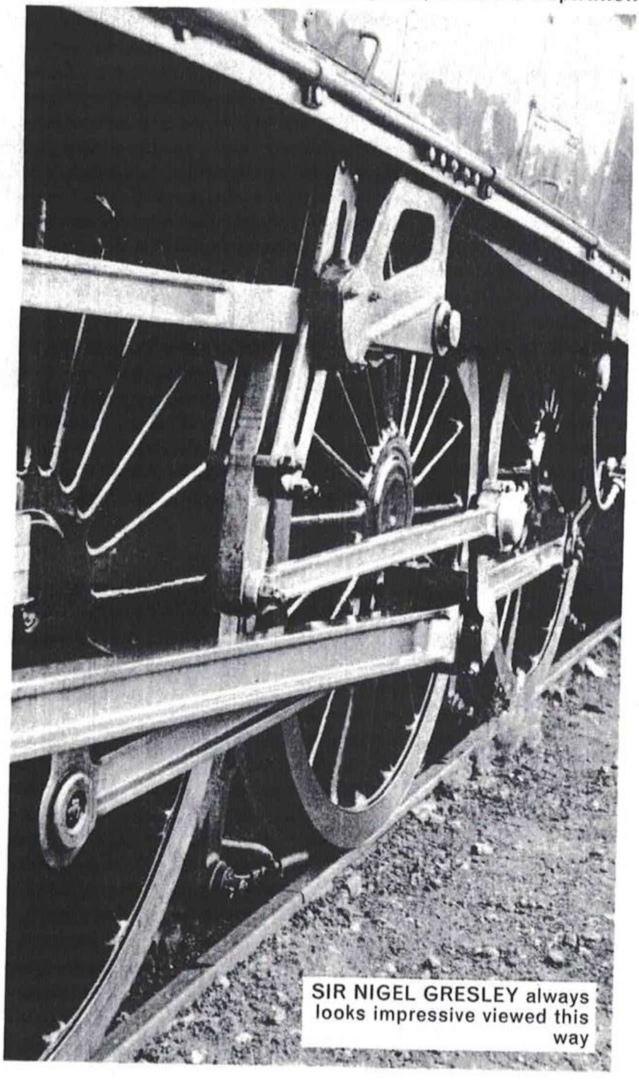
Doncaster — a 5in. gauge Gresley A1/A3 'Pacific'

by: DON YOUNG

Part 10 – The Valve Gear

We now come to perhaps the most exciting session of all, that on the valve gear, and for me it is particularly exciting as this was the very gear I cut my teeth on back in the 1950's; in refurbishing, erecting and setting. It was just prior to laying things out on the drawing board that I met Dr. Burrows at Llanuwchllyn, when we were able to discuss in some detail features of various valve gears, including that for the A3, as the weather raged outside the Cafe; it always does when I am around! It was Dr. Burrows hope to make improvement on the Gresley gear and I found myself in total accord with the means of achieving this, in fact after years as a lone wolf crying in the wilderness on the subject of valve gears, it has been a great comfort to find in Dr. Burrows a kindred spirit. Where we differ is in the application of our thoughts/convictions, for whilst Dr. Burrows is a genius in using the computer to arrive at answers to a multitude of decimal places, yours truly can better understand what is happening by setting things down to as large a scale as possible on the drawing board. Anyhow, from the inspiration of our meeting, things rapidly fell into place on the drawing board, but regrettably for my part, Dr. Burrows has not been able to check my figures, this through a step up the University ladder, from Bangor to London, which has taken up all his valuable time. Whilst it would have been nice to have had calculated verification of what I had set down graphically, there is no doubt that DONCASTER will 'chuff' in the approved manner as have all my earlier designs.



SIR NIGEL GRESLEY always looks impressive viewed this way

Moving from my line diagrams to full detailing brought back memories of erecting the components full size, right down to which nuts were real pigs to fit, but I am not going to spoil readers enjoyment in finding out for themselves which ones they are! It has also been one of those days, as I sit down to pen these notes, where nothing thus far has gone right, like scrapping seven gunmetal outside cylinder blocks for DONCASTER, even the horseless carriage does not seem to like me today, so I am going to enjoy relaxing for a few hours in your company.

A part of my pleasure derives from the fantastic number of new readers that the DONCASTER series specifically has been responsible for, more than I had ever dreamed. Just as LLAS No. 1 with my appreciative article on the LNER 'Pacifics' has become a collectors item, so is No. 16 that introduced DONCASTER rapidly selling out; at the time of writing there are barely 80 copies remaining. As No. 16 was the last issue produced by 'letterpress', as against our current 'litho', there is little hope of a reprint as not all the blocks can be remade for the newer process. On top of that, LLAS No. 25 that was available at both the Midlands and Wembley Exhibitions has done tremendously well, so I should be on Cloud Seven. Unfortunately this is not so, for despite continuing efforts not only to maintain but to improve on Magazine quality, the key word to the whole operation, just occasionally an imperfect Magazine has slipped through the control net. If you have been the unfortunate recipient of a less than perfect copy, then tell me and it will immediately be replaced; happily for most of you this last sentence will never apply. Complete customer satisfaction is paramount to me with LLAS though, for without it the 'fun' will go out of running our Magazine. On to brighter things, the subject for today.

Return Cranks

Start with two 3 in. lengths of $\frac{3}{4}$ in. x $\frac{1}{4}$ in. steel bar and first mark off for the No. 34 and 3/32 in. taper pin holes, drilling the latter initially at No. 51; now reduce to 7/32 in. thickness to keep this pair of holes nice and central in the bar. Next mark off from the initial pair of holes for the 9/32 in. square one, gripping in the machine vice and drilling same to 7.00mm diameter, then move the cross slide on by 1.441 in. to centre, drill and ream the second hole to $\frac{3}{16}$ in. diameter. The extra length of bar is for gripping in the machine vice to cut the 3/64 in. slot with a slitting saw; this latter is going to come in very handy during the fitting stage which follows.

Although it is possible to broach the hole out to a square using a lever operated tailstock, a whole series of broaches would be required to remove such an amount of metal, involving much time and effort, plus on my LNER Class K1/1 'Mogul' I proved that simply filing the square was both quick and accurate. If you like you can machine a square on the end of a piece of round material, as we did for the actual crankpin but a few thous smaller across flats and fit to same initially, though I went straightaway to the actual crankpin.

Approaching size, you do exactly as we did full size and drive a wee fox wedge into the slot so that the return crank will begin to go over its square, easing gradually until when the fox wedge is released, the slot is not more than .002 in. wider than in its 'relaxed' state. Now you can run the No. 51 drill through, just to take the corner off the square in that position, then use the taper pin drill or reamer to complete this hole. Before opening out from the 7.00mm hole to a 9/32 in. square one, it is feasible to start forming the flanks to 11/32 in. radius over a mandrel with an end mill, though this operation is fraught with the peril of 'digging in' and filing is much the safest way.

For ease of machining many of the rods and levers we have to deal with in this session, we need the same angle bar set-up as for the main rods, so bolt the embryo return cranks to said angle and mill the section as shown. Saw off the excess at the pin end and gripping firmly with a 'Mole' wrench, radius over a mandrel before sawing and filing the flanks to match; you may mill them of course if you are machine minded. At the ends of the No. 34 hole we have to spotface for the bolt head and nut, arriving at the $\frac{9}{16}$ in. dimension, so achieve this with a 7/32 in. 'D' bit or end mill, then mill the end square and file on the radius to complete.

The driving crankpin setting jig is a variation of that for drilling the crankpin holes in the coupled wheels, so make it up and fit to the driving wheel seat. Coat both crankpin end and hole with Permabond A118 and with the return crank in place, align over the $\frac{3}{16}$ in. diameter pin and slide the whole assembly home; allow to cure. All you have to do now is remove the return crank, tap it 7/32 x 40T and turn up the pin to suit, the threads being a tight fit. Incidentally, look at the drawing before assembling the crankpin to make sure the return crank is correctly orientated, when the driving wheels can in turn be finally fitted to their axle, a giant leap forward. My crankpin setting jig is merely a variation of the tool used full size to check the throw of the return crank pin, a tool I became very conversant with. Basically it was rather a large scribing block, with a heavy base, a substantial central pillar, to which a scriber was clamped and set at the correct throw. Underneath the base were three blocks, with a spring loaded centre right in the middle. You engaged the centre in that machined in the axle end, pressed firmly so that the three blocks came into contact with the wheel/axle end, then rotated the scriber to check against another small centre machined on the return crank pin end. Such was particularly important if a new crankpin had been fitted, as almost invariably there was an error, one corrected by welding the faces of the square in the return crank and then filing out to reorientate it to arrive at the correct throw; this is how I learnt that particular skill.

Drop Arm

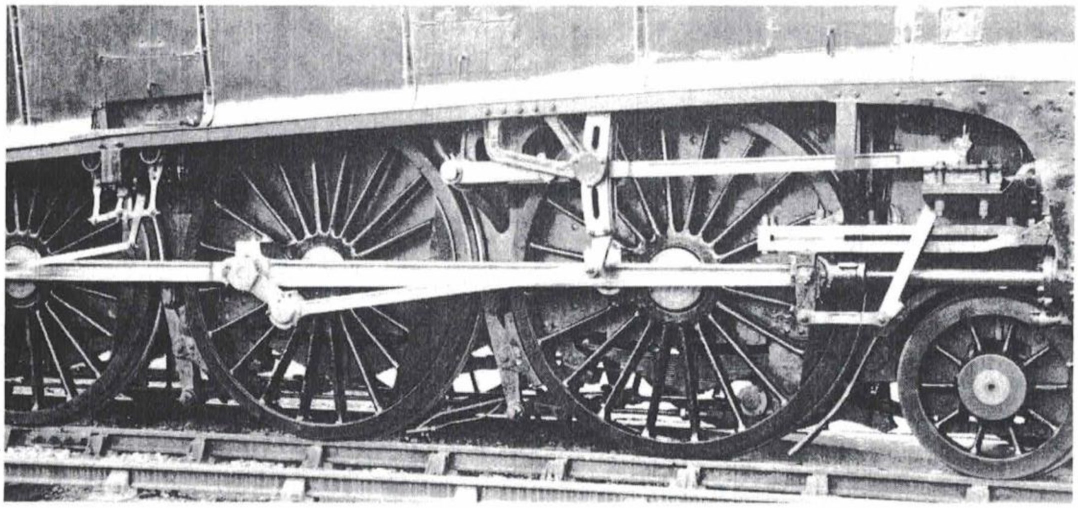
Let us next make progress with the 'running' part of the gear, as against the 'starting' portion initiated by the return crank, commencing with the drop arm. It is just possible with careful marking out to machine the arms from $\frac{1}{2}$ in. x $\frac{1}{4}$ in. bar, the centre one of course from $\frac{5}{16}$ in. x $\frac{1}{4}$ in. section. Mark off the No. 8, No. 41, and for the outer pair only the 5/32 in. reamed hole, though if you grip in the machine vice then you will be able to make use of the cross slide micrometer collar to get said holes spot on so to speak. Radius the bottom end of the outer pair over a mandrel, then produce the shape for the oil cap before milling down to $\frac{3}{16}$ in. thickness away from the top oil box, remembering this latter operation hands the arms. Now it is a matter of drilling and tapping for the oil caps, and you can turn up all 13 of them at this stage if you so wish.

Union Link and Pins

Because of the lightness of the section of all the valve gear components, I have specified chrome vanadium steel for the extra 'toughness' this provides, for the union links we require two $1\frac{3}{4}$ in. lengths from $\frac{3}{8}$ in. square section. Although to be strictly accurate, this bar should now be reduced to 11/32 in. thickness, I personally would leave it at $\frac{3}{8}$ in. for the extra bearing surface this provides at the fork ends, though of course each builder can make his/her own decision. Grip in the machine vice to first drill and ream the pair of 5/32 in. holes at 1.375 in. centres, the latter indicating use of the cross slide micrometer collar, then in the other face drill No. 12 holes at the end of the slots; saw and file or mill these to suit the drop arm, the combination lever too when made. Fit packers in these slots so they will not distort, then bolt to the angle to reduce the centre section to drawing, you will have to complete with files, using a Woodruff key cutter to deal with the wee flute. Grip with a Mole wrench to radius the ends over a mandrel, then mill or file the flanks to complete the profile.

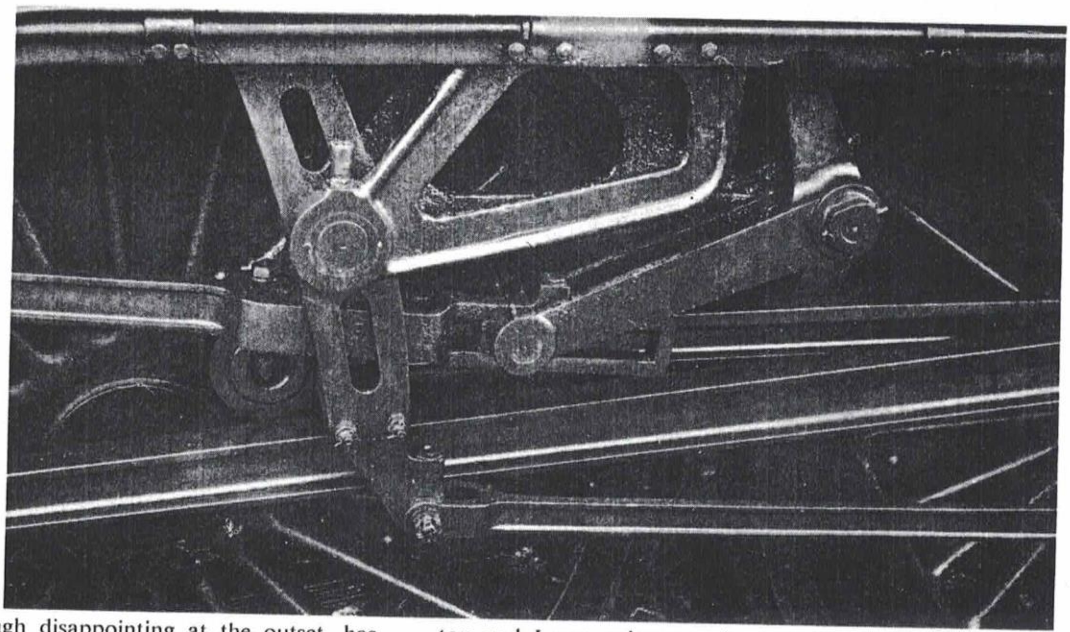
As we can now couple the union links to their respective drop arms, I may as well tackle the valve gear pins next, even though each will have to be made to place. Chuck a length of 7/32 in. (or 6mm) diameter silver steel rod in the 3 jaw and first reduce over an 11/64 in. length to .110 in. diameter, screwing 6BA. Use the vernier calipers over the union link fork to establish the plain length of pin required and turn this on, then part off to leave a full $\frac{1}{16}$ in. head; reverse and face off. To complete, mill two flats on the head to suit one of your spanners, such being more important than the 11/64 in. dimension shown.

Whistons have a marvellous selection of washers to suit most jobs and in days past I purchased one of their 'small nut



Valve gear on SIR NIGEL GRESLEY. The A3's and A4's were generally similar in this area, save for the valve crosshead guides.

FLYING SCOTSMAN with the lever well down, captured on film for us by John Michael Foster



mixtures' which although disappointing at the outset, has proved a real Alladin's Cave. For amongst the mixture are 6BA nuts which are castellated for split pins and although plain hexagon in form, only require turning down to a diameter at that end to arrive at authentic A3 valve gear pin nuts, whereas machining them from hexagon bar is extremely tedious.

Combination Lever

This is the first part we come to where the option exists to use a lesser and cheaper section of material and bending to shape; it is simply not worth considering if using chrome vanadium steel as specified as it has poor bending qualities, and in mild steel the part is out on the borderline strengthwise, as was demonstrated during IMLEC at Bristol a couple of years back; our requirement is two $3\frac{1}{2}$ in. lengths of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. section material. Again this is a minimum section, so do mark it out carefully, after which it is a case of dealing with the three pin holes in the machine vice to the degree of accuracy specified on the drawing detail. This time there is a fair amount of metal to be removed to arrive at the section depicted, so careful planning is required as to the machining sequence when bolted to the angle, so that packing can easily be inserted when the bar is turned over to complete the section. Even so, the 30 deg. sloping section will have to be filed, unless you are willing to tilt the angle over by said amount, and here a word of warning. Be careful when filing across the lever not to leave any marks, for these will be sources of weakness; for preference draw file along the length of the lever.

Although the bottom of the lever can be radiussed over a mandrel with an end mill in the normal way, around the top pair of holes such operation would be fraught with danger; filing buttons will be enormously helpful here. For the smaller radius, chuck a length of $\frac{5}{16}$ in. steel rod, face, turn down to 5/32 in. diameter over a 3/32 in. length and part off at $\frac{1}{4}$ in. overall; repeat. Heat to a bright cherry red, roll the buttons in casehardening powder, then heat and dip once more. Fitted from each side of the lever and gripped in the bench vice, you can now confidently file down to the hardened surfaces and get a decent result; turn up another pair of buttons for the 7/32 in. hole and $\frac{3}{16}$ in. radius.

Deal with the boss for the oil cup next, then carry on and complete the profile; mark off, drill and tap the oil holes as shown. This particular pattern of combination lever always look slightly archaic to me with it radius on each corner at the top and I can only guess it results from the longer valve travel later adopted and the need to clear the radius rod fork end. Anyhow, the lines I have drawn indicate both the extent and shape at the top of the lever; produce same with a file. To complete, turn up the bush to drawing, press it home and ream through the 5/32 in. hole again, remembering always to drill an oil hole into the bore of the bush.

Radius Rod and Slide Block

We can move in several directions at once now, but let us continue in logical order with the radius rod. This time our requirement is two $8\frac{5}{8}$ in. lengths of $\frac{5}{8}$ in. square chrome vanadium bar and there is a lot of surplus metal to be removed! Start by drilling the pair of No. 23 holes squarely at $6\frac{3}{8}$ in. centres and a pair of identical holes at the ends of the slot for the slide block, which allows us to use 4BA bolts to attach to the length of angle and to begin to deal with the section of the rod. Before going too far, mark off the 5/32 in. slot to accept the expansion link drill a row of $\frac{1}{8}$ in. holes along same and use an end mill to form most of the slot. As a 5/32 in. end mill may wander when you try to clean up that end of the slot, drill a 5/32 in. hole to form the end radius if you like; the other end will have to be filed square. Drill a 5.50mm hole to start forming the fork at the combination lever end of the rod, saw down and mill out to size, then radius this end over a mandrel. To be absolutely correct, there is a slight taper along the fluted length of the rod, 1/64 in. over nearly 6 in. length, which on all but Gold Medal standard DONCASTER's can be ignored, so bolt to the angle again, use an end mill to remove metal from the bottom edge, a Woodruff key cutter to deal with the upper edge, and the same key cutter to deal with the flute; all three operations will have to be dealt with in stages because of the great length of the rod.

Arriving at the portion for the slide block, turn the rod over and grip in the machine vice. Use a $\frac{3}{16}$ in. end mill to deal with the slot against a piece of $\frac{1}{4}$ in. square silver steel bar as gauge, then deal carefully with the profile using the same end mill. File the ends of the slot square, then relieve them as shown on the detail, then deal with the oil boss to complete.

Wee lumps of gunmetal or bronze are required for the slide blocks; first reduce them to $\frac{3}{16}$ in. thickness, then drill and ream the 5/32 in. hole. Now it is a matter of milling the top and bottom working faces to a good fit in the rod, keeping the hole nice and central, after which the ends can be completed to drawing, and the vital oil hole drilled.

Expansion Link and Trunnion

Staying in logical sequence where outside valve gear only is fitted, we come to the expansion links, a detail I seem to like drawing at $1\frac{1}{2}$ times scale, so they are half full size on Page 23. Our material requirement is two $3\frac{1}{4}$ in. lengths of 1 in. x 5/32 in. chrome vanadium bar which have to be marked out very carefully and accurately as there is very little we can machine, or at least very little that I will specify as being machined. First deal with the 7/32 in. hole for the bronze bush and the four No. 44 holes for the trunnion attachment, although these latter may be drilled back later from the trunnions. Next saw away as much of the surplus metal as possible to reveal the profile, in fact you can file to complete same at this stage if you wish, making filing buttons to deal with the radius at the pin. The hole for the oil cap is a real pig, for which you will have to braze lengths of rod to the drills to get at it, and likely make an extension for your tap wrench. 25 years back when I was working in the shipyard and had a problem like this, I used to hand a sketch to either the tool room or blacksmith in the morning and collect the finished job before I went home that night, reckoning in this I was not cheating as I preferred to build engines, not jigs and tools. Now I don't have time to build, saving it up for retirement says he!

All this leaves the slot, for which drill a row of 7/32 in. holes as closely spaced as possible. Use a square file to break the holes into one another, then change to a smooth flat file and deal with the convex surface to line, taking lots of care to get it right. Now with a half round smooth file, deal with the concave face a little at a time and using a length of $\frac{1}{4}$ in. silver steel rod as gauge until it is a good fit in the slot from top to bottom. This description may sound crude, but checking an identical form of expansion link on my K1/1, I found the maximum error was .003 in. over the whole length of the worst of the pair of links, whereas on the single occasion I tried to mill a pair of links, the end mill tended to go in a straight line.

