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

by: **DON YOUNG**

Gresley's 'Pacific' Locomotives have weaved a continuous thread throughout my life thus far, and with the advent of DONCASTER it is guaranteed to continue. It started at the limit of my early childhood memories, when my uncle Frank Young used to holiday with his parents, my grandparents of course, coming down from Doncaster to Adgestone each year, when he would tell of his exploits with the shovel and at the regulator. His firing exploits were legend, such that in 1936 he was promoted to 'Coal Inspector', when his main function was to instruct on driving and firing techniques for Gresley's engines, in particular the wide firebox type. One of uncle's tales is that on leaving Leicester on the old Great Central main line, where incidentally in G.C.R. days he had learnt his trade, he instructed the driver to fully open the regulator and gradually decrease the cut-off; he then went on to instruct the fireman in the technique of firing the wide box, in particular the back corners. Just 16½ minutes later the train braked quite violently to a halt on the outskirts of Nottingham, some 23 miles up the line; the driver had just wound the cut-off back to 8% and let the engine have her head! In later days I was to witness such expertise with the shovel at first hand, sheer artistry, though at the beginning of my tuition it nearly broke my heart, after around 30 minutes of sheer hard effort just to hold my own, to see a dozen shovelfuls perfectly placed and the boiler rally immediately as if by magic. I did become sufficiently proficient to really enjoy firing, though for a while I then tended to over-fire with the result that the safety valves kept lifting; I still have that fault in miniature! I remember one Sunday night when I got into all sorts of trouble with too big a fire and no way to quieten the boiler; uncle told me to leave things well alone as it would do the boiler good, so we ran for miles blowing off. Then when things had cooled down he opened the engine right out and I had to start again to rally the boiler; life was never made too easy for me on the footplate!

But I have overtaken myself, for uncle's tales during W.W.2 were of run down 'Pacifics' taking enormous loads, but with firing of his calibre, giving a brilliant account of themselves on many occasions. It was 1947 when I first went to Doncaster on holiday, 90% of the time being spent at the Station, which by the greatest of good fortune was situated adjacent to The Plant – Doncaster Locomotive and Carriage Works. Here I could see shining examples of Gresley's fine engines emerging newly refitted from The Plant and disappearing South on trials, also less pristine but infinitely more exciting Gresley 'Pacifics' hard at work on the East Coast main line, all faithfully recorded in my Ian Allan ABC booklet – oh that this record had been on film! Cousin Geoff, although employed at the local ropeworks, shared my love of steam and pointed out with pride the A3's as they flashed under the North Road bridge; I remember PAPYRUS and BOOK LAW particularly as a result of Geoff's enthusiasm. Highlight of this first visit was the late Sunday evening spent at Carr Shed, where uncle showed me a whole host of 'big injins', the icing on the cake being No. 103 FLYING SCOTSMAN, an engine shedded at Doncaster for many years.

