must have got bent in service, but this did not answer my question. Looking around the immediate area, it did not extend far enough downwards to shield either drain cocks or cylinder relief valves, leaving only the valve crosshead above, nowhere near as close as the slide bars to the rear bogie wheels where there was no protection, so my question remains as unanswered today as then. Being an addition after the first Locomotives entered service, it must have served some useful purpose, so fit them and you may find out for me. If you are able to fold the mudguard up from a single piece of 1.2mm steel sheet, size 3 in. x $1\frac{1}{4}$ in., then it will be immensely strong, the alternative being to make four separate parts and braze together; bolt to the frames.

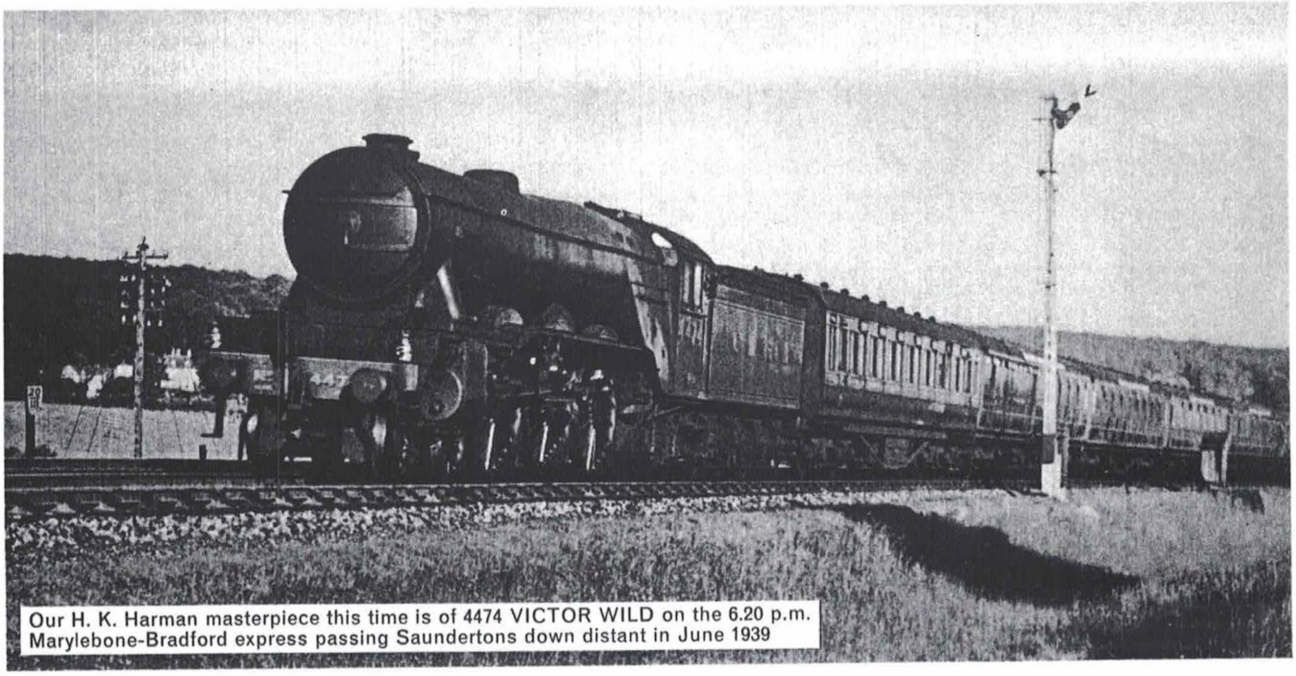
Expansion Link Bracket/Weighshaft Bearing

If the mudguard poses a question, the almost immediate design alteration away from separate expansion link brackets and weighshaft bearings to a combined version raises a mountain of queries. GREAT NORTHERN and indeed DONCASTER as built had short(ish) lap short(ish) travel valve gear, so a lot of their work was done at around 40% cut-off, whereas when I knew the engines they were worked commonly at 15% cut-off, but remember it was a different valve gear. It was said that the earlier engines could be heard approaching from seven miles away, such sound could well mean heavy loading of the valve gear, but many an engine shouted its coming, indeed unless you happened to be wielding the shovel at the time then this was part of the excitement of steam. I must admit that for a while, as I was trying to master the art of firing, I began to dread crashing exhaust beats, but soon the feeling changed to being locked in battle with the beast, real primeval adrenelin stirring stuff, and making sure I would come out on top. I did not fully realise it at the time, but in uncle Frank Young I was firing for a man who was a living legend for his exploits with the shovel and he was determined I uphold the tradition and those 'fitted fish' trains to either Manchester or Leicester on a Saturday night were the best possible training. Funny how a single component can set the train of thought racing again, so let me tame it as the last part in this particular session.

The frame fixing and top plates are almost exactly as those depicted for the prototype on Sheet 8, as is the outer bracket for the expansion link, but do take time and check everything out carefully. Instead of the separate weighshaft bearing, square off a 1 21/32 in. length of $\frac{1}{2}$ in. steel or bronze rod, centre, drill and ream out to $\frac{5}{16}$ in. diameter to be an integral part. It is the inner bracket where the major changes occur, for it extends right back and over the weighshaft bearing tube. Take a $3\frac{3}{4}$ in. length of $1\frac{1}{2}$ in. x $\frac{1}{8}$ in. steel flat, scribe a line along at $\frac{3}{8}$ in. above one edge and drill $\frac{9}{16}$ in. and $\frac{1}{2}$ in. holes at 2 27/32 in. centres. Turn up the bearing housing for the expansion link, use the same set-up as described for the prototype link bracket and assemble, trimming off the excess metal on the inner bracket to place.

I have had great difficulty in establishing the existence or otherwise of a lightening hole in the inner bracket to match that in the outer, though it would appear from the literally hundreds of photographs examined that the A4's had solid brackets, whilst some A3's were solid and others had the lightening hole; I found it all rather confusing. There is a vertical plate web fitted over the weighshaft tube and extending from the frame fixing plate to the inner expansion link bracket, and then a horizontal one forward to the main top plate, both being made to place, when the whole can be silver soldered together and completed as per the prototype.

For a 'bits and pieces' session, we have covered a lot of ground!



Our H. K. Harman masterpiece this time is of 4474 VICTOR WILD on the 6.20 p.m. Marylebone-Bradford express passing Saundertons down distant in June 1939