For the trunnions we need four $2\frac{1}{2}$ in. lengths of $\frac{3}{4}$ in. x 5/32 in. section mild steel; you may well have to start with $\frac{3}{16}$ in. thick material. Offer up to the links in turn, mark on the profile and saw roughly to line; next mill the section to drawing. Fit the trunnions back to back and drill a 7/32 in. hole through for the trunnion pin. Turn the latter up from $\frac{1}{4}$ in. silver steel rod, leaving an 11/32 in. length at $\frac{1}{4}$ in. diameter in the middle to suit the slot in the expansion link, and turning on 9/32 in. lengths at 7/32 in. diameter at each end; an extra $\frac{3}{16}$ in. length at $\frac{3}{16}$ in. diameter on the RH inner as lubricator drive. Assemble the whole, drill the No. 44 holes and bolt together, then braze the pin to the trunnions using a minimum of spelter to avoid spoiling the bearing surfaces. Saw out the redundant centre portion, tidy up to be flush with the trunnion plates, then tidy up the profile of the trunnions to match that of the link. Only the lightening holes to be dealt with, 7/32 in. slots which in $\frac{1}{16}$ in. thick material are best dealt with by filing, the trunnions can if you like be bolted back to back to double the material thickness, when it does become feasible to mill the slots.

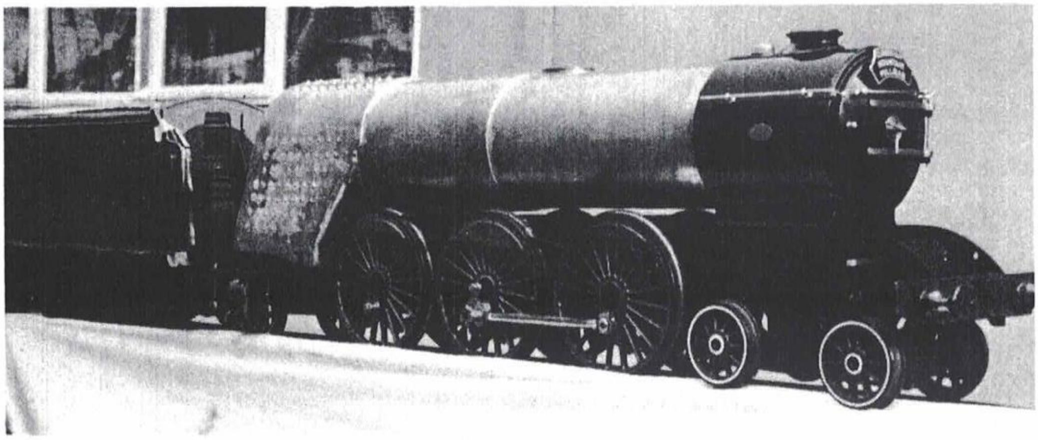
Die Block

Where is the die block detail?; don't say I've missed it out again; I have you know, unless your eyes are better than mine! Never mind, most of us know what a die block looks like, so I only have to fill in the dimensions. Overall length wants to be 13/32 in., the ends radial, with thickness to match both slot and expansion link at 5/32 in., material of course being bronze or gunmetal as for the slide blocks just made. Drill and ream centrally at 5/32 in. diameter for the pin and it is now a matter of bedding the working surfaces in to match the expansion link slot. This single component is the most prone of all to wear on an A3, be it large or small, so to help achieve a reasonable service life, make the fit a tightish one initially; it will soon ease when you start running.

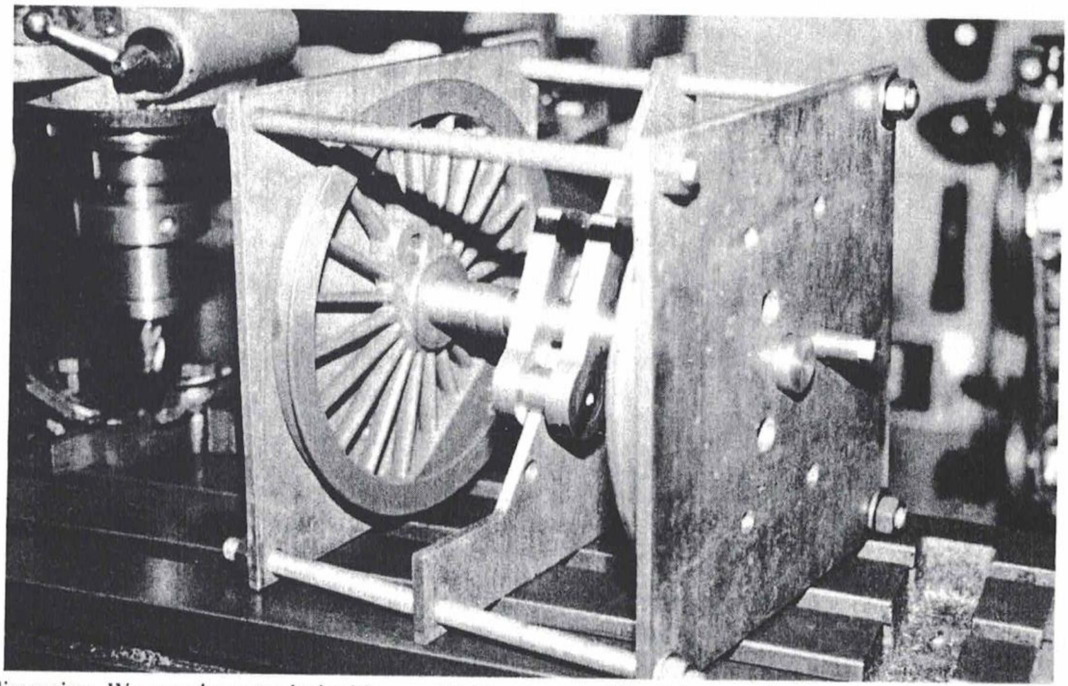
Fit the expansion link and die block in the radius rod slot and press in a plain length of pin to be flush with the outside faces of the rod, a bare 11/32 in. is indicated. Fit each trunnion to its expansion link bracket bearing, slide the expansion link into position and bolt up, and I should have said about countersinking the No. 44 holes on the inner trunnion for 8BA screws, then connect the end of the radius rod to the top of the combination lever with a plain pin, pressed home. I hate the use of temporary pins when assembling valve gear, anything else for that matter, preference being to assemble properly one component at a time, when any tight spot will manifest itself; locating a tight spot when everything is assembled can be a real problem.

Lifting Arms

Of all the items to be made this session, the lifting arms can be the most tricky, as they must align on the weighshaft for accurate valve events, more so than usual with the derived inside gear, and it is relatively easy to be a few thous out over a 1 31/32 in. length from square to slide block pin. The easy way out is that which I suggested when machining the weighshaft, but let us at least try to do the job properly for the satisfaction this provides, for which we require a simple jig. Take a 3 in. length of, say, $\frac{3}{4}$ in. x $\frac{3}{16}$ in. BMS bar and in the centre of a $\frac{3}{4}$ in. face, drill 7.90mm and No. 23 holes at 1 31/32 in. centres. Chuck a length of 5/32 in. rod and ease over a $\frac{9}{16}$ in. length to be a sliding fit in a No. 23 hole, part off at $\frac{3}{4}$ in. and press into the base. At the other end, insert the weighshaft itself with the $\frac{5}{16}$ in. diameter shaft 1/32 in. proud of the base; set the square as accurately as you can, though as any error will be repeated on both lifting arms it is not absolutely critical, the jig will ensure alignment. The arms will machine from $\frac{1}{2}$ in. square steel bar; first reduce the thickness to $\frac{7}{16}$ in. then drill a 7/32 in. hole at a full $\frac{1}{4}$ in. from one end; radius over a mandrel with an end mill to



Bill Holland is making fantastic progress with his 'Pacific', though I tell him I have never seen a full size A3 so far advanced but still minus cylinders!



Bill's fairly simple but highly successful crankpin setting jig. The jig starts off with three identically drilled plates, the centre one being cut away and the whole aligned with rod bolts and spacers.

arrive at the 15/32 in. dimension. We now have to deal with the $\frac{1}{4}$ in. slot to expose the two arms to clear the radius rod end. I remember now that on my K1/1 I cut the arms separately from 3/32 in. steel sheet, the square end boss being spigotted to accept them, but this time I reckon it will be better to grip in the machine vice and use a $\frac{3}{16}$ in. end mill to form the slot, a little at a time to minimise overhang from the vice jaws, filing to complete the required shape at the boss end.

Next task is to transform that 7/32 in. diameter hole into a square one, for which the file is the only real answer. You now have behind you the experience of fitting the return crank to its square; this time the length of square is far greater, the load much less, so as long as you get a decent fit over say 50% of the length then all will be well. For the radius rod pin bosses, chuck a length of $\frac{3}{8}$ in. steel rod, face, centre, drill No. 23 to $\frac{1}{4}$ in. depth and part off a full 5/32 in. slice; reverse and clean up, then repeat another three times. Next chuck a length of $\frac{1}{4}$ in. rod, face, centre, drill No. 22 to $\frac{1}{4}$ in. depth, part off a full $\frac{3}{16}$ in. slice, then reverse and clean up to $\frac{3}{16}$ in. length as a spacer to fit between the pair of bosses. Assemble to the jig, scallop the arms to match the end bosses and you can complete the flanks of the arms at this stage if you wish, then coat the base of the jig with marking off fluid to prevent spelter adhesion before brazing up.

DONCASTER can of course be either right or left hand drive, depending on the period in her life you choose to depict her; for somebody as ham-fisted as me RH drive is far easier, plus I could never fire a 'Pacific' properly left handed in full size; right handed neither for that matter! All this means that a reversing arm has to be fitted to one of the pair of lifting arms, and if you made the base of the jig from $1\frac{1}{2}$ in. wide material instead of the $\frac{3}{4}$ in. I originally specified, then it is easy to add another No. 23 hole at 31/32 in. vertically above that for the weighshaft. The arm is from $\frac{1}{2}$ in. x 5/32 in. steel flat, marked off and reduced to $\frac{1}{8}$ in. thickness below the reach rod pin hole, which latter is next drilled and reamed, when you can radius this end over a mandrel, scallop the other to sit on the lifting arm boss, then deal with the flanks to complete. Pack the main portion of the arm up 5/32 in. from the base of the jig, braze up, then thoroughly clean and oil to prevent rust forming. You can now erect the weighshaft and connect to the radius rods.

Writing is something I find totally absorbing, yet I am soon put in my rightful place when I pick up a Wilbur Smith novel and marvel at his use of the English language, so utterly descriptive; oh that I could write just a single sentence of his quality. TV programmes too like 'Countdown', 'Blockbusters' and 'Call my Bluff' show how little we know of the whole vocabulary available to us. Yet my engineering training has taught me the exact opposite, simplicity is the key; to be flamboyant is likely to introduce ambiguity which leads on to scrappage; I learnt that simple fact more than once in industry. This thought sprang to mind this evening simply because I beat the experts to the 'Countdown Conundrum' by all of 10 seconds, but only because the word was 'eccentric', a very familiar one and the next to receive a mention!

Eccentric Rod

There is no point in making the proper rods until we know their exact length between centres, for which a dummy rod is required. Take two 4 in. lengths of $\frac{1}{2}$ in. x $\frac{1}{8}$ in. BMS flat and at $\frac{1}{4}$ in. from the end of one piece, drill and ream a $\frac{1}{4}$ in. hole; at 5/32 in. from an end of the other piece, drill and ream at 5/32 in. diameter. Although it is possible to clamp the two pieces together to form a temporary eccentric rod, I much prefer a bolt fixing, for which 2BA is ideal, so drill a plain $\frac{3}{16}$ in. hole in one piece and cut a $\frac{3}{16}$ in. slot in the other to achieve a centre distance of $6\frac{1}{2}$ in. $\pm \frac{1}{4}$ in., then there is plenty of scope for adjustment.

Remove a front cylinder cover, sit a d.t.i. on the exposed piston and turn to front dead centre; rather surprisingly there is little or no dwell on the pointer at the dead centre, so the setting is accurate. Now adjust the length of the dummy eccentric rod so that when the radius rod is moved from full forward to full back gear, no movement is transmitted to the valve. Repeat the procedure at back dead centre, when again no movement should be imparted to the valve, though practically there will be some movement, a matter of less than .005 in. if you and I have both done our jobs properly. Such a small amount can well be left to the detriment of back gear, it is not worth worrying over, but if you are unlucky enough to have a more major error than this, then equalise same between fore and back gear.

For the eccentric rods proper we need two $7\frac{1}{4}$ in. lengths of 1 in. x $\frac{3}{8}$ in. chrome vanadium steel; the $\frac{1}{16}$ in. set we can achieve quite happily once the rods are complete. Bring up the dummy rod, remembering each side of the engine will have to be set separately and that the centre distances are likely to be at variance, and drill off as a first step. Grip the bar in the machine vice, with a stub of $\frac{1}{4}$ in. silver steel rod in that size hole, and with a d.t.i. held in the 4 jaw chuck, set the peg to be true. Change to the 3 jaw and drill through at $\frac{7}{16}$ in. diameter, then use a 90 deg. Rosebit to open out the mouth of the hole towards $\frac{5}{8}$ in. diameter. It is worth considering making up a special 'D' bit to cut the .563 in. diameter recess to $\frac{3}{16}$ in. depth for the bearing, that is what I did for my K1/1, though after 17 years it still remains to be fitted!, otherwise you will have to bore out to size, holding the tool in the 4 jaw.

Mark off the three cap fixing holes, drill them now at $\frac{3}{4}$ in. pitch circle diameter (p.c.d.) to show where the bosses will come, then turn up a special mandrel to suit the rod end before sawing metal away and carefully milling the $\frac{3}{8}$ in. radius to leave the bosses to be filed to complete. Next job is to mill the section, that $\frac{3}{16}$ in. dimension becoming $\frac{1}{8}$ in. for the moment by ignoring the $\frac{1}{16}$ in. set, then deal with the fork end. Bolt to the angle attached to the vertical slide, packing the fork of course so that it does not distort, then set over to mill the edge closest to the chuck and use a Woodruff cutter to deal with part of the flute. Turn the rod end for end, deal with the second edge and complete the flute, then tidy up with files.

I should have stressed much earlier on that all these machining operations produce burrs and sharp edges, very sharp ones which can cause a very nasty injury. Whilst it is possible to wear protective gloves, such tend to make one extremely clumsy, the real answer being to rub a file over the sharp edges before removing the job from the machine, then take special care in cleaning the job up whilst held in the bench vice. I regularly get quite deep cuts in my hands when handling printing paper, something one cannot remove the sharp edges from, but paper is far less dangerous to handle than newly machined metal parts.

The double row self-aligning ball bearings as employed on the Gresley engines used to be difficult to represent authentically in miniature – until I discovered Rose Bearings products back in the 60's, when I used them to good effect in industry. There are myriad variations, but those we require consist of a hardened steel housing in which runs a hardened steel ball. A primary application is control rod ends in aircraft, but they are perfectly suited to our rotary application and are highly recommended. The only problem is locating a source of same, thus I give the manufacturers address so that you may ask for details. Once I did have the rediculous situation when I approached Rose Bearings of being told that RBJ201L had never existed, this despite my having both literature to the contrary and actual examples in my hand. Reeves did ask me for details some years back as they wished to stock same, but as nothing has appeared in their Catalogue, I am wondering if they too had problems with the manufacturer. The bearing is vital to the whole concept of the valve gear, so I do trust that a supply will become available to builders, when you simply press the housing into the rod and assemble over the return crank pin.

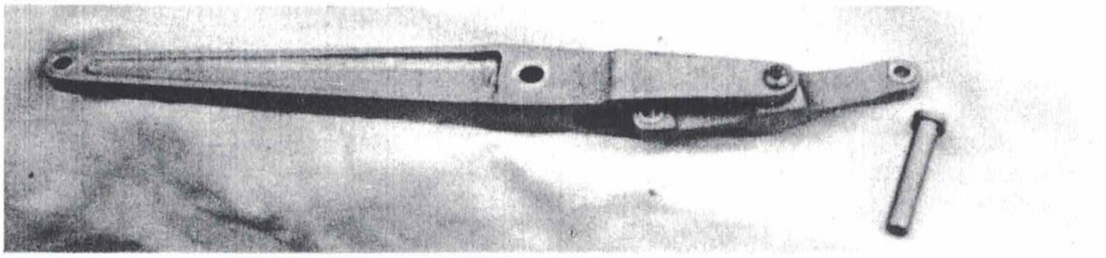
2:1 Lever

That completes two sets of valve gear, all we have to do now is generate movement to the inside valve by medium of the 2:1 gear. This part of the valve gear has been much maligned, wrongly so in my humble opinion, for MALLARD was so fitted when achieving the world record for large steam locomotives and there are plenty of preserved examples running happily with the gear today. When the Churchward design team broke up just prior to WW1, very few made a name for themselves on other railways, with a notable exception in Harold Holcroft who joined Maunsell at Ashford on the SECR. Not only did Holcroft influence Southern locomotive design, but he assisted Gresley in solving his conjugated valve gear problems, indeed there is no doubt that what I have drawn here is Holcroft/GWR rather than LNER, even the details have a distinct Swindon flavour when compared to the rest of the valve gear. Incidentally, the huge eccentric for driving a separate set of inside valve gear on both Thompson and Peppercorn 'Pacifics' was equally troublesome as all the 2:1 gear put together, indeed LBSC almost had the answer on his HEILIN LASSIE with 2:1 gear.

There are two major faults in placing the 2:1 gear ahead of the cylinders as on the A3's, A4's and V2 'Green Arrows'. First is that after every run the smokebox has to be cleared of ash and char, right over the gear, and although the bearings are fairly well protected, they cannot be completely so, with resultant wear; the modifications as to the means of access over the years highlights this drawback. The answer is to site the gear behind the cylinders, as on the B17 class 4-6-0's, which eliminates the second problem, that of expansion of the outside cylinder valve spindles by an amount which obviously affects the setting of the inside valve, pushing it backwards. The chief merit though of placing the gear ahead of the cylinders is ease of access for service and maintainance; on the B17s it was rather inaccessible. In our scale the ash problem remains, though with care it can be largely negated, and valve spindle expansion is not such a major problem, for we are dealing with inches instead of feet on the material parts. Our most major problem is going to be in making the parts, as we cannot forge them as full size.

The lever starts out as a 7 in. length of $\frac{3}{4}$ in. square bar; yet another bin full of swarf! When carrying out such machining operations, I have a jam jar full of suds which I apply to the workpiece with an ordinary paint brush, the best use I can think of for the latter! I also brush swarf away with same; it means after a time that the suds jar fills with swarf and the cutters trim the paint brush bristles, but it is a small price to pay for good machined surfaces.

Mark off and drill the three holes initially to provide the means for bolting to the angle on the vertical slide, then reduce the thickness first to an even 17/32 in. Next deal with the 9/32 in. portion where the 1:1 lever fits; pack it carefully and put the bolt back in, then concentrate on getting a 9/32 in. slot towards the fulcrum. You will note that the radius at the fulcrum is not straight across the rod, but radiussed in turn, so release the end bolts and pull round the end mill to form most of same, in fact you will probably be able to do nothing about the doubled back radius at the outside. Still with the 9/32 in. end mill, open out the slot to 25/64 in. as shown. The next part is to reduce the bulk of the lever down to $\frac{7}{16}$ in. thickness to complete the fulcrum area, easing with files out to the 17/32 in. portion at the other end to keep the rather slender .07 in. section, though it is plenty strong enough for



Superb 2:1 and 1:1 levers made by Bill Holland

the job it has to perform. Next radius the '2' end of the lever over a mandrel with an end mill and mill the flanks to the fulcrum, packing up level from the angle and dealing with the flute at the same settings; turn over to complete machining said flutes. As with the inside connecting rod, completing the flutes at the fulcrum end will call for use of a 'windy grinder' to tidy it up. Now reduce the '2' lever end to $\frac{3}{16}$ in. thickness as shown, when you can either mill, almost as quickly file, the tapering section. That leaves profiling the '1' lever end, quite simple this as not too much metal is involved, drilling and tapping for the oil, or grease, supply at the fulcrum, then turning up and pressing in the bushes to complete, reaming them again when in place.

2:1 Gear and Fulcrum Pins

Something a bit more straightforward for a few lines!, and though I have detailed the pins from solid bar, they are simpler still to fabricate.

For the fulcrum pin, chuck a length of 7/32 in. silver steel rod, face the end and slightly ease the corner with a wee chamfer for ease of entry, then part off at a full 1 7/32 in. Next chuck a length of $\frac{5}{16}$ in. rod, mild steel will be perfectly OK here; face, centre, drill 5.50mm to $\frac{3}{16}$ in. depth and part off a full 3/32 in. slice. Press this on to the end of the pin, braze it in place, then chuck to clean up the head.

The 2:1 gear pins start as lengths of 5/32 in. silver steel rod, the 'L' bit to place, reducing over a 5/32 in. length to $\frac{1}{8}$ in. diameter. Change to $\frac{1}{4}$ in. mild steel rod, face, centre, drill No. 31 to $\frac{3}{16}$ in. depth and part off a full $\frac{1}{16}$ in. slice; braze this to the pin. Chuck by the shank of the pin, tidy up the head, then centre deeply as shown and drill No. 60 to half way into the relevant bearing bush and cross drill to complete the oil passage. When erected, a thin washer is fitted at the lower end, followed by a cross drilled hole for a 3/64 in. split pin.

Eccentric Road and Weighshaft End Caps

In my haste to move forward to the 2:1 gear, I have forgotten to tidy up the outside gear, four caps being required, so nobody can accuse me of wearing my DONCASTER cap in this session!

For the eccentric rod caps, chuck a length of 1 in. diameter brass bar, face and then turn the .563 in. diameter spigot to trap the bearing in place, the 1/32 in. dimension being nominal. Drill and bore out to achieve a working clearance both for the spherical ball and head of the securing pin; this can make the section a rather thin one when the outside is turned to drawing. Start parting off to the $\frac{3}{16}$ in. dimension shown, then turn on the flange and remaining profile before parting right off. Rub the outside face on emery cloth to remove any machining marks then make up the wee boss and braze it in place, tapping out at 10BA for a hexagon headed plug. Offer up to the eccentric rod to correctly orientate the boss, then drill through the three holes at No. 51, fit 10BA countersunk screw and profile the flange to match the rod. These caps were finished to a high polish, so use 'Duraglit' or similar to emulate same.