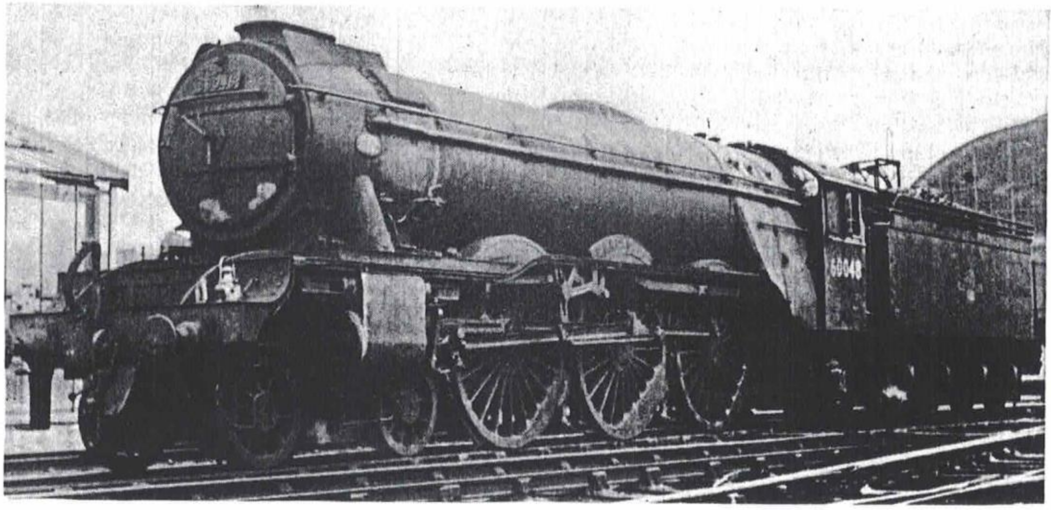
I went home determined that my career would be with these exciting large Locomotives and in December 1947, thanks to Uncle Frank, I was accepted as a premium apprentice at The Plant, subject to a few conditions such as good examination results, and like now to think I was the last premium accepted by Arthur H. Peppercorn in his role of C.M.E. of the L.N.E.R as not many days later Nationalisation swallowed up th separate identities. Much of my apprenticeship was covere in the 'Doncaster Plant Works' occasional series publishe in Model Engineer in the early 1970's; it was well receive then and if there is demand it can re-appear in LLAS as I d hold Copyright of this, in fact all my work that was eve published in Model Engineer. Basically though, except fc the bit about building 76026 that I am currently amplifyin this series was a case of self-indulgence in my love of Gresle 'Pacifics', particularly my special favourite 60097 HUMORIS as I knew her – I rated her the very best of the A3's.

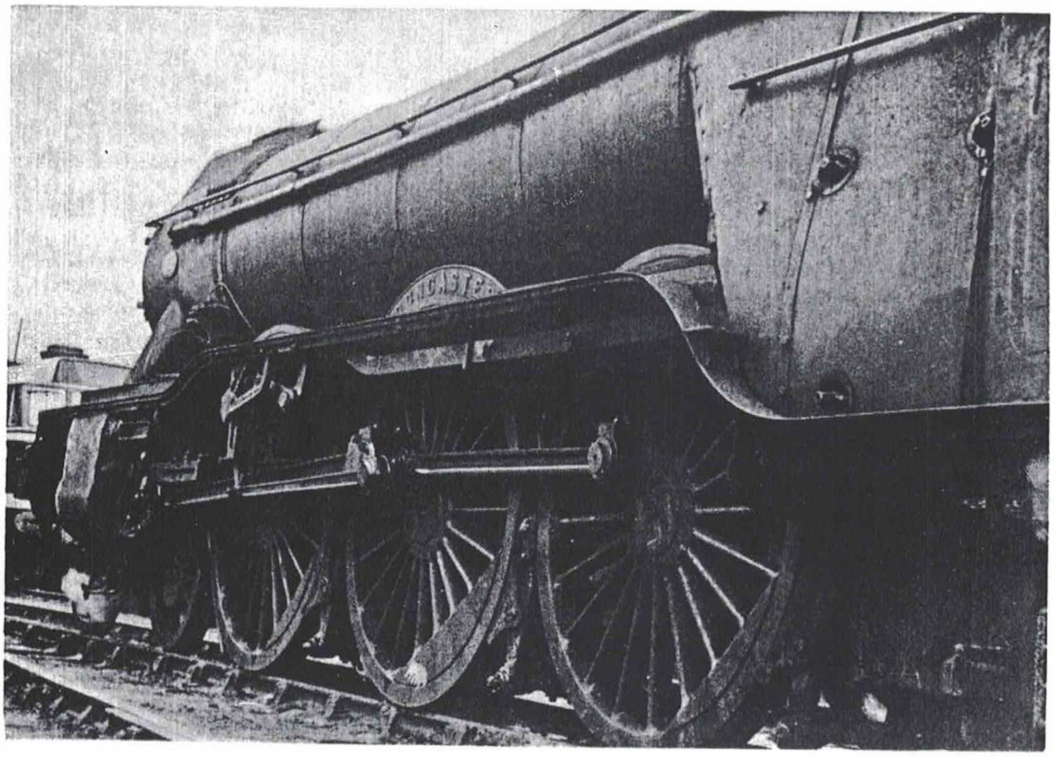
Sadly I could not enjoy the fruits of my steam locomotiv training on B.R., but cherished the thought of designing m own 5 in. gauge A3, HUMORIST of course, over man years, in fact my first effort was as early as 1947 and on th back of a Southern Railway poster advertising Bournemouth As I became more involved with miniature designs, so it wa realised that an A3. was no ordinary engine and to do ther real justice I required as much experience as possible; began to think of this project as a pinnicle of achievement, o rather THE pinnicle. Conversely, as time passed so memor grows ever more dim and by the time there was confidence t proceed, nearly 30 years of cobwebs had to be brushed aside.