Weighshaft end caps are similar to those for the rear coupling rod crankpins, so chuck a length of $\frac{7}{16}$ in. steel rod, face and turn down to $\frac{5}{16}$ in. diameter over a 3/32 in. length. Centre, drill No. 22 to $\frac{1}{4}$ in. depth and tap $\frac{3}{16}$ x 40T before parting off at a full 5/32 in. overall; reverse and face off. Fit to the weighshaft to orientate the two flats correctly and I would file these on, or grip flat in the machine vice and end mill them. Fitting to a screwed spigot and then trying to mill them, I find the cap wants to revolve, making a mess of the job and in the extreme, breaking the end mill. Reassemble, drill for and fit a $\frac{1}{16}$ in. taper pin to secure.

1:1 Lever and Connecting Rod/Link

1:1 lever next, for which we require a $2\frac{1}{2}$ in. length of $\frac{1}{2}$ in. x $\frac{5}{16}$ in. bar; mild steel is acceptable here, though so little is required that we may as well stick to the chrome vanadium variety for uniformity. First drill the three 7/32 in. holes and as the centre distances allow, use the cross slide to get them accurate. Bolt to the angle, deal with the section to drawing, then profile before turning up and pressing in the bushes; that one was easy! Assemble to the 2:1 lever, when all we have to do is connect to all three valve spindles; we will deal with the outer pair first.

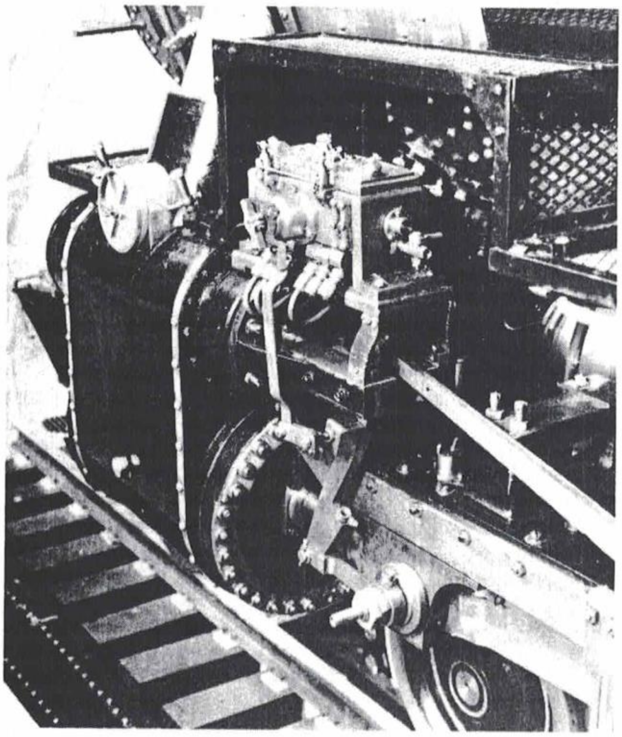
There is an awful lot to be said for turning up the end bosses from $\frac{5}{16}$ in. rod, assembling on a jig at 27/32 in. centres, then making the central part to fit and brazing up before fitting the bushes, but let me attempt to describe them machined from $\frac{3}{8}$ in. square bar as specified. Start as usual by drilling the pair of 7/32 in. holes, then bolt to the angle and start milling the section. Change to the machine vice to mill the fork to the $\frac{3}{16}$ in. dimension, a close fit over the end of the levers, then change to the mandrel and end mill technique to radius the ends. With a ball-ended end mill, that sounds good!, and very carefully holding with a Mole wrench, it is just possible to produce the circular end bosses as detailed, in fact if your mandrel is screwed at the end so that a nut can be fitted to hold the link firmly axially, so much the better. All you have to do now is complete profiling with files, a glib sentence if ever I wrote one!

The inside valve connecting rod uses the same $\frac{3}{8}$ in. square bar, the ends too are identical, but of course the bit in between is $3\frac{1}{8}$ in. longer. That extra length is useful for machining, but that is about all, as if the fluting is produced to scale then it does make the finished rod rather flimsy. I recommend you flute it on one side only initially and then assess the strength of same before dealing with the second face if at all. Practically the rod can only be seen from below, and then only with a mirror, so you can cheat here with only yourself knowing; I would be tempted to!

Valve Setting

I have already described 50% of the setting procedure in establishing the correct length of eccentric rod, leaving only the motion derived from the crosshead to be accounted for. Really we should wait until the reverser is complete and installed, the reach rod made and connected up, so that we can precisely set the engine in mid gear, full gear too, but I am sure you will want at least to make some check at this stage. Remove the front valve crossheads from both outside cylinders and sit a d.t.i. on the exposed valve spindle. Use a second d.t.i. on some part of the main crosshead on that side of the engine so that you can assess its approach to front dead centre, then connect a rubber tube to the front drain cock. With the engine in mid gear, turn towards front dead centre until you can both hear and feel air beginning to pass the front valve ports as you blow by 'mouth pressure'; this is amazingly accurate. Make a note of the d.t.i. reading on the valve spindle, then turn to front dead centre on the other d.t.i., when you will have an accurate reading on the first of the port opening. Repeat on the back port at back dead centre, blowing through the back drain cock, compare the two port openings and you simply move the valve on its spindle to equalise said openings. You can now carry on and check port openings, both at the dead centre positions and maximum openings at different cut-offs, in other words play to your hearts content before repeating things on the other side of the engine.

Recouple the 2:1 gear, remove the rear steamchest cover on the middle cylinder and fit a d.t.i. to the exposed valve spindle. The second one fits to the middle crosshead, the rubber tube to the drain cocks again, when you repeat the procedure and centralise the inside valve, only I recommend you set it .010 in. forward in the 'cold' condition to allow for valve spindle expansion. As a final check on your workmanship, see how much the valve will move to take up all the slack in the 26 pins/bearings on the long journey from the return cranks, it was quite an eye opener full size.



Reach Rod

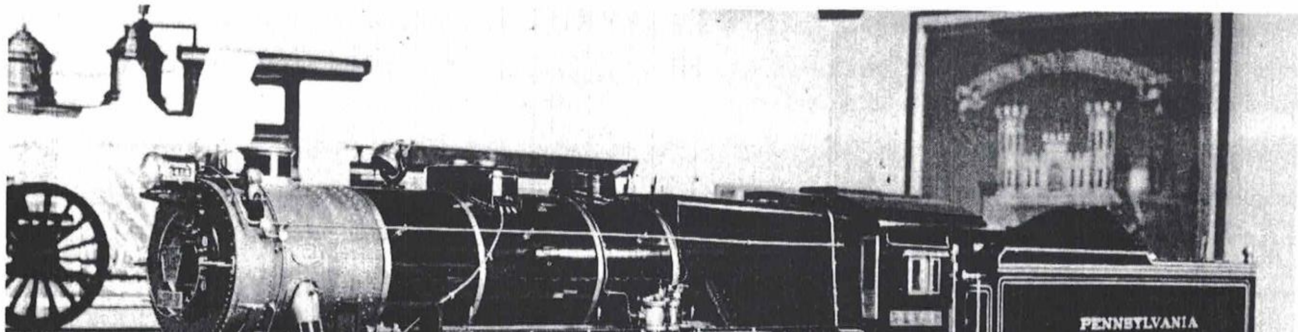
Because the reach rod is almost two feet long and has to pass close to the firebox, which latter can have a tendency to 'grow' during manufacture, it is very much a make to place item; the necessity to use 5/32 in. thick material is not going to make the job any easier either, unless a ready source of same can be unearthed.

For the front section we need a 10 in. length of, hopefully, $\frac{3}{8}$ in. x 5/32 in. section, which is first heated and bent to a swan neck, before brazing on a $\frac{3}{4}$ in. length of $\frac{3}{8}$ in. square bar. Reduce the end first to $\frac{5}{16}$ in. thickness, drill and ream the 5/32 in. hole, then deal with the 5/32 in. slot to accept the reverser arm. Radius over a mandrel with an end mill, then complete the front profile to drawing.

The back end is best left to be dealt with on completion of the rear section of the reach rod; again heat, bend, drill, radius and blend as a first operation. At its front end, machine up the $\frac{7}{16}$ in. x $\frac{1}{4}$ in. block, mill in the $\frac{5}{16}$ in. x 5/32 in. groove, then braze on to arrive at around the $13\frac{7}{8}$ in. dimension, one you will have to check to place; alternatively allow for adjustment at the back end of the front section. Basically it is a question of both reverser and die blocks coinciding in the mid gear position, achieved by adjustment of the overall length of the reach rod, so assess and then mill the $\frac{5}{16}$ in. wide spigot on the back end of the front section clamp together and drill the three No. 34 holes right through for hexagon head bolts.

Despite the difficulty of some of the description, this session has proved good therapy for yours truly, and much has been achieved; next time we can add some of the 'clever bits'.

I don't really need any excuse to feature this 2 in. scale Pennsy K4 'Pacific', though of course these engines were the inspiration for DONCASTER and all her sisters. The photographs came my way from LLAS reader Fred McCarthy in New Jersey and served as my introduction to builder Edward Steelman Sholl, a character and a half if ever I knew one! Ed's dad ran No. 5414 on the Pennsy's famous Atlantic City train, THE NELLIE BLY, so his replica is a labour of love, but that is only the beginning of a fantastic story. Ed's grandfather was fireman of the 1831 Stephenson built JOHN BULL and he lives in the home of the engineer of that historic engine, so preserving the link. Mention of link, he still has strong ties with England, his father being born in Surrey, a relative was Poet Laureate who is entombed in Westminster Abbey, and Ed tells me the black sheep of the family was Captain Kidd! Sadly No. 5414 must be sold, the sum required being in keeping with the work of art that she is, so if any reader would like to give her a good home, then please contact me.



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

by: **DON YOUNG**

Part 11 – Reverser, Brake Gear, Lubricators and part Sanding

Although there will be some light relief in this session, much of it will be heavy going, though infinitely satisfying nonetheless, a perfect example of this being the reverser.

Reverser

Newly refitted, this reverser could be extremely stiff to operate, a reason why many an apprentice at Doncaster managed to drive a Gresley 'Pacific'. Once the newness had worn off however, this reverser was a delight to use, being just about perfectly positioned, especially on a LH drive engine. Mention of LH reminds me to say that what I have drawn is for RH drive, LH being a mirror image of same, though this only affects the stand and shaft.

The stand will test both our resolve and patience, so this is the ideal place to start this session, when everything else will be downhill! Cut the base 2 in. square from $\frac{1}{8}$ in. or 3mm thick steel, then the main vertical member, on the inside, from the same material, size $3\frac{1}{8}$ in. x approximately $2\frac{1}{4}$ in. Next deal with the outer bearing plate, size $1\frac{3}{4}$ in. x approximately 29/32 in. and 3mm thick. A prime consideration is to get the bearings in alignment for the shaft, and an aid to this is the stay between the two bearing plates, a $1\frac{1}{2}$ in. length of $\frac{1}{2}$ in. x 2.5mm section steel flat. Cut four $\frac{3}{4}$ in. lengths from $\frac{1}{4}$ in. square bar and square off to an identical $\frac{11}{16}$ in., then mark off and drill two of them No. 44 at 17/32 in. centres, offer up to the other piece, spot through, drill and tap 8BA. Bolt together and chuck both bearings in the 4 jaw, centre, drill and ream right through to $\frac{1}{4}$ in. diameter. Mill the end flanges, then file to profile before dealing with the bearing plates to accept same, the tapped portions of the bearing shell.

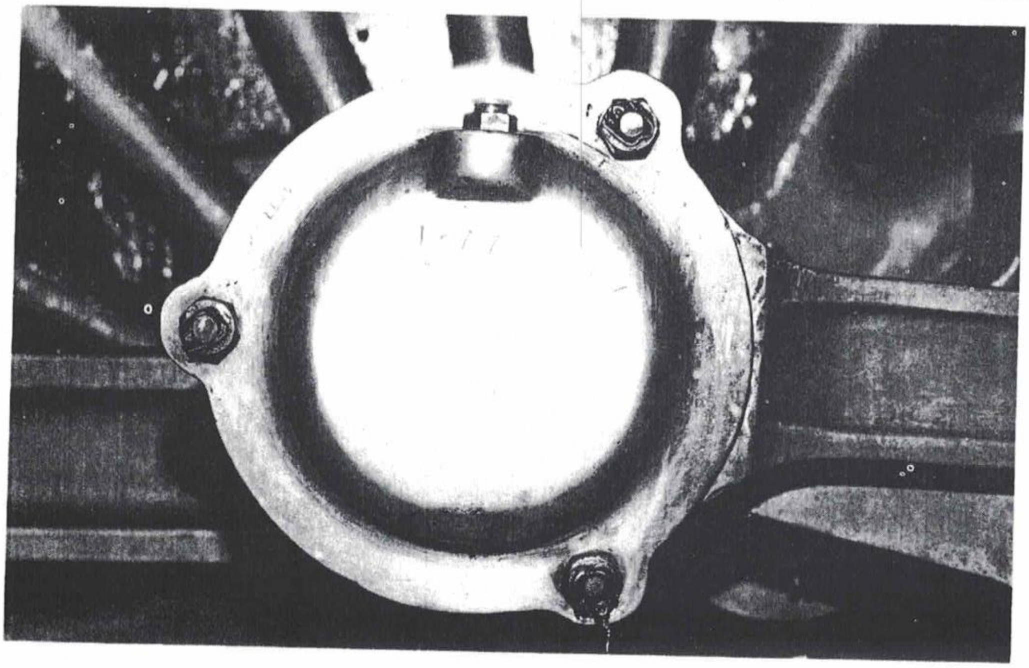
The intermediate vertical plate is from 1.6mm material and matches the profile of the outer plate save at the extremities. At the bottom, that dotted line means it sweeps down and picks up the bearing stay; at the top the extension is to form the fulcrum for the sleeve, where a stepped bush pressed into the plate is an alternative to the plain one sitting in the scallop as detailed. Between the intermediate and outer plates is another web stay, from 2.5mm material, made and fitted to place as shown.

The limit on travel in back gear is when the screw thread bottoms in the nut, but going into full fore gear, the lever is limited in travel by a $\frac{1}{4}$ in. x $\frac{1}{8}$ in. stop strip located on top of the baseplate, again as shown. I would use a mixture of 8BA screws and home made clamps to hold the stand together for brazing, cleaning off all the excess flux and then zinc spraying to avoid rust.

For the stool, take a 2 in. finished length of $1\frac{1}{2}$ in. x $\frac{1}{2}$ in. steel bar, reduce to $\frac{7}{16}$ in. thickness and then mill a $1\frac{1}{8}$ in. wide channel to $\frac{5}{16}$ in. depth to leave one flange at $\frac{1}{8}$ in. thickness. Now it is a question of tapering the second flange to match the mainframes, so the reverser sits no closer than 5/32 in. to the backhead cleading; drill all the fixing holes specified, tap as necessary from same and have a trial assembly, not forgetting the doubler as I have!

Shaft next, so first assemble the bearings and run the $\frac{1}{4}$ in. reamer through again, in fact it would be a good idea to have a temporary length of shaft fitted before brazing. First job is to square off a 2 in. length of $\frac{1}{4}$ in. steel rod and turn up the 3/32 in. thick collar from $\frac{3}{8}$ in. steel rod. The lever that fits to the screw starts as a $1\frac{1}{2}$ in. length of $\frac{3}{8}$ in. x $\frac{1}{8}$ in. BMS flat; drill $\frac{1}{4}$ in. diameter and No. 23 holes at $1\frac{1}{16}$ in. centres, radius the ends and file the flanks. For the reverser arm, start with a $1\frac{1}{2}$ in. length of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. BMS bar, again drilling the $\frac{1}{4}$ in. and 5/32 in. holes first. Next deal with the fork end to the dimensions shown, then mill away below the fork to arrive at the shape shown, the outer face of the lower part of the arm aligning with the inner face of the fork end. Check by assembling to the stand, then braze up, clean and erect.

For the screw, form the fork end first from $\frac{5}{16}$ in. square bar and then braze to a $2\frac{7}{8}$ in. length of 5/32 in. steel rod; chuck in the 3 jaw and screw the upper $1\frac{1}{8}$ in. length of rod at 32T.



A component I became very conversant with at Doncaster — the Eccentric Rod Cap protecting the double row self-aligning ball bearing.

To complete, drill and tap 10BA to 3/32 in. depth for the indicator strip, the latter being a length of 5/32 in. x .028 in. brass or phosphor bronze strip cut to length to place. Remember the backhead moves as the boiler heats up, relative to the reverser that is, so the indicator strip must be free to flex without impeding said boiler expansion. The indicator plate is highly polished brass and screws to the backhead cleading plate; mill the slot so that the indicator strip slides freely in same. When the indicator strip length is known, much later this, turn up the tapped bush and silver solder together, then cut the diamond shaped indicator after drilling the No. 51 hole; screw it in place.

We now come to an area where everything is interdependent, the sleeve, thrust plate and nut; let us deal with them in that order. Take a $1\frac{1}{2}$ in. length of $\frac{5}{8}$ in. square steel bar and first reduce to $\frac{9}{16}$ in. square, then chuck truly in the 4 jaw, face and turn down to $\frac{3}{8}$ in. diameter over a $\frac{15}{16}$ in. length with a round nose tool; centre and drill right through to $\frac{1}{4}$ in. diameter, then part off at a full $1\frac{1}{8}$ in. Rechuck by the $\frac{3}{8}$ in. diameter stem, face off to length, then 'D' bit $\frac{1}{2}$ in. diameter to 3/32 in. depth. The bottom face is relieved $\frac{5}{16}$ in. wide to 3/64 in. depth, a job for the end mill, then mark off and drill the four No. 51 holes before radiusing the corners of the flange. Chuck the embryo thrust plate, the remnants of the length of $\frac{9}{16}$ in. square bar, set the $\frac{1}{4}$ in. bore to run true, then face off to thickness and 'D' bit as for the sleeve, relieve the bolting face, align to the sleeve with a stub of $\frac{1}{2}$ in. rod and drill through the No. 51 holes to complete.

The sleeve still requires its fulcrum pins, so chuck a length of $\frac{3}{8}$ in. steel rod, face and turn down to 5/32 in. diameter over an $\frac{1}{8}$ in. length, then use a round nose tool to produce a radius down to 11/32 in. diameter as shown. The fulcrum bosses actually have to be elliptical to fit properly to the sleeve, so file them to shape, saw off and scallop to suit the barrel of the sleeve. It may be preferable to make a wee jig to hold the fulcrum pins in correct alignment for brazing, though I would simply clamp them to the sleeve and align by eye.

The nut is now plain turning from $\frac{1}{2}$ in. rod, bronze for preference, and if you have any problems finding a tap long enough to deal with the thread, then make one out of silver steel. PTFE washers are quite widely available, though you can always turn them up from rod as an alternative; assemble the whole and erect to the stand, engaging the screw.

Only the side plate to complete and I have already discussed alternative ways of making it, so carry on and then drill the six No. 44 fixing holes, offer up to the stand, spot through, drill and tap 8BA for hexagon head bolts; we have a reverser. Now you can establish the correct length of reach rod, arrive at this, erect and check out the valve gear.

Steam Sanding Valve

Full size there was a band brake over a drum on the weighshaft, actuated by a small vacuum cylinder, operated by means of a valve attached to the reverser stand. This is one refinement we can do without, but as the valve is rather prominent on the back of the stand, we can substitute in its place a steam sanding valve, the tapping being shown for same. On the drawing it states that the valve is a standard DYD fitting; sadly although true in 1983 when Sheet 11 was drawn, it is not so today, but hope springs eternal. Basically it is a 3/32 in. Globe Valve with a stud on the bowl of the valve body which screws into the reverser stand, and instead of an ordinary handwheel to operate, a lever like on the blower valve is substituted, all quite straightforward.

Brake Gear

We have already completed a large slice of the engine brake gear in the shape of the vacuum cylinders, which are erected and awaiting the brake shaft as connection; let us tackle same as the first piece part.

Chuck a length of $\frac{3}{8}$ in. mild steel rod, lead-free as we have to braze on the arms, face and turn down to $\frac{1}{4}$ in. diameter over a $\frac{5}{16}$ in. length to suit the trunnion bushes. Set the tool over to produce a taper over a 13/32 in. length as shown, then part off at a full $3\frac{3}{4}$ in. overall, reverse and repeat. The long arms from the vacuum cylinders, I would make from $2\frac{7}{8}$ in. lengths of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. steel bar. Mark out carefully to get the profile on the $\frac{1}{2}$ in. face, then drill $\frac{3}{8}$ in. and No. 30 holes at $2\frac{3}{8}$ in. centres. Next produce the $\frac{1}{8}$ in. slot at the fork end, pack it carefully, then bolt to the piece of angle we used to machine the side and valve gear rods, bolting this in turn to the vertical slide. Reduce the section with an end mill on the upper face, turn over, pack securely and mill the second face, remembering that the thickness increases to 5/32 in. at the shaft. Now it is a question of radiusing the ends, marking on the profile again and filing to line.

The small arms to the pull rods are from 12mm x 2mm strip, $\frac{7}{8}$ in. long initially and we want four pieces. Mark off and drill one piece, then use as a drill jig for the rest and I suggest you bolt them all together and complete by filing. Erect the brake shaft as shown, use a length of $\frac{1}{8}$ in. rod through the No. 30 holes, both sets of them for correct alignment, then braze up and clean. Full size brake gear was not painted, at least that was my experience, but so that ours continues to look the part, lightly zinc spray and follow up with a single coat of black undercoat, wiping with an oily rag once the paint is properly dry.

Brake Gear and Brake Shoe Pins

We now require our first pair of brake gear pins, to couple from the arms to the vacuum cylinders, so we may as well mass produce all 28 of them. I much prefer to make pins such as these in two pieces, a shank from plain steel rod which is thus bound to be the right diameter, and a separate head brazed on. I have described the method several times already in LLAS, so will avoid needless repetition this time. Slightly chamfer the end of the shank for ease of entry, fit a thin washer at each end, then cross drill No. 57 for the 3/64 in. split pin. Incidentally, when you come to erect the brake shaft to its trunnions, I trust you found the reason for the separate bushes, fitted from the outside of course.

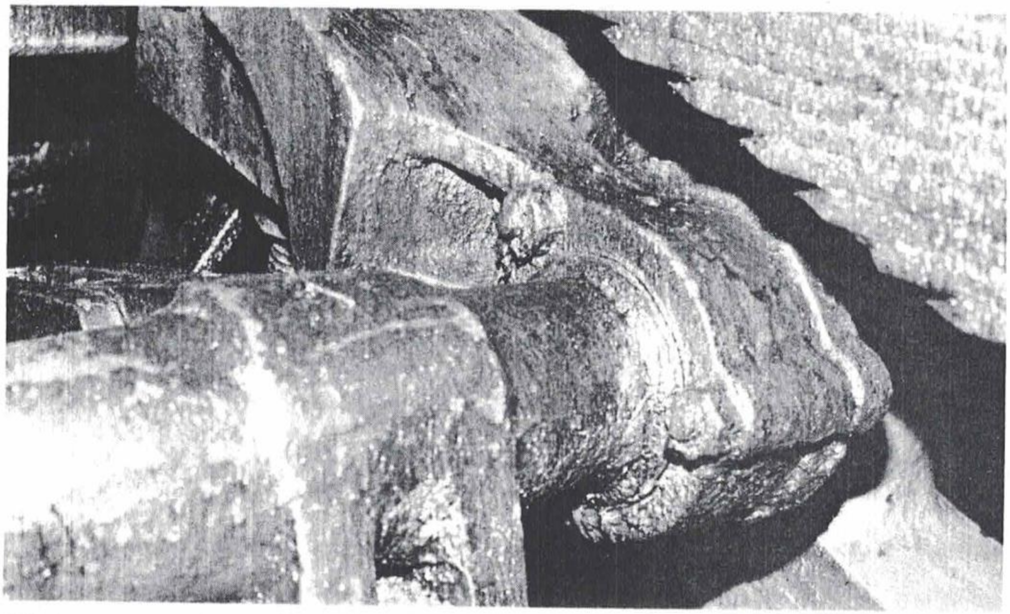
Brake Hanger Brackets

The pair of rear hanger brackets I would make in two pieces as for the brake gear pins, the main portion from 5/32 in. steel rod, brazing on the collar; assemble to the frames.

For the other four hanger brackets, start with a length of $\frac{3}{4}$ in. x $\frac{3}{8}$ in. BMS bar. Mark off and drill the four holes; you may do this from the frames when you will get the sizes correct, then with a 5/32 in. mandrel and end mill, produce the 11/64 in. radius around the No. 22 hole to full thickness, but leaving the $\frac{1}{4}$ in. wide bottom fixing flange. Mill the $\frac{5}{16}$ in. slot to accept the brake hanger, then the step at the top before sawing off to length and using filing buttons to form the end radii; file the flanks to complete. For the hanger pins, braze a length of 7/32 in. x 18 s.w.g. steel strip to the end of a $\frac{3}{4}$ in. length of 5/32 in. steel rod, offer up to the bracket and drill the No. 44 hole, then complete shaping to drawing.

Brake Hanger

Full size these were lovely forgings, ones we can best emulate by fabrications. First requirement is a simple building jig, a 3 in. length of, say, $\frac{3}{4}$ in. x $\frac{1}{4}$ in. BMS bar. Mark off and drill the pair of No. 11 and single No. 22 holes, fitting $\frac{3}{4}$ in. lengths of $\frac{3}{16}$ in. and 5/32 in. steel rod respectively. The top boss is a plain $\frac{5}{16}$ in. length of 11/32 in. diameter steel rod, drilled centrally at No. 22, but requires a 1/32 in. thick washer to position it correctly on the jig. The bottom boss is barrel shaped, from $\frac{7}{16}$ in. steel rod and tapering down to $\frac{3}{8}$ in. diameter, length being $\frac{7}{16}$ in. and drilled centrally at No. 11;



Brake shaft and trunnion on FLYING SCOTSMAN photographed by John Michael Foster.

fit in turn to the jig. Now take a 2 in. length of 5/8 in. x 5/32 in. steel flat and scallop the ends to suit the bosses on the jig, drill back the No. 11 hole from the jig and then complete the profile. Set the centre portion up 5/32 in. from the base of the jig, only coat the latter first with marking off fluid to avoid spelter adhering, then braze up. Make three hangers to this hand, then transfer the pins to the other side of the base-plate to make three more to the opposite hand.

Brake Shoes

From a cast iron brake shoe ring it would be possible to get at least a dozen shoes, so one would finish up with a spare set, the problem being to machine the ring, hence the specification of steel shoes, from 1 in. x 3/8 in. section bar. Saw and square off into 1 5/8 in. lengths, then simply file the concave face to match the wheels, though it will be just that little bit easier if the thickness is reduced to 11/32 in. first. Mark off and drill the No. 11 pin hole, then grip in the machine vice and mill the 5/32 in. slot to a tight fit over the hanger, the only tight fit on the whole of the brake gear – the rest wants to be a sloppy fit to follow the wheels. Reason for specifing the tight fit here is so that the shoes do not 'trip' and the top edge bind to the tyre, especially when running backwards; fit to the hangers.

Brake Beams

Mill the main portion of the beams from 5/8 in. x 1/8 in. lead-free steel flat, leaving the ends square at 4 5/8 in. overall for the moment. Chuck a length of 5/16 in. steel rod, face and reduce to 3/16 in. diameter over a 5/8 in. length, parting off at 13/16 in. overall. Grip by the 3/16 in. end and mill an 1/8 in. slot to 3/32 in. depth to accept the beam, then rechuck and radius the end to leave the 3/32 in. thick collar as shown. Braze the ends to the beams, clean and then radius the ends of the flat portion to drawing, drill each pair of holes to drawing to arrive at individual beams, then finish as the brake shaft to look smart. Erect the whole to the brake hanger brackets, to drill for and fit the 1/16 in. split pins.

Links and Compensators

For COUNTY CARLOW, the late Colin Archer supplied me with lots of punchings for the tender spring hangers; oh, that the brake gear links for DONCASTER could be made that way. My alternative is to make a single link as accurately as possible, case harden it thoroughly, and then use as a drilling and filing jig for the other seven pieces.

With only a pair each of compensators, a different technique is indicated; drill as a pair, bolt together and then file to complete, using wee filing buttons for the radii if you wish.

Pull Rods

The beauty of compensated brake gear is that the pull rods do not need to be of exact length for all the shoes to engage the wheels and apply the same pressure, though the pairs of pull rods want to be of identical length, indicating a simple jig for their manufacture, a length of BMS flat with 1/8 in. pins fitted at the requisite centres, this for the rear and intermediate pair of course. For my K1/1, I bent up the ends from 5/16 in. x 1/16 in. steel strip, finding this gave a better looking result than machining from square bar; I also used aluminium alloy bar for the base of my jig and lived to regret it when it melted! Fit packing in the slot, centre pop and drill through for the brake gear pin, then use filing buttons to radius the end of the fork before filing the flanks to the 1/4 in. width specified. Assemble over the jig, cut and file the 1/8 in. pull rod to fit between the ends and braze up; clean, zinc spray, paint and oil.

The leading pull rod has one end as we have already made; next chuck a length of 5/32 in. steel rod and reduce in stages to 1/8 in. diameter over a 1 13/16 in. length. Part off to leave a 11/16 in. length at 5/32 in. diameter and screw this 32T, then braze the rod to the fork end.

For the shaft pull rod, I would start with a length of 5/16 in. square bar chucked truly in the 4 jaw, reduce to 5/32 in. diameter over a 11/16 in. length and screw 32T. Next drill the four No. 30 holes and then reduce the thickness to 5/32 in. to match the rod, followed by the depth to 9/32 in., sawing off and then filing the end radii to complete.

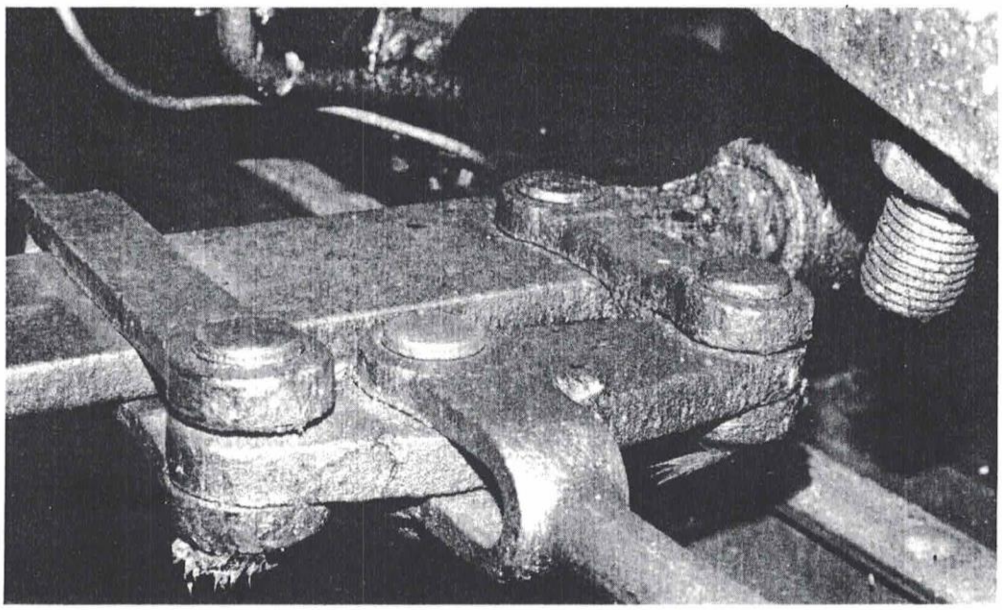
Adjuster

I much prefer the pattern of adjuster shown hereabouts to that detailed for the tender, it being plain turning from 5/16 in. A/F hexagon steel bar. Although to be exact it should be screwed L & RH, I doubt if any builder has the necessary LH tap, plus it is a simple matter to release the pull rod from the brake shaft to take up 1/2 turn, this being just about perfect adjustment as wear occurs. Erect the whole and if you have a source of vacuum then you can try the brakes.

Brake System

The whole brake system is shown diagrammatically on Sheet 4 as published in LLAS No. 21 and really the routes that the

John Michael swivels his camera to take in detail of the brake beam, compensator, link and brake pull rods.



pipes take on both engine and tender are dictated by what else is present in a particicular area; pipe runs are therefore more easily established on DONCASTER herself than I could ever arrive at on the drawing board. In the Engine Drawing Office at shipbuilders J. Samuel White & Co., my main work was with turbines, but I did help out for a week or two on the 'pipe section', checking the drawings of same against the actual installation on board. I came to the conclusion then that pipe diagrams would have been sufficient for the fitters to complete the installation, for they had taken very little notice of the drawings and gone their own, best, way. Main reason for this was that there were a number of trades all competing for the same space, with the electricians usually winning as their main cables were not very flexible. However, on DONCASTER, we must at least get the vacuum standpipes in their rightful place, they being $\frac{3}{4}$ in. off centreline as shown on the GA's. Piping can either be in copper or brass, with screwed elbows and tees made from the latter material, ditto pipe clips; use a mild grade Loctite or PTFE tape for thread sealing.

For the condensate valve, an important feature to avoid 'hydraulic lock' at vital moments, first chuck a length of $\frac{1}{4}$ in. brass rod. Face and drill $\frac{1}{16}$ in. diameter to $\frac{1}{2}$ in. depth, then follow up with an $\frac{1}{8}$ in. 'D' bit to $\frac{1}{4}$ in. depth. Next 'D' bit 5/32 in. diameter to $\frac{3}{16}$ in. depth and tap $\frac{3}{16}$ x 40T before parting off at $\frac{3}{8}$ in. overall. Use a square file or a punch to destroy the seat at the $\frac{1}{16}$ in. hole in the end, so that condensate will not be trapped when the 3/32 in. rustless ball is fitted. The connector is a 9/32 in. length of screwed brass rod, drilled through centrally at No. 51, a PTFE washer being trapped between the two pieces as the ball valve seating; this arrangement works well.

About the time I was drawing Sheet 11, LLAS reader Doug Hewson sent me samples of vacuum hose and connectors that he had just started to produce commercially. They are excellent and were drawn in, but I should have drawn attention to them in Trade News much earlier than this; my apologises Doug. Perhaps you will be good enough to provide us with the latest information on their availability and price to allow builders of DONCASTER to order same from you; others too of course.

Sanding Gear

At first sight it might seem confusing to have lubricators mixed up with the sanding gear, but they share the same area in part, in fact the lubricator drive had to be modified early on when the filler tubes were moved, too early for us to worry about, but it did indicate to me that care was required to avoid a clash. There is more to come on sanding on Sheet 12, but we can at least complete the driving sandboxes in this session, though before we even make a start, a decision is required as to which size of sandbox to construct.

Sand is vital for a 'Pacific' to be surefooted and when the A1/A3's first ran non-stop from Kings X to Edinburgh Waverley, there was concern in the latter stages when the weather was inclement, solved by introducing driving sandboxes of roughly double the previous capacity, ones that were better mounted too. We won't have any problem with lack of sand, it is the very last thing we want to get in our painstakingly produced motion!, so really the builder can make his own choice of driving sandbox either based on the period in which his engine is to be depicted, or simply for ease of manufacture; I am not going to influence said choice.

With either/or and separate handing, it was not economic to make patterns and produce castings for the sandboxes, plus in any case I much prefer to fabricate them, when at least they can be demonstrated to work. Start by making a wooden former $\frac{1}{16}$ in. less all the way round than the external dimensions shown, then cut a decent length of brass strip, $\frac{15}{16}$ in. wide and 1.6mm thick, to wrap around the former; trim off to a neat joint. Now cut end closing plates to match, the frame fixing one to include the bolting flanges, which can be trimmed off to size after silver soldering; remove the former and do just that. I forgot to mention that for the lower capacity sandbox, part of the top face is sloping to accept the filler pipe; again match the plate to the former. Never try to silver solder, soft solder for that matter, a vessel that will become completely sealed at conclusion, for it will try its best not to become fully sealed! In this instance you can either drill the No. 11 hole for the sand trap, or filler pipe at the top. For the high capacity sandbox, I doubt very much if you can make the filler tube flange a bolting one, so I suggest you make the stub a push fit into the top of the sandbox. Erect the sandboxes and you will find the frame stay in the way of the high capacity pair; it must be repositioned as shown. Mention of frame stays reminds me that I did not make mention of the later addition weighshaft stay other than on the frame plan; it is identical to that just referred to. Peter Baker in Durban telephoned me for that last bit of information, a costly reminder!, but was delighted to report that his chassis looks like the real thing. Also despite all the problems of importing items into South Africa, Peter reversed his earlier decision to make many of his own patterns in favour of my supply, this on sight of the 'difficult' items that comprised his first order; I take that as a great compliment Peter.

Usually I try to specify all holes in the mainframes on that detail, but this time I thought it wiser to leave the slots for the sandbox filler tubes until later; like now. The problem of course is to clear the weighshaft area, the lubricator drive too, and although the slots can now be cut after you check that all will be well, the rest cannot be completed until the running boards are fitted, though we can make the parts. The sandbox filler I would turn up from $\frac{7}{8}$ in. diameter steel bar, finally exposing the four lugs to bolt under the running board. Turn the lids from $\frac{1}{2}$ in. steel rod and do not make the fit to the filler too tight, as air has to enter as sand is displaced. Fashion the bar for the handle from 1/18 in. square bar and braze in place, then zinc spray and paint black. Full size there was an internal retaining chain to stop the lids from falling off the running board and getting lost, but for DONCASTER this would be the ultimate refinement.

Moving below the sandbox we come to the sand trap, a quite ingenious device. Chuck a length of $\frac{7}{16}$ in. brass rod, face and turn down to $\frac{3}{16}$ in. diameter over a $\frac{3}{8}$ in. length; lightly radius the end. Centre and drill No. 50 to $\frac{1}{4}$ in. depth and tap 8BA, then part off at a full $\frac{1}{2}$ in. overall. Reverse in the chuck, face and turn the $\frac{3}{16}$ in. spigot over a $\frac{1}{16}$ in. length, then centre and drill No. 41 to a bare $\frac{7}{16}$ in. depth. For the outlet flange, take a length of $\frac{1}{2}$ in. x $\frac{1}{4}$ in. brass bar, shape to suit the main part of the body and drill the No. 41 hole before chamfering the end at 30 deg. as shown; part off at $\frac{1}{4}$ in. overall. Braze to the body, then drill the No. 41 connecting hole into the main body. Next drill the four No. 50 holes in the flange, offer up to the sandbox, spot through, drill and tap the sandbox 10BA for hexagon head bolts; studs and nuts if you like.

The sand trap shields are one of the trickiest parts to make on the whole engine and two of them will be more than enough! Take a large piece of .015 in. thick brass shimstock and produce a dimple in it roughly as shown; I would do this on a block of lead using a ball pein hammer. Once satisfied with the shape, use tinsnips to cut the top plate to size, cut a skirt to match and carefully silver solder together. Drill the pair of No. 51 holes, offer up to the top of the outlet flange spot through, drill and tap 10BA, but only to 5/64 in. depth as we have another pair of tapped holes for the sandpipe flange immediately below. Drill a length of $\frac{1}{4}$ in. x 1.6mm brass strip for the latter, shape to match the outlet flange on the sand trap body, then drill and tap the latter 10BA again.

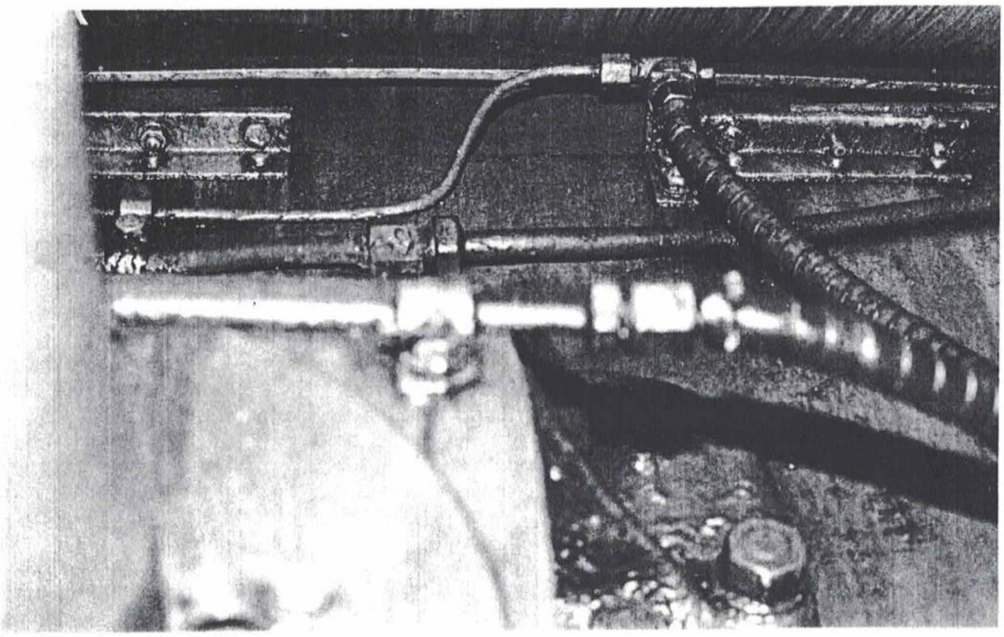
A steam sanding ejector made to drawing works and really well, thus is worth spending a little time on. Start with a $\frac{3}{8}$ in. length of $\frac{3}{8}$ in. x $\frac{3}{16}$ in. brass bar, chuck in the 4 jaw and at 3/32 in. from one end, centre, drill right through at No. 51, then follow up with a 5/32 in. 'D' bit to 9/32 in. depth. Transfer to the machine vice, set over at 35 deg. as specified, snape the corner with an end mill, centre and carefully drill at No. 30 into the main bore, changing to an $\frac{1}{8}$ in. end mill as you break into same. The nozzle is a $\frac{13}{16}$ in. length of 5/32 in. o.d. thin wall copper tube, chamfered at its inner end to allow sand to pass freely; the $\frac{1}{8}$ in. o.d. sandpipe and $\frac{1}{16}$ in. o.d. steampipe are cut to the required length to place, when the whole is silver soldered together. Erect roughly as shown, with the nozzle end at least $\frac{1}{4}$ in. clear of the track, this to avoid accidental contact with same, which would be disastrous.

Gravity Sanding Lever

The space left at the bottom RH corner of Sheet 11 was insufficient to detail the gravity sandboxes for the leading coupled wheels, but ideal to show the lever in the cab for same. Again we can make all the parts, but erection will have to await the cab sides towards the end of the saga. Uncle Frank Young would make adverse comment on this lever were he here today, for with an identical arrangement on the 'Hush-Hush' No. 10,000 as he experienced a bad slip getting away with her, he wrenched at the gravity sanding lever, and the bottom end of it broke his small toe! We won't have that problem, in fact ours will be to make things sufficiently robust to operate properly.