My starting point on the drawing board was Doncaste Works Drawing No. Q90, general arrangement of the A (A10) 'Pacifics', but I soon discovered that this drawing wa to a lesser standard than I had become used to from previou projects, which was disappointing to one brought up t think that Doncaster was best, even though uncle Frank di pass comment on more than one occasion that 'Gresley' engines were all designed in the aftermath of a heavy drinkin session – morning after!' Anyhow, I managed to get some thing down on paper which to me looked in outward appear ance to bear resemblance to an A3, plus as more lines wer added so the mental picture was rekindled, but there remaine many queries. I tried this drawing, then identified as 275 HUMORIST, on Allan Garraway, with result which th notes added to Sheet 1 largely reflect, but Allan besides bein a very stern critic, the sort I really appreciate, will also g out of his way to be helpful, so in time I was able to exhaus his knowledge of A3's. Enter John Bellwood, C.M.E. at th National Railway Museum and another Doncaster traine man, as are all the best we say! Anyhow, through the triangl of Allan, John and myself another mind was brought to bear plus drawings and photographs from the archives, this t put the project back initially as I learnt new facts, but the to advance again on a more sure footing; the rail heads ha been well sanded with information.

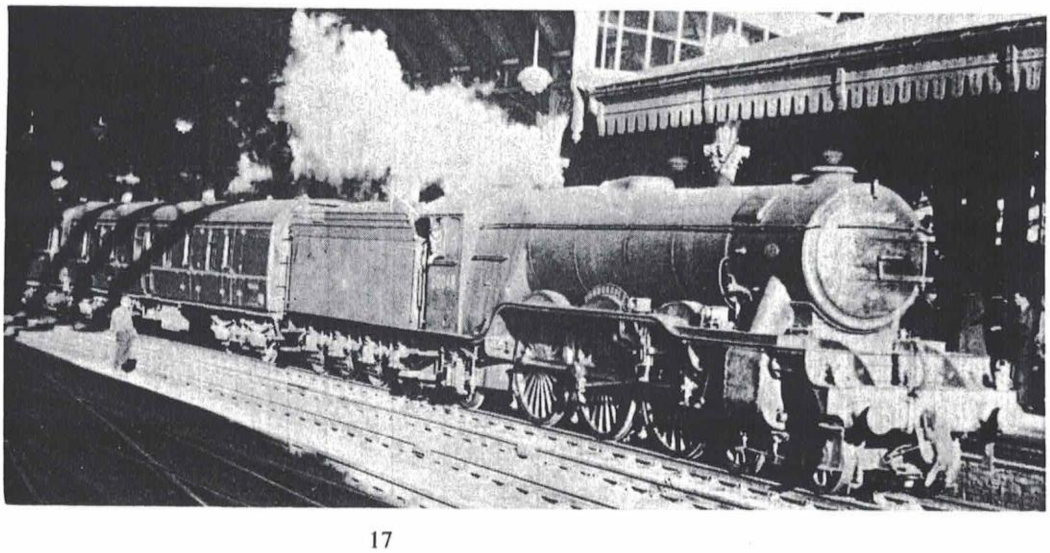
At Doncaster, a very good friend and fellow premiur apprentice had been Tommy Greaves, with whom I ha completely lost touch after leaving railway employ. I di learn from our mutual friend Allan Garraway that Tom wa rising to stardom within B.R., knew he was a keen photo grapher and still very much an enthusiast, in fact for his par in the preservation of Brian Hollingworth's Class 5M No. 5428, I dedicated my 5 in. gauge BLACK FIVE t Tommy, though I did think at the time he would remai anonymous. Finally and after almost exactly 30 years, Alla Garraway said I really must get in touch with Tom Greave again and the voice of the Traction and Train Crew Manage