For the fulcrum, chuck a length of $\frac{3}{8}$ in. steel rod and turn down over a 7/32 in. length to 3/32 in. diameter. The flange was attached full size to the cab side with four rivets, but we will do best to produce a spigot on this side of the flange, 3/32 in. diameter and about 3/32 in. long, to fit through said cab side and then peen over the end to hold it firmly in place. The lever starts as a $2\frac{1}{2}$ in. length of $\frac{3}{16}$ in. x $\frac{1}{16}$ in. steel strip, drilled No. 47 at the end dimensions and No. 41 at the fulcrum. Radius and taper to $\frac{1}{8}$ in. at one end and 5/32 in. at the other, then turn up the wee operating handle and rivet in place.

The base of the lever guide is a $1\frac{5}{8}$ in. length of $\frac{1}{4}$ in. x 3/32 in. strip, drilled No. 51 at $\frac{1}{8}$ in. from each end. The curved guide can either be cut from the solid or bent up from $\frac{1}{8}$ in. x $\frac{1}{16}$ in. strip, in both instances offer up to the base and drill through



Pipe runs on the A3's always looked rather like an after-thought when compared with, say, a BR Class 4 Standard like 76026 with its neat pipe runs, grouped or singly, all properly clipped. The lower pipe is the mechanical feed to a coupled axlebox.

before radiusing the ends. The lever wants to be an easy fit between the guides, so turn up spacers from $\frac{1}{8}$ in. rod, drilled centrally at No. 51 and to be a full $\frac{1}{16}$ in. thick. Full size the base was rivetted to the cab side and the curved guide was held by studs, but if we use 10BA countersunk screws fitted from the outside, the slots being filled with plastic metal or the like, the end result will look perfectly authentic. There is a lot more to the gravity sanding, but this is as far as we can go in this session.

Mechanical Lubricators

When DONCASTER was on the drawing board, I was still able to discuss features with Gordon Chiverton, and she is the better for this. I had already decided to employ hydrostatic lubrication for the cylinders, as per full size until the Wakefield mechanical lubricator became virtually a Gresley standard. Because of the capability of DONCASTER on the track, something I am looking forward to sampling!, I wanted to provide positive lubrication to the main axleboxes and slide bars, but having played with scale size lubricators on my K1/1, I knew that fitting the internals into the tank left precious little room for any oil. Gordon suggested I extend the tanks below the level of the running boards, this to gain valuable extra capacity and yet still look correct, so this idea is his rather than mine. The whole subject of fittings supply for DONCASTER is a thorny one, but in many ways I am fortunate that Merlin Biddlecombe has been making some of my 'standards' for many years now, his whistles for instance are really superb! He is also the finest of machinists, witness the middle cylinder for DONCASTER that graced LLAS No. 24. Well, that particular cylinder block is now fitted to Bob Howard-Alpe's ROBERT THE DEVIL, no comment on Bob's choice of name!, and Merlin was mightily impressed with this engine when he delivered a machined pair of outside cylinder blocks to match. Steve Titley of GEORGE and DERBY 2P fame among many others, loaned Merlin his set of DONCASTER drawings with the result that Merlin announced last weekend his decision to build an A3. This means he will require the fittings for same, so hopefully he will be able to make a few extra in due course for other builders, though as I keep him busy in other directions as well, his production must necessarily be somewhat limited.

I am now going to tell a tale against Merlin, though I am sure you will agree that really it reflects great credit on him. Last year he undertook a large batch of LUCKY 7 safety valves for me, taking immense care with them and even making a new test boiler to check their operation. When it came to testing, he was horrified that the time it took for them to 'pop' and then reseat was of the order of four seconds, pressure falling quite dramatically in the process in the test boiler. I told Merlin this was a characteristic of the valve and that the pressure drop on his small boiler was irrelevant; on a proper locomotive boiler with steaming capacity for which the safety valves were designed, the pressure drop would only be a few p.s.i.g. I don't think Merlin really believed me, for it took me another week to prize them off him, and even then they were accompanied by a written report of test procedure and results. At the 4th DYD Rally, Merlin witnessed the operation of a LUCKY 7 safety valve on Fred Wills lovely 5 in. gauge TORQUAY MANOR, not quite genuine Swindon I know, but the perfect means of pressure control in that boiler. 'Is that one of mine?' asked Merlin, 'then its not bad' – that is putting it midly!

The lubricators are simply a variation on the LBSC theme, very little original design in them, so I will run fairly quickly through their construction. The tank is $\frac{3}{4}$ in. square x $\frac{15}{16}$ in. overall length including the baseplate. Cut the mounting lugs, pack them up to the $\frac{5}{16}$ in. dimension and silver solder together. The stand is 'L' shaped from $\frac{1}{2}$ in. x $\frac{1}{4}$ in. brass bar, height to match that of the tank. Relieve $\frac{1}{16}$ in. to 25/64 in. depth at each side at the top, drill and tap $\frac{1}{4}$ x 40T for the bearing, then move down $\frac{7}{16}$ in. and drill through at No. 44 before milling the relief for the pump body; reverse and 'D' bit $\frac{3}{16}$ in. diameter to $\frac{1}{8}$ in. depth for the spring housing.

For the bearing, chuck a length of $\frac{3}{8}$ in. brass rod, face and turn down over a 19/64 in. length to $\frac{1}{4}$ in. diameter and screw 40T. Centre, drill and ream $\frac{1}{8}$ in. diameter to $\frac{7}{16}$ in. depth and part off to leave a 1/32 in. flange at $\frac{3}{8}$ in. diameter. Turn up the $\frac{1}{4}$ x 40T backnut from $\frac{5}{16}$ in. A/F hexagon brass bar, then drill a $\frac{1}{4}$ in. hole in the tank and erect. The stand must sit on the bottom of the tank with the outlet hard against the side wall, so ease the $\frac{1}{4}$ in. hole with a round file to achieve this if necessary, then drill the No. 51 hole through the side wall into the stand. Remove the stand and chuck in the 4 jaw with the No. 51 hole running true, then drill to a full $\frac{1}{4}$ in. depth before following up with an $\frac{1}{8}$ in. 'D' bit to 11/64 in. depth; tap 5/32 x 40T not to disturb the seating just formed. To complete the stand we have to cut the inlet and outlet passages, the inlet a No. 55 hole to about 3/64 in. depth and then a wee groove filed down to the base, the outlet passage is simply a No. 55 hole into that at No. 51 already drilled from the outlet.

Outlet valve next, the body being from 5mm A/F hexagon brass rod. Chuck in the 3 jaw, face and turn down to $\frac{3}{16}$ in. diameter over a 5/32 in. length and screw 40T. Centre deeply to form the pipe nipple seat and continue at No. 55 to $\frac{7}{16}$ in. depth, then part off at $\frac{3}{8}$ in. overall. Chuck a screwed adaptor, fit the embryo valve body to same, face, turn down to 5/32 in. diameter over an $\frac{1}{8}$ in. length and screw 40T. To complete, 'D' bit at $\frac{1}{16}$ in. diameter to $\frac{3}{16}$ in. depth for the valve spring housing; erect with a 3/32 in. rustless ball.

For the pump body, start with a length of $\frac{5}{16}$ in. square brass bar. Chuck slightly off centre in the 4 jaw to deal with the ram bore; face, centre and drill No. 53 before reaming $\frac{1}{16}$ in. diameter to at least $\frac{9}{16}$ in. depth. Follow up with an 1/18 in. 'D' bit to $\frac{1}{8}$ in. depth and tap 5/32 x 40T, turning up a wee gland to suit. Part off at $\frac{7}{16}$ in. overall, rub the working face on a sheet of fine emery cloth laid on a flat surface, then grip in the machine vice, deal first with the 8BA tapped hole in the centre of the face to no more than 3/32 in. depth, then move on to the No. 55 hole as the port some full 5/32 in. below. Turn up the bottom plug from $\frac{1}{8}$ in. brass rod to be a press fit in the pump body, then we won't have to worry about getting solder into the finished bore, then file the radius on the outer face of the body, this simply to allow a little extra oil capacity in the tank.

The fulcrum bolt is from 7 or 8BA hexagon steel rod, turned to place so that the head just clears the tank wall, the spring being ground nice and square at both ends so that it will not 'trip' the pump body. For the ram, chuck a length of $\frac{1}{8}$ in. stainless steel rod in the 3 jaw, face, centre and drill No. 51 to $\frac{1}{8}$ in. depth, then part off a $\frac{1}{16}$ in. slice. As clearance with the gland is minimal, file a wee flat on the ram journal just made, fit a length of $\frac{1}{16}$ in. stainless steel rod to same and silver solder together. The length of ram wants to be the maximum possible without fouling the plug at the bottom of the bore, so that at the upper end of its stroke, there is still sufficient engagement in the gland/body not to jam up; this is important. For the spindle, choose a length of $\frac{1}{8}$ in. rod that is a tight fit in the roller clutch, the latter a proprietory item available from Messrs. Reeves, and a veritable godsend. Chuck in the 3 jaw, face and turn down to 3/32 in. diameter over a 3/32 in. length and screw 7BA, then part off at 1 in. overall, reverse and screw 7BA at this end over a 5/32 in. length. Chuck a length of $\frac{3}{8}$ in. brass rod for the drive disc, face, centre, drill and tap 7BA to at least 5/32 in. depth and part off a 3/32 in. slice. Mark off, drill and tap for the drive pin at $\frac{1}{8}$ in. throw; turn up the latter to suit. To make the roller clutch operate correctly, we need a means of holding the spindle on the return, a simple friction washer from fibre or the like is just perfect; erect.

Next chuck a length of $\frac{7}{16}$ in. brass rod for the roller clutch housing, face and bore out to accept the clutch and part off to length. Lay on a length of $\frac{1}{2}$ in. x 1.6mm brass strip, silver solder together, then mark off, drill the No. 51 hole and shape the arm. Fit the roller clutch, drill back through its bore and open out the arm to a clearance; press onto the spindle. The handwheel as well as being aesthetic, is also very useful for priming oil through; turn up to drawing from $\frac{1}{2}$ in. stainless steel rod and pierce to reveal the spokes. Tap the centre 7BA and secure with a 7BA nut to complete; all bar the lid. The latter is folded up from 1.0mm brass to be a tight fit over the tank, the corners being silver soldered for strength, although of course you can fit hinged lids as per Wakefield.

You will have to remove the delivery valve body to be able to erect to the running boards, and I won't be too popular when you come to put it back!, but at least I am spared your wrath until those running boards exist.

The feed nozzles are plain turning, but before dealing with them a few words about the oil feed. I envisage the neatest way to make the installation is a 3/32 in. o.d. thin wall copper tube as the feed rail or gallery, with tee pieces fitted to same and going to the individual feed points, either in the horns or the top slide bars. Now the problem is the different lengths of feed pipe to each outlet and how to get the feeds roughly the same to each. It will require some experimenting to achieve this and I would recommend drilling all the feed nozzles to No. 80 initially, opening up any which are starved a little at a time until you get satisfaction, remembering that the length of orifice is a function of rate of flow as well as its diameter. Check this out operating the lubricator drive by hand; now we can couple to the expansion link.

Lubricator Drive Arm and Links

For the drive arm, chuck a length of $\frac{5}{16}$ in. steel rod in the 3 jaw, face, centre, drill No. 13 to $\frac{1}{4}$ in. depth and part off a $\frac{3}{16}$ in. slice. Take a length of $\frac{5}{16}$ in. x $\frac{1}{16}$ in. steel strip, scallop to suit the end boss and silver solder together. Drill the No. 51 hole, radius the end, then file the flanks to match. Ease over the expansion link trunnion pin, still to be a tight fit though, then cross drill for a spring or taper dowel pin to secure.

The links are fairly long and it is just possible their thickness will have to be increased to 2mm for them not to flex unduly; much will depend on the stiffness of your lubricators in operation. Couple up and we have completed another large slice of DONCASTER; only four more sessions to go!

Another great shot by H. K. Harman. This one is from a much later era, 1959, and at a location further north at the famous Cockburnspath bank. 60080 DICK TURPIN recently fitted with the Kylchap double chimney looks in fine fettle as she storms up the bank, with not the slightest problem of drifting exhaust.

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

by: DON YOUNG

Part 12 - Gravity Sanding, Drain Cocks and Smokebox

An Omission

In my haste to complete description of the Mechanical Lubricators last time (LLAS No. 28), I made a serious omission on Page 21, one which David Piddington of Reeves was kind enough to point out to me. It is that the fit of the spindle to the bore of the roller clutch is fundamental to the success of the drive. For this reason the spindle must be made from silver steel and one of the problems is that this material is almost always 'size', whereas our requirement is about .002 in. oversize, which on the surface means turning down from 5/32 in. rod. However, turning down silver steel, especially in such a small size, is not my cup of tea, and to achieve the correct fit I knurl the rod in way of the clutch, and with the inherent hardness of the rod I find you arrive at the right size virtually automatically. Then it is a case of hardening the rod right out to a blue colour, when you will get years of trouble-free service, and I am off the hook!

Gravity Sanding

Back to the present, where we can plunge straight into the procedings without preliminary, as we left the, leading, gravity sanding gear very much in the air.

The sandbox is plain 13/16 in. as far as its width goes, so with 1.6mm end plates, I make it we need a sandwich strip which is 11/16 in. wide; cut the end plates and sandwich said strip in place, then silver solder together, after making a hole for the filler tube.

The sand valve body is a right little pig and I would start with a length of 7/8 in. diameter brass bar in the 3 jaw. Face and turn on the 3/8 in. spigot over a 3/32 in. length, then leave the 1/16 in. thick flange and reduce the next 1/4 in. length down to 7/16 in. diameter. Centre and drill No. 41 to 3/16 in. point depth, then part off at 19/32 in. overall. Next grip in the machine vice, shape the bottom end off at 30 deg. to arrive at the 7/16 in. dimension, then mark off, centre and drill No. 23 to 5/16 in. depth for the sand pipe. Now we can mark off and drill the three No. 51 holes indicated, two for flange fixing and the third as the sand passage. File the flange to profile, then drive a length of 5/32 in. rod into the No. 23 sand pipe hole. Grip this rod in the 3 jaw and carefully turn the end of the body down to around 7/32 in. diameter, all the way to said dimension if you have the courage. Now it is a matter of filing the rest of the body to match the shapes at boss and flange, when you can drill the sandbox at 3/8 in. diameter to accept the spigot. Mark this latter hole carefully, as we need another in the top face which is vertically above, this one drilled 9/32 in. diameter and tapped 5/16 x 40T.

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Arms next, the bosses being 5/32 in. lengths of 3/16 in. steel rod, drilled centrally at No. 42, with lengths of 1/16 in. steel flat brazed on. Drill the No. 47 hole specified, then shape the arm to drawing. Fit over the sand valve spindle and cross drill No. 60 for a 1mm spring pin, orientating the arms so that the sand valves operate in unison.

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Pivot first, plain turning, the end result being rivetted directly to the running board by peening over the projecting spigot. Take a length of 3/16 in. x 1/16 in. steel strip for the lever, drill the fulcrum hole No. 41 and the pair of end ones No. 47 at 15/16 in. either side, then shape to drawing. All rods have 5/32 in. diameter end bosses brazed to lengths of 5/32 in. x 1/16 in. steel strip, the end bosses being drilled No. 47 for 5/64 in. pins and slotted to accept the arms. The exception is the cab rod, where the rear end slips over the pin provided on the operating handle. It will be best if you build each rod up on the engine itself, sitting it on the relevant arms, and then cut the slots to fit said arms after brazing.

Drain Cocks

For once I do not have to apologise, for Merlin Biddlecombe makes the most excellent plug type drain cocks for me, the superb ball pattern too, which I am delighted to offer builders, thus letting you on with the other bits and pieces.

Having struggled with operating gear for drain cocks on all sorts of LNER and SR Locomotives, I rate the Bowden cable solution on the Gresley 'Pacifics' very highly, though Uncle Frank did not agree, having broken his little toe when opening the cocks on No. 10000 when she primed. Let us get the end fittings in place first before running the tube through to place.

The main shaft sits under the middle cylinder, using the No. 22 holes provided in the mainframes and sited 1/4 in. behind the rear bogie wheel centre. Cut the shaft from 5/32 in. steel rod to 4 3/8 in. length to fit the frames, then turn up the wee end collars from 1/4 in. rod to firmly locate it, cross drilling No. 60 for 1mm spring pins, very useful these latter. Next cut the link for the middle cylinder pair of cocks from 1/8 in. x 1/16 in. strip, drill the ends for 1/16 in. brass snap head rivets as pins.

Next cut the main arm for the shaft from 5/16 in. x 1/16 in. steel strip, drill the fulcrum hole No. 23 and two others No. 51 at 3/8 in. and 3/4 in. distant from same, opening the centre one out into a slot. Profile to drawing, press onto the shaft and position to pick up the link from the drain cocks; drill the hole No. 51 to place for another pin.

Pulleys next, so chuck a short length of 3/4 in. diameter steel bar in the 3 jaw, face and turn down to 11/16 in. diameter over a 5/16 in. length. Grind a parting off tool down to a 3/64 in. thick blade and use this to cut the groove down to 9/16 in. diameter, then centre and drill No. 22 before parting of at 1/8 in. thickness. To complete, saw and file, or mill the cut-away for the Bowden cable ends. Erect one pulley on the shaft, checking that with my dimension you have sufficient clear- ance from the bogie wheel or I shall be in trouble!, then braze up.

A second cross shaft couples to the outside cylinder drain cocks and for a bit of extra stiffness the shaft can be from 3/32 in. silver steel rod; 1/8 in. if you are unhappy with its flexibility. Arms and levers we have already made that are sufficiently similar for me to avoid repetition, the trunnions being made from 5/32 in. x 1/8 in. BMS flat, shaped to place. Now you can make up the other five links to place and check that the drain cocks operate properly thus far.

At the cab end, we first have to make the pivot and position it correctly on the cab side, this time by means of four 1/16 in. copper rivets. Except for the set and bottom end fixing, we have already made a similar handle for the gravity sanding. Slip a pulley and the finished handle over the pivot, spot through the No. 51 hole to drill and tap the pulley at 10BA. The bracket you will have to cut from 3/8 in. x 3/8 in. x 1/16 in. brass angle and I suggest you do not bolt or rivet it in place ahead of the Bowden cables being fitted and tried.

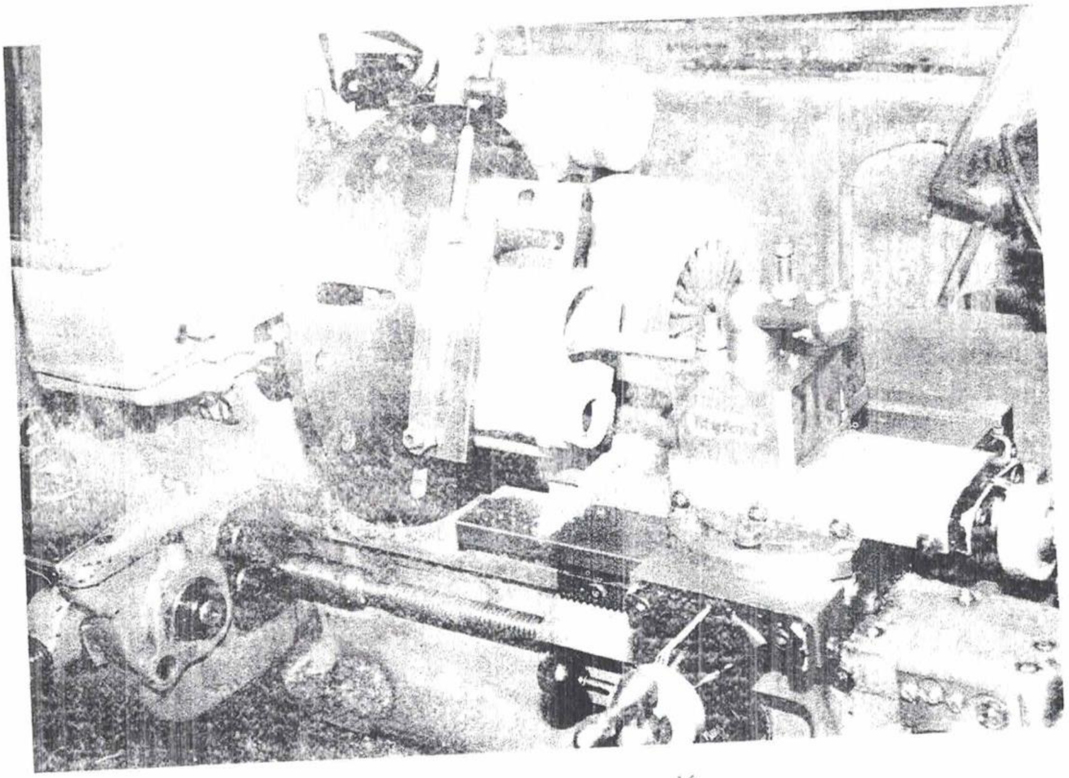
The significance of the 3/4 in. radius shown for the Bowden tube at the cab end is not that the radius need necessarily be here, but that this is the minimum bend possible for correct operation. It does no harm to feed in the piano wire as cable first, then you can check the resistance as you make each bend all the way down to the shaft. You must also use sufficient clips to ensure the tube is firmly held along its length. Once satisfied, sweat a brass ferrule onto one end of each cable, liberally grease it and each tube, then feed in from the front end. Feed the end of the cables around the pulley at the cab end, fit another ferrule over the end and on reflection, I would crimp the ferrule at this end if at all possible, rather than try to sweat it on; blobs of solder are a last resort.

THE SMOKEBOX

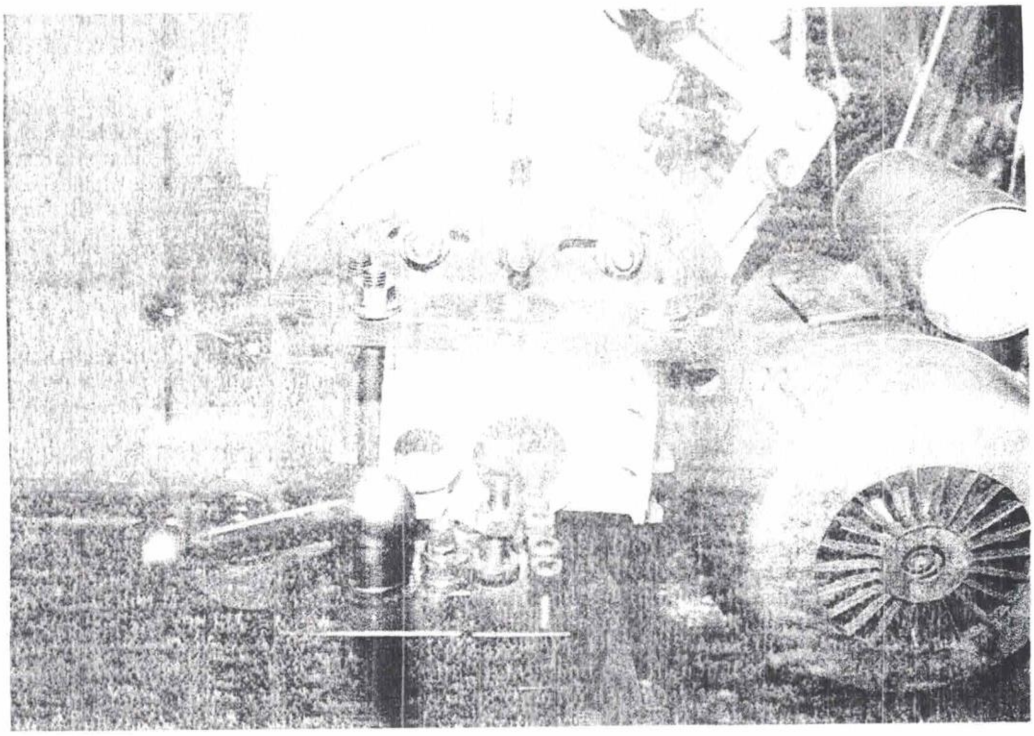
Yesterday, time of penning these notes, I had just sent out LLAS No. 28 and was experiencing the lull before the storm, and what a storm it has proved! Anyhow, having checked that the morning post was a light one, it comes in around 7.00 a.m., I had retired again with a good book, one that is reviewed in these pages, when the phone rang at around 8.30 a.m. It was Alec Farmer from Reeves and after an exchange of pleasantries, for Alec is a gentleman, I was asked for the sizes of my DONCASTER smokebox shell. The drawing was hurriedly sought out and the measurements 6 3/8 in. o.d. x 3/32 in. wall x 6 3/16 in. long given, when I also told Alec about the machined recess at the front for the ring. 'How do you do that Don' said Alec: 'Don't know' I replied, but I will do shortly when I write my description'. From this you will gather that I had missed two points from not being sufficiently wide awake, the first being my note on the drawing about machining from 6 1/2 in. o.d. tube, the second and much more important being the smokebox shell service provided by Reeves, and others; it was a rude awakening.

I must admit that DONCASTER being both an LNER and Gresley locomotive, that I lean heavily on my K1/1 sitting in the office as a yardstick for many things, and her smokebox is turned from thick steel tube. I even remember how enjoyable it was to turn and bore to size and was only exchanging notes with Bill Holland on this the other day, but as a result of that telephone conversation with Alec, please take my recom- mendation with a pinch of salt, for a rolled shell that will fit the spigot on the end of the boiler barrel is the proper answer. Then all you do at the front ring is step it so that externally it looks as I have drawn it, with the shell only 1/16 in. thick to be scale.

Full size, smokebox shells were rarely of an exact diameter to sit on the saddle, but by cutting out the large portion inside the saddle flange, the joint could be easily pulled down to be airtight; we can do likewise. If you made up a simple drill jig for the saddle flange, all you have to do now is lay it on the shell and drill though, otherwise you will have to spot through the saddle, which is not easy in every position. From the saddle, we can mark up and establish the top centre line of the smokebox shell, and the first hole to be dealt with is that at 25/32 in. diameter for the anti-vacuum valve, when we must make up and fit the related parts to the boiler.



Back to Bill Holland's workshop, where the R.H. outside cylinder block is almo bored to size; note his simple set-up



Bill must have taken my caption to heart on Page 18 of LLAS No. 27, for he has moved on to bore out the inside cylinder block, and broke into the exhaust passage above! The replacement casting has proved satisfactory, so I am keeping my fingers crossed this A3 will be steamed in 1987

Superheater Header/Anti-Vacuum Valve

I have a cast gunmetal stick, introduced as balance piston and bush material for DON HUNSLET, that is extremely useful for such items as superheater headers and the like, so chuck same in the 4 jaw, face and turn down over a 1⅜ in. length to 1¼ in. diameter. Further reduce the outer 9/16 in. to ¾ in. diameter and part off a full 1 3/16 in. chunk. Grip by the ⅝ in. portion in the machine vice and mill the projecting spigot to ⅝ in. square, then back to the 3 jaw to face off, centre, drill and 'D' bit ½ in. diameter to 15/32 in. depth; lightly scribe the bolting circle at 1 in. diameter. Back to the machine vice to deal with the anti-vacuum valve tapping, so centre, drill and 'D' bit 11/32 in. diameter to 17/32 in. depth, tapping the outer ¼ in. at ⅜ x 32T; just clean up the seating face with an end mill to be perfectly square. Drill the No. 11 connecting hole and we have to get steam to the superheater elements.

Chuck a length of ½ in. bronze rod, face, centre deeply and drill 5/16 in. diameter to ½ in. depth. Screw the outer 5/16 in. at 32T then part off at 7/16 in. overall and scallop the plain end to suit the header; repeat for the other two connections. In the early days, my workshop was prone to condensation, so it was never a problem to find three stubs of 5/16 in. very rusty steel rod with which to align the connectors. It is no real problem to turn up 3/16 in. lengths of brass rod to be a tight fit in the 5/16 in. holes and drill them out afterwards; either way braze on the connectors. Offer up to the superheater flange after marking off and drilling the four No. 30 holes, then spot through, drill and tap 5BA, checking that the superheater elements are central in their flues. Fixing I suggest be by 5BA studs made from ⅛ in. stainless steel rod, secured with commercial 5BA commercial brass full nuts.

This anti-vacuum valve I first made for my K1/1, in some trepidation I will admit, but it works just perfectly with just a whiff of steam before the most authentic 'the-ump' you could imagine - music to my ears! For those in need, I also have sticks of continuously cast bronze which are ideal for anti-vacuum valve manufacture, so let us proceed once more.

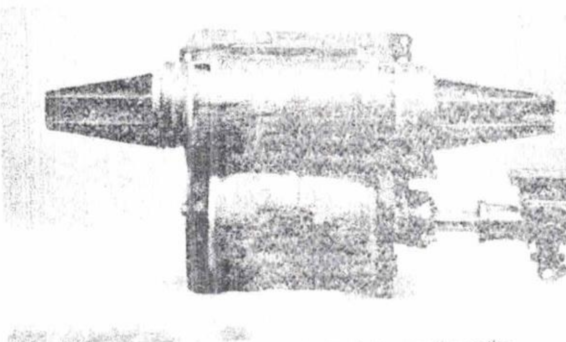
For the body, chuck a length of ¾ in. diameter bar in the 3 jaw, face and turn down to ⅜ in. diameter over a 7/32 in. length, screwing 32T. Move on and turn the next ½ in. down to ½ in; diameter, then part off at 1⅛ in. overall. Reverse in the chuck and grip by the ½ in. portion to face off to length, then centre and drill through at 3/16 in. diameter. Follow up at ½ in. diameter to 3/16 in. depth and 'D' bit to 9/32 in. depth as shown. Drill No. 53 and fit the 1/16 in. peg in the bore with 3/32 in. stand-out, then mill or file a couple of flats in the ½ in. portion for a spanner.

I specify the valve from bronze, but can see no reason why stainless steel could not be substituted; in either material it is a plain turning exercise. Chuck the ¾ in. diameter bar again for the valve cap, face and turn down to .086 in. diameter over a 3/32 in. length and screw 8BA. Reduce the next ⅛ in. to 3/16 in. diameter and then turn on the spherical portion out to ½ in. diameter, the length involved being 5/32 in. Start parting off to leave an ⅛ in. thick flange, but when you reach about 9/16 in. diameter, move on a further full 1/16 in. and part right off. Rechuck by the flange in the 3 jaw, check the job is running true, then face off and turn the 1/16 spigot down to ½ in. diameter, a neat fit in the body. Next centre and drill No. 41 to ¼ in. depth, then bore out or 'D' bit the 11/32 in. diameter recess to 1/16 in. depth, finally cleaning up the working face again and then scribing on the bolting circle.

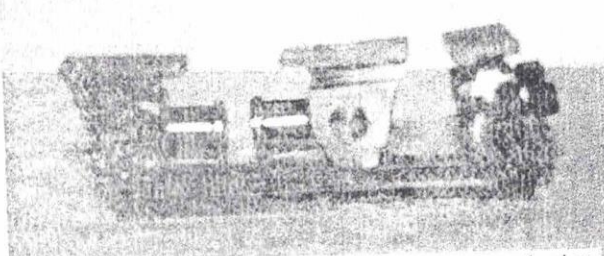
Offer the cap up to the body, spot through, drill and tap 10BA, fit bolts or studs, then mark off and drill the four No. 44 escape holes, or rather air entry ones, followed by the No. 50 one into the spindle hole. Slide, or tap, as the fit will dictate, the smokebox shell over the end of the barrel and screw in the anti-vacuum valve; once centred in its hole you can go on and fix the shell to the boiler barrel with countersunk screws or the like, temporarily only as our next job is to cut the 1 13/16 in. hole on the top centre line to accept the petticoat pipe.

I machined a petticoat pipe casting and found all operations were possible in the 3 jaw chuck. First I gripped the main parallel portion on the outside, turned the bell mouth down to 2⅜ in. diameter and faced this end, then rechucked by the bell mouth. This allowed me to turn most of the parallel portion down to 1¾ in. diameter, carefully face off to 2 11/16 in. overall and bore out to 1 11/32 in. diameter, only a whisker needing to be removed at the top. I then set the top slide over

2 deg. and bored out to a taper, until the tool came out of engagement with the metal 1 11/16 in. from the outer end of the casting. Reversing the job again in the 3 jaw, I was able to complete the bell mouth, inside and out, and I still find a course round file the best way of achieving the internal bell mouth, my eye the best gauge, tidying up with emery cloth.
Most books tell of the reduction in height of the boiler mountings, cab and chimney in the change from GNR to LNER group Standard loading gauge, but I have yet to see it in print that the chimney became much smaller in diameter too, in fact I nearly made a fundamental error in shortening the original chimney and retaining its profile; until Allan Garraway put me right. From this it is obvious that the opportunity of the change of loading gauge was taken to improve the draughting, something that was never quite mastered in single chimney days, which was way HUMORIST with her Kylchap double chimney was the best A3 for so long and a personal favourite.
Anyhow, chuck the, correct', profile single chimney by its chucking spigot, tidy up the outside down to the skirt, then bore out to 1 7/16 in. diameter. At this stage set the chimney on top of the smokebox shell, judge its fit and if there are any problems, file the base to a fit before going on to bore out to 1¾ in. diameter to suit the petticoat pipe over a ⅛ in. length. Now set the top slide over again at 2 deg., only its the other way this time, and bore out a little at a time until, when the petticoat pipe is brought up, your fingers tell you the bores have no step between them. Complete the skirt with files and emery cloth, then part off the chucking spigot. If I remember correctly, the chimney was held down by eight ¼ in. bolts; I do recall it was a struggle for this apprentice to fit the nuts inside!, but most of the examples I have seen of this feature in miniature do not look right, so why not omit them altogether?
Next cut a 2¼ in. square from 1.6mm brass sheet, find its centre by the 'X' method, scribe on a 1¾ in. diameter circle and cut same out. Bend the piece to fit inside the smokebox shell, then ease the bore to be a tight fit over the petticoat pipe and assemble 'dry'; if the fit to the chimney is also a tight one then it should hold the petticoat pipe in position.
On the centre line of the smokebox saddle there are two exhaust stubs and flanges, the outside pair feeding into the saddle itself and the middle one poking up through the floor of the saddle; we have to build up the blastpipe on these. The first requirement are two 90 deg. commercial copper bends, which entails a visit to a builders merchant or heating engineer. Some bends have plain ends, but most available these days are extended, swaged out end including a solder ring, which we don't want, so cut the ends off to leave just the bend. Next step is to turn up flanges to suit those on the stubs and bored to accept the 90 deg. bends [illegible] in place and cut a mating piece of tube [illegible] between the two bends.
The final item for this assembly is the pipe saddle, the wee one that accepts the blast nozzle, so chuck a length of [illegible] in. diameter brass, or bronze, bar in the 3 jaw. Face and screw



Bill's completed L.H. outside cylinder ready for erecting to the frames



A trio of crossheads, just like I used to see them on the shop floor at Doncaster

26T over a 5/16 in. length, then centre and drill 19/32 in. diameter to 13/16 in. depth before parting off at a full 11/16 in. Start scalloping the plain end to suit the blastpipe, but before completing same, make up a simple alignment tool. This latter is merely a 7 in. length of ⅝ in. or ¾ in. diameter bar, with one end reduced to 19/32 in. diameter, a good fit in the saddle piece, this over a 5/16 in. length. Continue with the scalloping, sit the saddle in place, lower the alignment tool down the chimney and engage the saddle. Now check with calipers that the tool can be placed central within the chimney/petticoat pipe, the latter being upright on the smokebox top, when you should scribe a line around the saddle where it fits on the blastpipe as a further guide.
Build the whole assembly up on a steel plate, clamping the flanges to same and then silver solder together; remove from the base, pickle and wash off. Next step is to drill from the saddle 19/32 in. diameter into the blastpipe, when you can erect, drill the flanges No. 44, tapping the matings ones 8BA as shown on Sheet No. 6.
I can never repeat the next instruction enough, this being to make sure that the chimney is sitting upright on top of the smokebox, not like a leaning tower of Piza, then fit the alignment tool again and use as such if necessary to bring the saddle upright and central to the petticoat pipe/chimney. If much movement is required, then turn up a nut to suit those fragile saddle threads, or they will distort and ruin a good job. Once you are happy, mark off and drill four No. 34 holes on a 2⅝ in. p.c.d. on the steel around the chimney, carry on through the petticoat pipe flange and fit 6BA screws and nuts.

Blast Nozzle

Before we close up the smokebox at the front, we had better fit more internals, beginning with the blast nozzle. Chuck a length of the cast gunmetal stick and turn down to 1¼ in. diameter over a ¾ in. length after facing off. Centre and drill 7/16 in. diameter to the same ¾ in. depth, then bore out to 45/64 in. diameter and 5/16 depth to tap ¾ x 26T; part off at a full ½ in. overall. Next chuck an odd end of 1 in. diameter bar, face, turn down to ¾ in. diameter over a 7/32 in. length and screw 26T; fit the embryo blast nozzle to same. Face off to length, then turn down to 1⅛ in. diameter to leave a 1/16 in. flange at the base. This diameter is to suit a short piece of 1¼ in. o.d.d. x 16 s.w.g. copper tube remaining from the superheater flues, or of course it can be machined from the solid gunmetal bar. Next cut the steam groove to the blower jets with a parting off tool, ¼ in. wide and ⅞ in. diameter at its base. That leaves just the top portion to turn as part of the nozzle, with tool set over 30 deg. and ⅝ in. diameter at the tip. Change to a boring tool and set it over 10 deg. to deal with the actual nozzle, to .47 in. diameter at the business end. Fit a 7/32 x 40T connector to the blower belt, slip it over the nozzle and silver solder the joints; pickle, wash off and we can drill the No. 70 blower holes. Now some builders have told me stories about these holes having to be angled inwards, Terry Phelps with his superb SAINT being one example and it certainly helped his cause, yet other builders of the same engine, plus COUNTY CARLOW, No. 4321, DERBY 4F and 2P with the same

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

by: DON YOUNG

Part 12 - Gravity Sanding, Drain Cocks and Smokebox

An Omission

In my haste to complete description of the Mechanical Lubricators last time (LLAS No. 28), I made a serious omission on Page 21, one which David Piddington of Reeves was kind enough to point out to me. It is that the fit of the spindle to the bore of the roller clutch is fundamental to the success of the drive. For this reason the spindle must be made from silver steel and one of the problems is that this material is almost always 'size', whereas our requirement is about .002 in. oversize, which on the surface means turning down from 5/32 in. rod. However, turning down silver steel, especially in such a small size, is not my cup of tea, and to achieve the correct fit I knurl the rod in way of the clutch, and with the inherent hardness of the rod I find you arrive at the right size virtually automatically. Then it is a case of hardening the rod right out to a blue colour, when you will get years of trouble-free service, and I am off the hook!

Gravity Sanding

Back to the present, where we can plunge straight into the procedings without preliminary, as we left the, leading, gravity sanding gear very much in the air.
The sandbox is plain 13/16 in. as far as its width goes, so with 1.6mm end plates, I make it we need a sandwich strip which is 11/16 in. wide; cut the end plates and sandwich said strip in place, then silver solder together, after making a hole for the filler tube.
The sand valve body is a right little pig and I would start with a length of 7/8 in. diameter brass bar in the 3 jaw. Face and turn on the 3/8 in. spigot over a 3/32 in. length, then leave the 1/16 in. thick flange and reduce the next 1/4 in. length down to 7/16 in. diameter. Centre and drill No. 41 to 3/16 in. point depth, then part off at 19/32 in. overall. Next grip in the machine vice, snape the bottom end off at 30 deg. to arrive at the 7/16 in. dimension, then mark off, centre and drill No. 23 to 5/16 in. depth for the sand pipe. Now we can mark off and drill the three No. 51 holes indicated, two for flange fixing and the third as the sand passage. File the flange to profile, then drive a length of 5/32 in. rod into the No. 23 sand pipe hole. Grip this rod in the 3 jaw and carefully turn the end of the body down to around 7/32 in. diameter, all the way to said dimension if you have the courage. Now it is a matter of filing the rest of the body to match the shapes at boss and flange, when you can drill the sandbox at 3/8 in. diameter to accept the spigot. Mark this latter hole carefully, as we need another in the top face which is vertically above, this one drilled 9/32 in. diameter and tapped 5/16 x 40T.
The sand valve, on reflection, I would make in three pieces. The centre spindle is from 3/32 in. stainless steel rod, lengths 2 15/16 in. and 3 1/4 in. respectively. Next square off two 2 1/32 in. lengths of 3/16 stainless steel rod, centre each end and drill No. 42 to meet. The valve itself is from 3/8 in. stainless steel rod; chuck, face, centre, drill No. 43 to 3/16 in. depth and part off a 3/32 in. slice. Press the disc onto the centre spindle, slide on the sleeve and silver solder only if the assembly is not rigid, then drill the sand port to match the passage in the valve body. The bearing is plain turning from 5/16 in. brass rod, the backnut from 3/8 in. A/F hexagon, when you can assemble the whole and erect to the frames. The sand pipe itself can only be fitted to place, it wants to be 5/16 in. above rail level and is sweated, or silver soldered for preference, into the valve body.
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Next cut the main arm for the shaft from 5/16 in. x 1/16 in. steel strip, drill the fulcrum hole No. 23 and two others No. 51 at 3/8 in. and 3/4 in. distant from same, opening the centre one out into a slot. Profile to drawing, press onto the shaft and position to pick up the link from the drain cocks; drill the hole No. 51 to place for another pin.
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the Bowden cable ends. Erect one pulley on the shaft, checking that with my dimension you have sufficient clearance from the bogie wheel or I shall be in trouble!, then braze up.

A second cross shaft couples to the outside cylinder drain cocks and for a bit of extra stiffness the shaft can be from 3/32 in. silver steel rod; 1/8 in. if you are unhappy with its flexibility. Arms and levers we have already made that are sufficiently similar for me to avoid repetition, the trunnions being made from 9/32 in. x 1/8 in. BMS flat, shaped to place. Now you can make up the other five links to place and check that the drain cocks operate properly thus far.

At the cab end, we first have to make the pivot and position it correctly on the cab side, this time by means of four 1/16 in. copper rivets. Except for the set and bottom end fixing, we have already made a similar handle for the gravity sanding. Slip a pulley and the finished handle over the pivot, spot through the No. 51 hole to drill and tap the pulley at 10BA. The bracket you will have to cut from 3/8 in. x 3/8 in. x 1/16 in. brass angle and I suggest you do not bolt or rivet it in place ahead of the Bowden cables being fitted and tried.

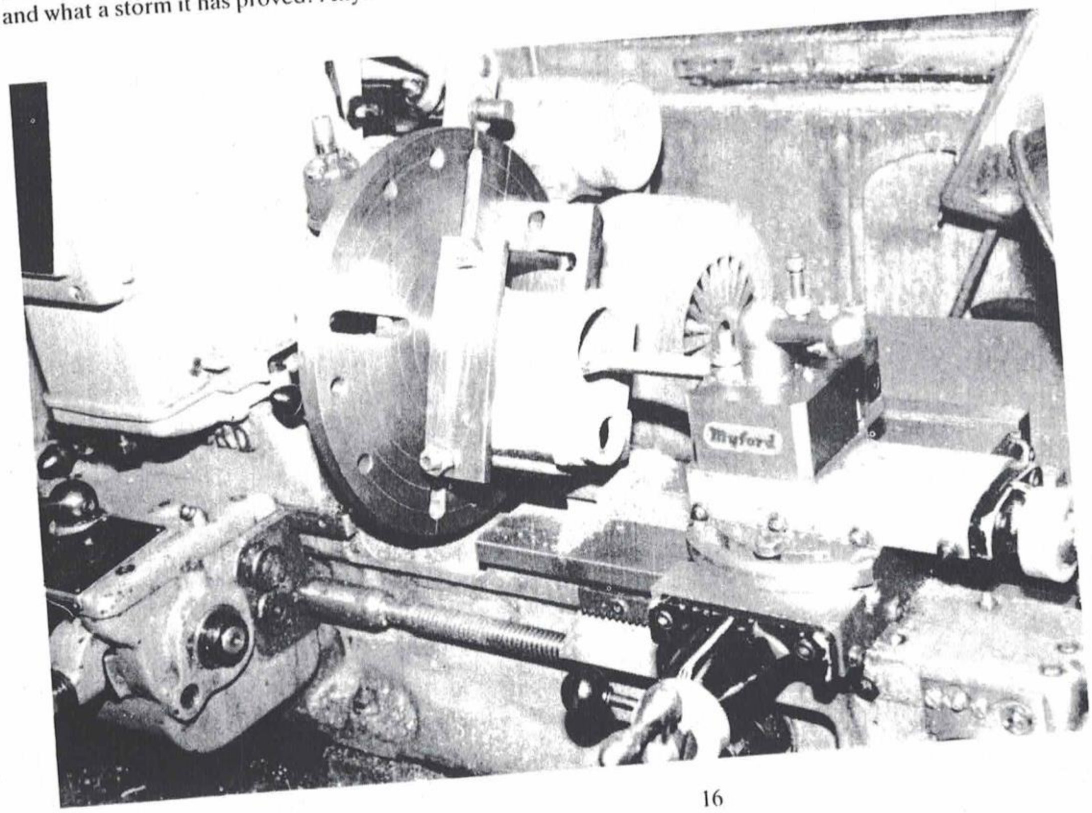
The significance of the 3/4 in. radius shown for the Bowden tube at the cab end is not that the radius need necessarily be here, but that this is the minimum bend possible for correct operation. It does no harm to feed in the piano wire as cable first, then you can check the resistance as you make each bend all the way down to the shaft. You must also use sufficient clips to ensure the tube is firmly held along its length. Once satisfied, sweat a brass ferrule onto one end of each cable, liberally grease it and each tube, then feed in from the front end. Feed the end of the cables around the pulley at the cab end, fit another ferrule over the end and on reflection, I would crimp the ferrule at this end if at all possible, rather than try to sweat it on; blobs of solder are a last resort.

THE SMOKEBOX

Yesterday, time of penning these notes, I had just sent out LLAS No. 28 and was experiencing the lull before the storm, and what a storm it has proved! Anyhow, having checked that the morning post was a light one, it comes in around 7.00 a.m., I had retired again with a good book, one that is reviewed in these pages, when the phone rang at around 8.30 a.m. It was Alec Farmer from Reeves and after an exchange of pleasantries, for Alec is a gentleman, I was asked for the sizes of my DONCASTER smokebox shell. The drawing was hurriedly sought out and the measurements 6 3/8 in. o.d. x 3/32 in. wall x 6 3/16 in. long given, when I also told Alec about the machined recess at the front for the ring. 'How do you do that Don' said Alec; 'Don't know' I replied, but I will do shortly when I write my description'. From this you will gather that I had missed two points from not being sufficiently wide awake, the first being my note on the drawing about machining from 6 1/2 in. o.d. tube, the second and much more important being the smokebox shell service provided by Reeves, and others; it was a rude awakening.

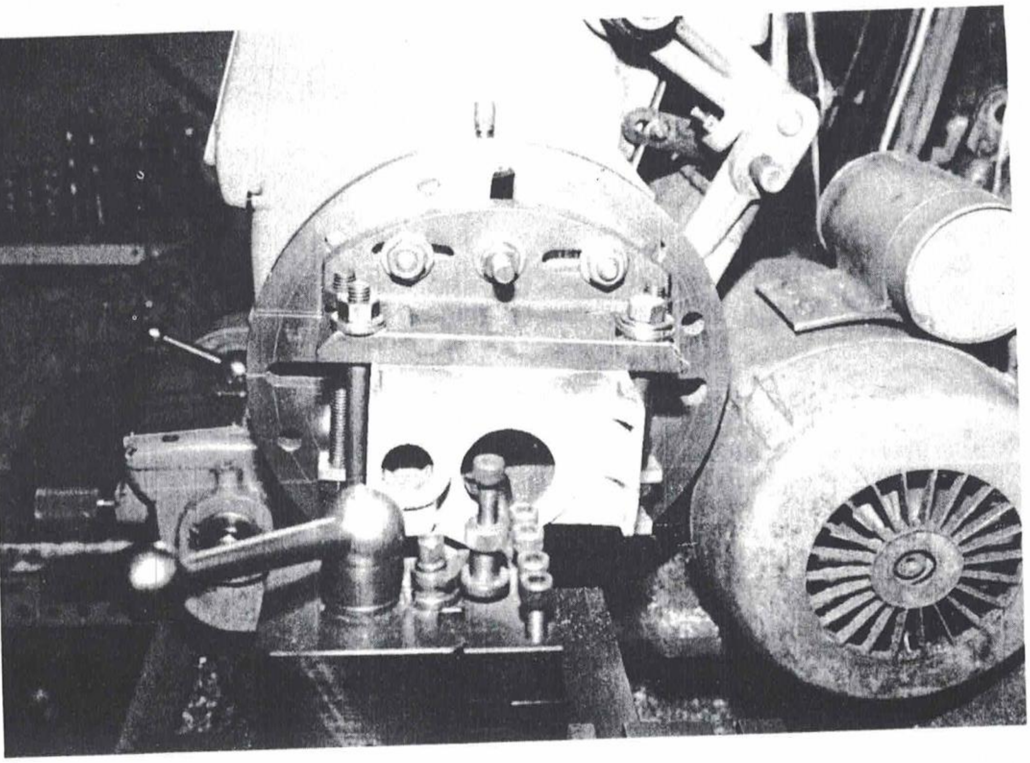
I must admit that DONCASTER being both an LNER and Gresley locomotive, that I lean heavily on my K1/1 sitting in the office as a yardstick for many things, and her smokebox is turned from thick steel tube. I even remember how enjoyable it was to turn and bore to size and was only exchanging notes with Bill Holland on this the other day, but as a result of that telephone conversation with Alec, please take my recommendation with a pinch of salt, for a rolled shell that will fit the spigot on the end of the boiler barrel is the proper answer. Then all you do at the front ring is step it so that externally it looks as I have drawn it, with the shell only 1/16 in. thick to be scale.

Full size, smokebox shells were rarely of an exact diameter to sit on the saddle, but by cutting out the large portion inside the saddle flange, the joint could be easily pulled down to be airtight; we can do likewise. If you made up a simple drill jig for the saddle flange, all you have to do now is lay it on the shell and drill though, otherwise you will have to spot through the saddle, which is not easy in every position. From the saddle, we can mark up and establish the top centre line of the smokebox shell, and the first hole to be dealt with is that at 25/32 in. diameter for the anti-vacuum valve, when we must make up and fit the related parts to the boiler.



Back to Bill Holland's workshop, where the R.H. outside cylinder block is almos bored to size; note his simple set-up

Bill must have taken my caption to heart on Page 18 of LLAS No. 27, for he has moved on to bore out the inside cylinder block, and broke into the exhaust passage above! The replacement casting has proved satisfactory, so I am keeping my fingers crossed this A3 will be steamed in 1987



Superheater Header/Anti-Vacuum Valve

I have a cast gunmetal stick, introduced as balance piston and bush material for DON HUNSLET, that is extremely useful for such items as superheater headers and the like, so chuck same in the 4 jaw, face and turn down over a 1⅜ in. length to 1¼ in. diameter. Further reduce the outer 9/16 in. to ¾ in. diameter and part off a full 1 3/16 in. chunk. Grip by the ⅝ in. portion in the machine vice and mill the projecting spigot to ⅝ in. square, then back to the 3 jaw to face off, centre, drill and 'D' bit ½ in. diameter to 15/32 in. depth; lightly scribe the bolting circle at 1 in. diameter. Back to the machine vice to deal with the anti-vacuum valve tapping, so centre, drill and 'D' bit 11/32 in. diameter to 17/32 in. depth, tapping the outer ¼ in. at ⅜ x 32T; just clean up the seating face with an end mill to be perfectly square. Drill the No. 11 connecting hole and we have to get steam to the superheater elements.

Chuck a length of ½ in. bronze rod, face, centre deeply and drill 5/16 in. diameter to ½ in. depth. Screw the outer 5/16 in. at 32T then part off at 7/16 in. overall and scallop the plain end to suit the header; repeat for the other two connections. In the early days, my workshop was prone to condensation, so it was never a problem to find three stubs of 5/16 in. very rusty steel rod with which to align the connectors. It is no real problem to turn up 3/16 in. lengths of brass rod to be a tight fit in the 5/16 in. holes and drill them out afterwards; either way braze on the connectors. Offer up to the superheater flange after marking off and drilling the four No. 30 holes, then spot through, drill and tap 5BA, checking that the superheater elements are central in their flues. Fixing I suggest be by 5BA studs made from ⅛ in. stainless steel rod, secured with commercial 5BA commercial brass full nuts.

This anti-vacuum valve I first made for my K1/1, in some trepidation I will admit, but it works just perfectly with just a whiff of steam before the most authentic 'the-ump' you could imagine - music to my ears! For those in need, I also have sticks of continuously cast bronze which are ideal for anti-vacuum valve manufacture, so let us proceed once more.

For the body, chuck a length of ¾ in. diameter bar in the 3 jaw, face and turn down to ⅜ in. diameter over a 7/32 in. length, screwing 32T. Move on and turn the next ½ in. down to ½ in; diameter, then part off at 1⅛ in. overall. Reverse in the chuck and grip by the ½ in. portion to face off to length, then centre and drill through at 3/16 in. diameter. Follow up at ½ in. diameter to 3/16 in. depth and 'D' bit to 9/32 in. depth as shown. Drill No. 53 and fit the 1/16 in. peg in the bore with 3/32 in. stand-out, then mill or file a couple of flats in the ½ in. portion for a spanner.

I specify the valve from bronze, but can see no reason why stainless steel could not be substituted; in either material it is a plain turning exercise. Chuck the ¾ in. diameter bar again for the valve cap, face and turn down to .086 in. diameter over a 3/32 in. length and screw 8BA. Reduce the next ⅛ in. to 3/16 in. diameter and then turn on the spherical portion out to ½ in. diameter, the length involved being 5/32 in. Start parting off to leave an ⅛ in. thick flange, but when you reach about 9/16 in. diameter, move on a further full 1/16 in. and part right off. Rechuck by the flange in the 3 jaw, check the job is running true, then face off and turn the 1/16 spigot down to ½ in. diameter, a neat fit in the body. Next centre and drill No. 41 to ¼ in. depth, then bore out or 'D' bit the 11/32 in. diameter recess to 1/16 in. depth, finally cleaning up the working face again and then scribing on the bolting circle.

Offer the cap up to the body, spot through, drill and tap 10BA, fit bolts or studs, then mark off and drill the four No. 44 escape holes, or rather air entry ones, followed by the No. 50 one into the spindle hole. Slide, or tap, as the fit will dictate, the smokebox shell over the end of the barrel and screw in the anti-vacuum valve; once centred in its hole you can go on and fix the shell to the boiler barrel with countersunk screws or the like, temporarily only as our next job is to cut the 1 13/16 in. hole on the top centre line to accept the petticoat pipe.

I machined a petticoat pipe casting and found all operations were possible in the 3 jaw chuck. First I gripped the main parallel portion on the outside, turned the bell mouth down to 2⅜ in. diameter and faced this end, then rechucked by the bell mouth. This allowed me to turn most of the parallel portion down to 1¾ in. diameter, carefully face off to 2 11/16 in. overall and bore out to 1 11/32 in. diameter, only a whisker needing to be removed at the top. I then set the top slide over

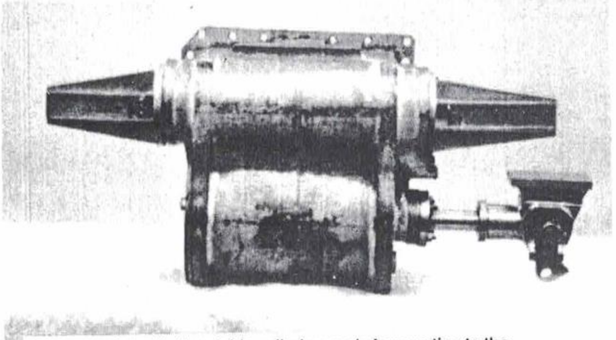
2 deg. and bored out to a taper, until the tool came out of engagement with the metal 1 11/16 in. from the outer end of the casting. Reversing the job again in the 3 jaw, I was able to complete the bell mouth, inside and out, and I still find a course round file the best way of achieving the internal bell mouth, my eye the best gauge, tidying up with emery cloth.

Most books tell of the reduction in height of the boiler mountings, cab and chimney in the change from GNR to LNER group Standard loading gauge, but I have yet to see it in print that the chimney became much smaller in diameter too, in fact I nearly made a fundamental error in shortening the original chimney and retaining its profile; until Allan Garraway put me right. From this it is obvious that the opportunity of the change of loading gauge was taken to improve the draughting, something that was never quite mastered in single chimney days, which was why HUMORIST with her Kylchap double chimney was the best A3 for so long and a personal favourite.

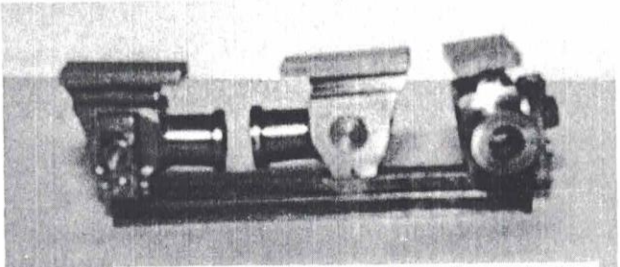
Anyhow, chuck the, correct!, profile single chimney by its chucking spigot, tidy up the outside down to the skirt, then bore out to 1 7/16 in. diameter. At this stage set the chimney on top of the smokebox shell, judge its fit and if there are any problems, file the base to a fit before going on to bore out to 1 3/4 in. diameter to suit the petticoat pipe over a 1/8 in. length. Now set the top slide over again at 2 deg., only its the other way this time, and bore out a little at a time until, when the petticoat pipe is brought up, your fingers tell you the bores have no step between them. Complete the skirt with files and emery cloth, then part off the chucking spigot. If I remember correctly, the chimney was held down by eight 1/4 in. bolts; I do recall it was a struggle for this apprentice to fit the nuts inside!, but most of the examples I have seen of this feature in miniature do not look right, so why not omit then altogether?

Next cut a 2 1/4 in. square from 1.6mm brass sheet, find its centre by the 'X' method, scribe on a 1 3/4 in. diameter circle and cut same out. Bend the piece to fit inside the smokebox shell, then ease the bore to be a tight fit over the petticoat pipe and assemble 'dry'; if the fit to the chimney is also a tight one then it should hold the petticoat pipe in position.

On the centre line of the smokebox saddle there are two exhaust stubs and flanges, the outside pair feeding into the saddle itself and the middle one poking up through the floor of the saddle; we have to build up the blastpipe on these. The first requirement are two 90 deg. commercial copper bends, which entails a visit to a builders merchant of heating engineer. Some bends have plain ends, but most available these days are extended, swaged out and including a solder ring; which we don't want, so cut the ends off to leave just the bend. Next step is to turn up flanges to suit those on the stubs and bored to accept the 90 deg. bends; clamp them in place and cut a mating piece of tube to fit between the two bends. The final item for this assembly is the pipe saddle, the wee one that accepts the blast nozzle, so chuck a length of 3/4 in. diameter brass, or bronze, bar in the 3 jaw. Face and screw



Bill's completed L.H. outside cylinder ready for erecting to the frames



A trio of crossheads, just like I used to see them on the shop floor at Doncaster

26T over a 5/16 in. length, then centre and drill 19/32 in. diameter to 13/16 in. depth before parting off at a full 11/16 in. Start scalloping the plain end to suit the blastpipe, but before completing same, make up a simple alignment tool. This latter is merely a 7 in. length of 5/8 in. or 3/4 in. diameter bar, with one end reduced to 19/32 in. diameter, a good fit in the saddle piece, this over a 5/16 in. length. Continue with the scalloping, sit the saddle in place, lower the alignment tool down the chimney and engage the saddle. Now check with calipers that the tool can be placed central within the chimney/petticoat pipe, the latter being upright on the smokebox top, when you should scribe a line around the saddle where it fits on the blastpipe as a further guide.

Build the whole assembly up on a steel plate, clamping the flanges to same and then silver solder together; remove from the base, pickle and wash off. Next step is to drill from the saddle 19/32 in. diameter into the blastpipe, when you can erect, drill the flanges No. 44, tapping the matings ones 8BA as shown on Sheet No. 6.

I can never repeat the next instruction enough, this being to make sure that the chimney is sitting upright on top of the smokebox, not like a leaning tower of Piza, then fit the alignment tool again and use as such if necessary to bring the saddle upright and central to the petticoat pipe/chimney. If much movement is required, then turn up a nut to suit those fragile saddle threads, or they will distort and ruin a good job. Once you are happy, mark off and drill four No. 34 holes on a 2 5/8 in. p.c.d. on the steel around the chimney, carry on through the petticoat pipe flange and fit 6BA screws and nuts.

Blast Nozzle

Before we close up the smokebox at the front, we had better fit more internals, beginning with the blast nozzle. Chuck a length of the cast gunmetal stick and turn down to 1 1/4 in. diameter over a 3/4 in. length after facing off. Centre and drill 7/16 in. diameter to the same 3/4 in. depth, then bore out to 45/64 in. diameter and 5/16 depth to tap 3/4 x 26T; part off at a full 1/2 in. overall. Next chuck an odd end of 1 in. diameter bar, face, turn down to 3/4 in. diameter over a 7/32 in. length and screw 26T; fit the embryo blast nozzle to same. Face off to length, then turn down to 1 1/8 in. diameter to leave a 1/16 in. flange at the base. This diameter is to suit a short piece of 1 1/4 in. o.d.d. x 16 s.w.g. copper tube remaining from the superheater flues, or of course it can be machined from the solid gunmetal bar. Next cut the steam groove to the blower jets with a parting off tool, 1/4 in. wide and 7/8 in. diameter at its base. That leaves just the top portion to turn as part of the nozzle, with tool set over 30 deg. and 5/8 in. diameter at the tip. Change to a boring tool and set it over 10 deg. to deal with the actual nozzle, to .47 in. diameter at the business end. Fit a 7/32 x 40T connector to the blower belt, slip it over the nozzle and silver solder the joints; pickle, wash off and we can drill the No. 70 blower holes. Now some builders have told me stories about these holes having to be angled inwards, Terry Phelps with his superb SAINT being one example and it certainly helped his cause, yet other builders of the same engine, plus COUNTY CARLOW, No. 4321, DERBY 4F and 2P with the same arrangement, swear by my draughting rather than at it! It is one of life's mysteries, for it does not show on paper and thousands of you with my pet Ell draughting are getting 100% satisfaction, as will DONCASTER builders with just four No. 70 holes; I find it best to tackle these with my 6/9d (34p) Woolworth drill of 1956 vintage.

We must fit the main steam pipes ahead of coupling up the blower, ⅛ in. o.d. copper pipe being easier to bend than ⅜ in. o.d.! One part that should have been made and fitted much earlier is the steam connection to the middle cylinder, only I could not work it out properly until the smokebox was drawn. Really it wants to be fitted to the middle cylinder before it is erected, the saddle brought up and a wee hole cut in its back face to allow fitting the oil connection; let us try to repair the damage. Chuck a length of ⅝ in. A/F hexagon bronze bar, steel will do at a pinch, in the 3 jaw, face and turn down to ½ in. diameter over a ¼ in. length, screwing 32T. Screw hard into the middle cylinder and adjust so that one face of the hexagon is across the locomotive axis, this so that the oil connection will be correctly orientated, as we won't want to 'fish' for it. Back to the 3 jaw, to leave an 11/16 in. length of hexagon and then reduce the next ¼ in. or so down to ½ in. diameter. Centre and drill 5/16 in. diameter to 1¼ in. depth before parting off at 1⅛ in. overall. Next chuck a length of ½ in. rod, face, centre deeply and drill 5/16 in. diameter to ½ in. depth. Screw the outside 32T over a ¼ in. length, then part off at 13/32 in. overall. File or mill the two joint faces to give the required 15 deg. set, then braze up to include the oil connection, the latter drilled No. 22 at this stage. Now carry on and drill No. 22 into the main bore and tap out 3/16 x 40T.

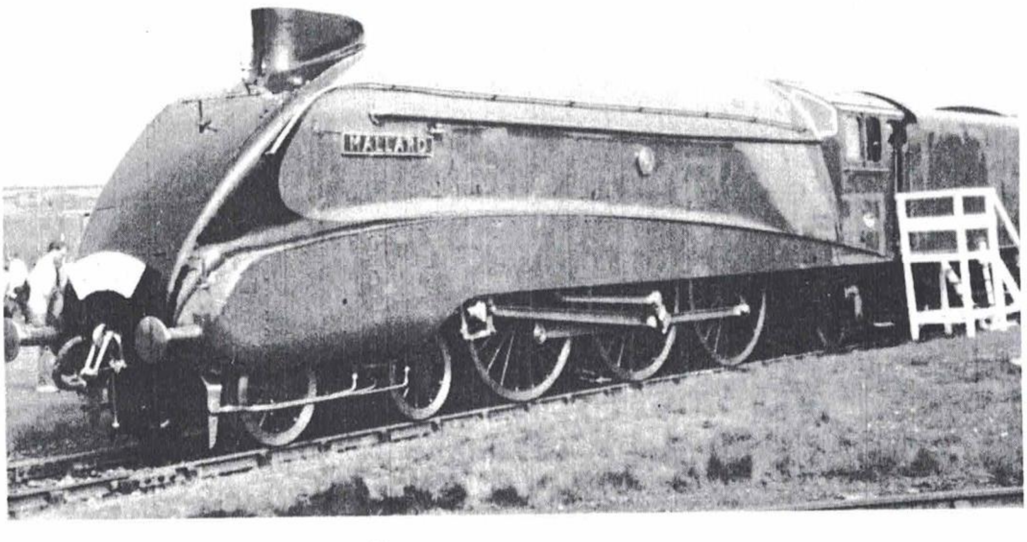
We may as well continue to complete the middle cylinder steam pipe before moving onwards, it is by far the worst. For the superheater connector, chuck a length of ½ in. A/F hexagon bronze rod in the 3 jaw, face and turn down to ½ in. diameter over a ¼ in. length, screwing 32T; any wee flat left when turning will not matter in the slightest. Leave ⅛ in. of the hexagon, then reduce to round bar, a little less than ½ in. diameter if you have to, over a 1⅜ in. length. Centre deeply, drill ⅜ in. diameter to 1¾ in. depth and part off at 1⅝ in. overall. The process of forming a bend from slices of bar is called 'lobster backing' and the more pieces employed, the closer you can get to a smooth bend, both externally and internally. Ours will not be too bad at all with just a single intermediate piece, so saw and file the plain end of the connector to arrive at the end result as shown. I would braze up the bend as a separate operation using B6 spelter, rather than fit the pipe, when you can bend up the latter to place against the two end connections and silver solder to the top one with Easyflo No. 2, at the same time fitting a nut and nipple at the lower end. This being a man sized smokebox means you can get inside OK to tighten the nuts.

The holes in the smokebox shell for the outside steam pipes want to be located about ⅜ in. away from the saddle bolting flange and in line with the steam entry to the outside cylinders; mark them off to place and drill through at 17/32 in. diameter. Turn up the steam pipe unions, 3/32 in. thick backnuts from ⅝ in. A/F hexagon bar, and the pair of superheater connectors too as they are very similar; erect them all. Last item to machine is the cylinder flanges, ¾ in. diameter and 3/32 in. thick, bored centrally at ⅜ in. diameter and secured by four 8BA bolts. Now bend up the outside steam pipes into a gentle curve to fit both steam pipe union and flange, when I have forgotten another machined item, the oil delivery boss which faces backwards on each steam pipe and roughly in the position shown; silver solder together. Although it is just feasible to make the steam pipes inside the smokebox to the outside cylinders in one piece, it is so much easier to make them in two pieces with a scarfed joint as shown that I would not even try the harder way; braze together to complete the steam circuit and we can move on to close up the front of the smokebox.

Front Ring, Door and Hinges

The front ring I have already mentioned and reckon it is best burnt out of ½ in. thick mild steel plate, then turned to size, much more economic in this instance than a cast gunmetal ring. Once you are satisfied with the internal piping, plus the two lugs to support the crossbar have been rivetted in place, the front ring should be silver soldered to the shell to ensure the joint is perfectly airtight.

Door next and this is a gunmetal casting, one on which I was surprised to find the foundry had cast the chucking spigot on the inside, so I decided to machine up a sample. I found it best to chuck the casting in the 3 jaw using the external set of jaws, this helped support the door and kept it running true, when turning the outside profile was not a problem, neither was facing the seat to the front ring. I then centred and drilled right through the spigot at No. 27, when I could only part off the spigot flush with the joint face of the door; I could find no easy way to cut the spigot back flush with the skin of the door. This does not affect operation of the door, in fact it might be



Bill played truant from his workshop to visit The Plant and turned his camera on MALLARD; that brings back memories!

possible to use the residue of the spigot to hold a circular shield in the manner of full size, but I did find it disconcerting not to be able to part off a chucking spigot, so will await builders comments before deciding if the spigot will be moved outside the door as is usual. Before completing the door, let us make the crossbar and dart, in that order.

For the crossbar, take two finished 6 in. lengths of 1/2 in. x 2.5mm steel strip, clamp together, drill the six 3/32 in. holes for rivets and shape to drawing. Turn up the 3/16 spacers and rivet in place, using snaps to arrive at the detail shown. The dart starts life as a length of 3/8 in. steel rod, face and reduce the outer 5/16 in. to 3/32 in. diameter, screwing 7BA, the next 7/16 in. to 9/64 in. diameter and then a 5/32 in. collar at 3/16 in. diameter. Turn the next 1 3/16 in. down to 5/32 in. diameter, then erect dart, crossbar and door to check the length to place, adjusting as required. Part off to leave 3/16 in. length of original bar, then shape to drawing to complete save for the 7/64 in. square, which latter is best dealt with to suit the handle.

For the rear handle, chuck a length of 1/4 in. steel rod, face, centre and drill No. 35 to 1/4 in. depth; part off a 3/16 slice. Cut a full 3/4 in. length from 1/8 in. rod, radius one end as shown and scallop the other to match the boss; braze up. To complete, use a swiss file to deal with the square, then file the dart to match. The outer handle has a boss from 7/32 in. rod and handle 3/32 in. diameter, set out before brazing; erect the door and get it nice and central to the front ring.

Talking of the front ring, those four holes should be drilled No. 34 before brazing, the upper hinge block one being spot faced to 5/16 in. diameter at the raised face. For the hinge blocks, chuck a length of 7/32 in. square steel bar truly in the 4 jaw, face and turn down to .11 in. diameter over a 1/2 in. length, screwing the outer 3/16 in. at 6BA. Cross drill No. 42, then part off and radius the end. The hinge pin is a 2 7/16 in. length of 3/32 in. stainless steel rod, the head a 5/64 in. disc of 3/16 in. rod drilled centrally at No. 43. Press the head onto the end of the pin, braze it in place if you like, then turn the head profile to drawing and ease the bottom end of the pin; erect.

Hinges next and these can only be made to place. Start with the same 7/32 in. square bar as for the hinge blocks and saw and file, or mill away 5/32 in. of the metal over a 4 in. length, bedding the hinge to the door. At 9/64 in. from the end of the hinge, cross drill No. 41 for the hinge pin and shape the boss around same with files; but unlike the usual pattern of hinge with its circular end boss, this one has an 11/32 in. projecting lug reduced to the same 1/16 in. thickness as the hinge proper. There is a very practical reason for this in that this huge door, if it was allowed to swing wide open, not only could it knock an unsuspecting fireman off the running board, but would also foul the next line of track - very dangerous that. Shape the end of the hinges, drill them for 1/16 in. rivets at roughly 1/2 in. pitch, offer up to the door, drill through and rivet in place.

Door adornments

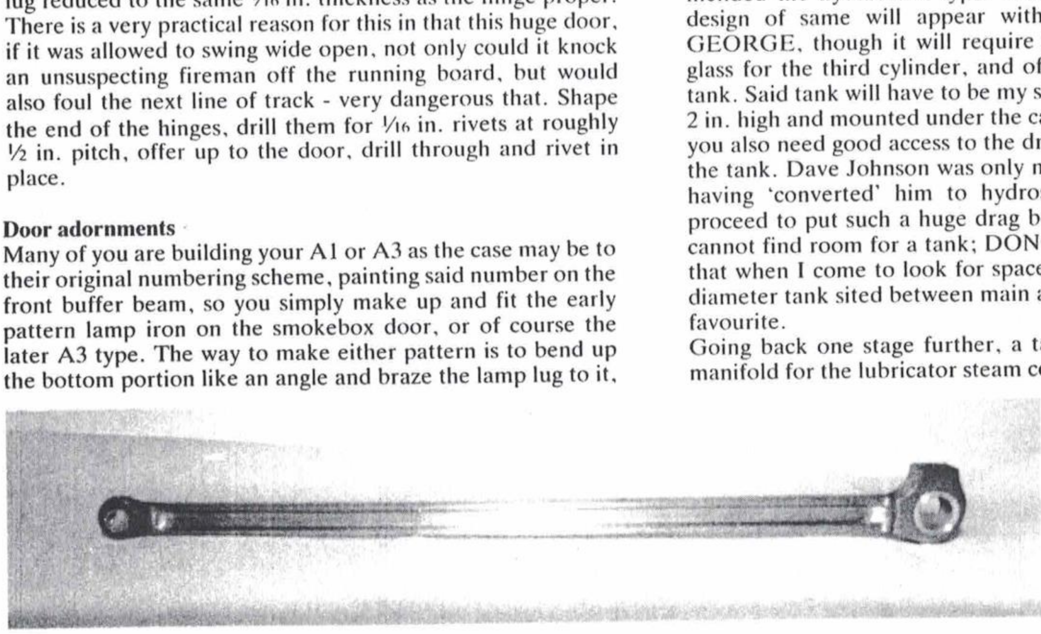
Many of you are building your A1 or A3 as the case may be to their original numbering scheme, painting said number on the front buffer beam, so you simply make up and fit the early pattern lamp iron on the smokebox door, or of course the later A3 type. The way to make either pattern is to bend up the bottom portion like an angle and braze the lamp lug to it, finally fashioning to place. The problem arises when we reach BR days and the advent of the cast front numberplate. As I fitted them, they looked just perfect sitting above the handrail, but of course the lamp iron had to be sited somewhat higher, and it doubled as a headboard carrier. One only has to look at the H. K. Harman masterpiece on Page 22 of LLAS No. 23 to see that THE MASTER CUTLER was being carried far too high, like a huge wind barrier, and apart from the difficulty in stepping it, up there it was a definite hazard. Gradually the cast numberplates were moved down over the top hinge, the lamp iron reverting to its lower position; it didn't look quite so neat but it was infinitely safer.

The handrail as far as I am aware, never moved on the smokebox door, unlike along the boiler where there were myriad variants. One always had to be careful carrying a bag of tools along by the firebox, for one reached up instinctively for the upper handrail; sometimes it was not where one expected! The LNER handrail stanchions are very distinctive and worth making a form tool to produce, especially as the knob for opening the door and which uses the third No. 34 hole has the same shape; I left it off my first G.A. and earned the wrath of both Allan Garraway and Tom Greaves. Last Saturday, time of penning these notes, I had an insight into one of the more sombre aspects of Tom's job as Traction and Train Crew Manager for the whole of BR. Peter Baken rang from Durban in South Africa for builders plate details for his No. 2752 SPION KOP - what else? I found she emerged from The Plant in April 1929 and was first shedded at Doncaster, but could not find her Works number. Allan Garraway had deserted his post for the evening at Boat of Garten up in the Highlands, so I tried Tom, who obliged in his usual thorough and helpful manner, but told me that he had only just got back from that horrible level crossing accident at Lockington on the Bridlington-Hull line; at such times I would not be a CME for all the tea in China.

Before closing the smokebox door in this session, there are a few more bits and pieces to be added, plus a bonnet to be fitted on top of the anti-vacuum valve. Despite trying my very hardest, I failed to find a bonnet gracing an A3 that was like the pepperpot that authentically adorns my K1/1, all the 'Pacifics' sported only a single row of holes. At least it is a pleasure turning up the bonnet from 1 in. diameter brass bar, when you will need a rotary table or dividing head to accurately position said row of holes.

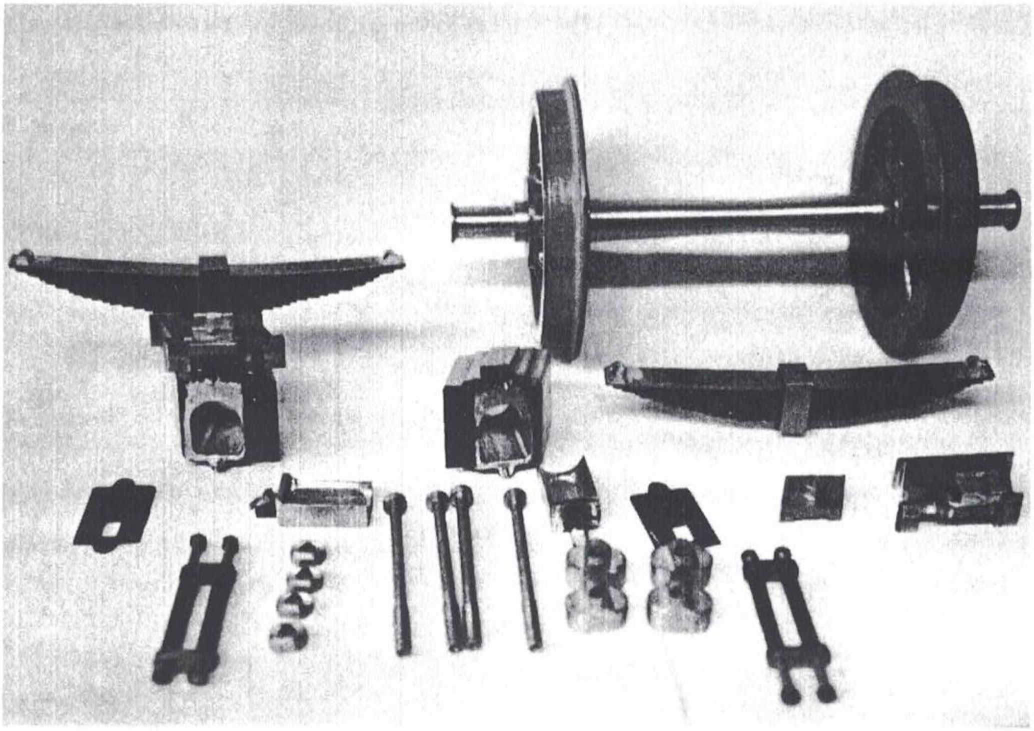
Cylinder lubrication next, for which I have already recommended the hydrostatic type. It so happens that a suitable design of same will appear with the next instalment of GEORGE, though it will require an additional single sight glass for the third cylinder, and of course a much larger oil tank. Said tank will have to be my standard 1 1/2 in. diameter x 2 in. high and mounted under the cab floor for ease of access; you also need good access to the drain valve at the bottom of the tank. Dave Johnson was only moaning last weekend that having 'converted' him to hydrostatic lubrication, I then proceed to put such a huge drag box on POM-POM that he cannot find room for a tank; DONCASTER is a wee bit like that when I come to look for space, in fact a slightly smaller diameter tank sited between main and trailing frames may be favourite.

Going back one stage further, a tapping is provided on the manifold for the lubricator steam cock, a 3/32 in. o.d. thin wall



Bill's outside connecting rod is so highly polished that it reflected back into the camera lens!

All the components for the Cartazzi trailing axle on Bill's A3



copper pipe running down to the bottom of the oil tank; this pipe must be of sufficient length to ensure the steam condenses before it arrives at the tank, otherwise you will finish up with a horrible emulsion. The sight glasses are sited as high in the cab as possible whilst remaining visible, a twin one at one side of the cab and a single at the other, oil feeding from the tank up to the base of the sight glass fittings. Emerging at the top fitting, the piping is diagonally along the boiler down to the oil distribution blocks, and here we are back on terra firma. The early A1's with hydrostatic lubrication had these pipes visible along the boiler, but if yours is a later engine either by building or conversion, then run the pipes forward inside the lagging.

What I call the oil distribution blocks in 5 in. gauge were actually oil atomisers full size, and they were prone to blow back into the mechanical lubricator tank and make a mess, just as sometimes happens to us in miniature. For the single block, chuck a length of 1/4 in. square brass bar truly in the 4 jaw, face and turn down over a 3/16 in. length to 7/32 in. diameter, screwing 40T. Centre deeply for the pipe nipple and drill No. 41 to about 7/8 in. depth, then part off at 5/8 in. overall, reverse in the chuck and repeat. Drill No. 48 into the square portion, tap it 7BA and fit a length of studding, silver soldering it in place to be secure.

The double block starts off as a 19/32 in. finished length of 1/4 in. square brass bar, cross drilled No. 22 at 11/32 in. centres; turn up four 7/32 x 40T connectors to be a press fit in these holes and silver solder together. This time there is no possibility of the 7BA studding entering the oil way, so it need not be fixed in any way other than by its thread. Bend up the mounting brackets from 1/4 in. x 1/16 in. steel strip, drill the smokebox shell in the position indicated on each side, just ahead of the boiler barrel, and mount the oil distribution blocks; couple up the pipes from the cab. We now have to run pipes forward to the cylinder connections fitted to the outside steam pipes, the third bending downwards and backwards before turning forward again to the connection at the back of the smokebox saddle. I will say more about hydrostatic lubrication in the GEORGE article, but the main thing to remember is to limit oil flow at each sight glass to one drop every two minutes, any faster and steam will not condense in the pipe leading to the oil tank, also oil will build back into the sight glass.

Now that we have oil arriving at the outside steam pipes, we may as well cover them with their distinctive spats, at least once we have the running board. Assuming as I must that it is fitted, cut the base of the spat 21/16 in. x 11/4 in. from 0.7mm copper sheet and trim the outer end to a 5/8 in. radius. Now cut metal away in the middle to clear the steam pipe and clamp in place. Cut another piece 11/4 in. wide from the same material, this time 31/4 in. long Radius one end as before and cut out the centre 3/4 in. wide to match the contour of the inside; fit this to the smokebox shell and saddle to meet up with the base. Remove the steam pipe and cut a wooden former block to the spat profile, then flange the spats proper over same and trim off. Build up the whole on your brazing hearth and silver solder together with Easyflo No. 2. To complete, use 10 or 12BA round head screws to attach the spat to the running board and smokebox shell, except that I forgot to mention the hole required for the oil pipe.

The distinctive Gresley inside connecting rod; it could be for real!

Vacuum Ejector Exhaust in Smokebox

When I described the petticoat pipe earlier in this session, I omitted to mention that the plain one was suitable only for a non-vacuum fitted DONCASTER, and with her mighty hauling power, I trust nobody is going to build her without said vacuum brakes, for they are essential. Going back to the petticoat pipe, before fitting the smokebox flange, chuck in the 3 jaw and cut a 'V' 1 11/16 in. down from the top, this being at the choke, down to 1 9/16 in. diameter. From the upper face of the 'V', drill twelve fairly equi-spaced No. 51 holes as ejector exhaust into the chimney. Next chuck a chunk of brass or gunmetal bar that will turn down to 2 1/4 in. diameter and machine to drawing, then part off and turn up a 5/16 x 40T union connection; fit same, orientating towards the correct side of the smokebox, which of course depends on whether your engine be right or left hand drive. Braze up, pickle and wash off, remembering to deal with the smokebox flange at the same heat. I have yet to determine what noise such an arrangement makes in use, as my K1/1 is still minus its vacuum ejector, much else too!, but hopefully it will emit a true rasping sound, not a raspberry!

Working backwards we come to the ejector elbow next and regretably the foundry could not core such a wee casting, nor include the spigot to pass through the smokebox shell. Chuck by the spigot provided, face and turn down the raised boss to 3/8 in. diameter, screwing 32T. Next centre and drill 3/16 in. diameter to 15/32 in. depth, taking care not to break through the casting wall. Face off and then follow up with a 1/4 in. 'D' bit to 3/32 in. depth. Next grip by the chucking spigot in the bench vice and file the flange to suit the smokebox shell, then saw and file away the spigot before marking off and drilling the five No. 51 fixing holes. To complete, drill a 3/16 in. hole angled from the centre of the flange, into that already drilled. Fit the internal 3/16 in. o.d. thin wall copper tube from the ejector belt back to the elbow; then braze on said elbow to, I am afraid, make the pipe a captive one once the nut and nipple are fitted.

We must leave the ejector exhaust pipe until the ejector itself is fitted in the cab, but swaging the ends is fairly easy. Clamp two short lengths of 1/4 in. square steel bar together and drill a 1/4 in. hole down through the joint. Fit over the end of the pipe, grip the whole in the bench vice and tighten the jaws a fraction at a time, turning the pipe all the while. The pipe nipple is plain turning and self-explanatory; on to the ring nuts. Chuck a length of 1/2 in. brass rod in the 3 jaw, face and turn down to 15/32 in. diameter over a 3/4 in. length. Centre and drill 1/4 in. diameter to 1/4 in. depth, follow up with an 11/32 in. 'D' bit to 5/32 in. depth and tap 3/8 x 32T. The slots can either be end milled at this stage, or the nut parted off and then dealt with files.

The ejector pipe supports are the last item for this session and I could not have picked a worst one to end on! Chuck a length of 7/16 in. nickel silver rod in the 3 jaw and first turn on the spherical end. Remove to the machine vice and mill away each side to leave a 3/16 in. thickness of metal. Centre this and drill initially at about 3/16 in. diameter, correcting any out of centre error with a swiss file before opening out in stages to 5/16 in. diameter. Back to the 3 jaw to turn the rest of the support to size before parting off, the spherical end still outermost, so it is rather awkward. When satisfied, part off, then screw the shank by hand. I will emphasis that last sentence by stating not to chuck the head of the support in the 4 jaw, for I tried it when checking out the operations, and found the head simply collapses!

Our H. K. Harman masterpiece this time is of 60052 PRINCE PALATINE, a Leicester engine in 1950, passing High Wycombe with THE MASTER CUTLER and going well