DONCASTER in penultimate form at Kings X, one of only four A3's fitted with the, useless, small wing type deflectors in 1959 and attached to a G.N. pattern Tender.





DONCASTER as a L.H. drive A3 in 1960. Photographs by Tom Greaves.



DONCASTER at York in early B.R. days, sporting the banjo dome type boiler that was to remain with her to the end.

for B.R. on the other end of the telephone was unmistakable. The voice alone stirred many memories, but the photographs and comments on my proof drawings were even more helpful, plus the former have the dual role of illustrating this introductory article.

By chance I have been reading the book Ollie Johnston wrote with Frank Thomas called 'Disney Animation' – the illusion of life'; readers will of course remember Ollie for the MARIE E design which appeared in LLAS Nos. 8, 9 and 10. Well, Ollie had the difficult job of describing in print what made the name of Walt Disney immortal – the animated pictures made under his name too. Two points were made with which I am in total agreement, the first being that to work really hard one must have a sense of fun, call it mischief if you like, and that occasional interludes of high spirits actually aid production; I have been lucky to experience this in industry and still try to work that way even today. A paper glider still flies at the end of each month as the calendar sheet is torn off, but never again will I ever be able to afford to fly the eight feet long linen monster that was my 'ultimate weapon'! Second point Ollie makes is that from constructive criticism within a friendly team will emerge results far superior to those which any individual working alone can produce. Now, I have cultivated this sort of criticism for some years and found it extremely stimulating, indeed for DONCASTER I have gone out of my way to build up a little team of critics, but it was only on reading Ollie's book that I began to see the, unconscious, reason behind this.

DONCASTER in the end was an obvious choice and I first decided to draw her circa 1947. However, as more research was carried out it became clear that what in fact I had committed to paper was an A1 rather than an A3 'Pacific' and of a period some 14 years earlier. A telephone call to Tom Greaves confirmed this, so I then sat down and started again to depict DONCASTER in final form as she was withdrawn in 1963, thus all the major changes in a lifespan of nearly 40 years will be covered in the series when it appears, and this article must only be its prelude, for there is still a little way to go to complete the drawings. It is appropriate at this stage though to list some of the alterations which were made over those 39 years, with acknowledgement for the source of most to 'Locomotives of the L.N.E.R. – Part 2A', published by the Railway Correspondence and Travel Society.

I will skip the early years covering superheater trials, adoption of longer valve travel, imperfections of the 2:1 gear, and start in 1927 when the 43-element Robinson type superheater was introduced, characterised by the cover plates on the sides of the smokebox to accommodate the additional header length; in reality DONCASTER should not have been shown so fitted in 1933, but for me this is a very special feature as far as appearance is concerned, which is rather unique in that 'after-thoughts' usually tend to spoil good looks.

Never having worked on a Gresley 'Pacific' bogie other than when wheeling, there was a distinct flaw in my knowledge, one which showed in my earlier writings and for which I deserved to be roasted! For the original bogie fitted, a swing link design with pivot 1½ in. behind centre, another of several features which dated back to Patrick Stirling, first had insufficient side play for such a long engine, and when this was corrected, evidence was then found of the rear bogie wheels striking the outside cylinders. Darlington designed, with a free hand, the D49 Class 4-4-0's in 1927, whose bogies had side control springing and centre support plate. This bogie was first tried on a 'Pacific' in 1931 and after receiving favourable reports was authorised for all the A1/A3's in 1932, though the programme was not completed before 1937.

Turning now to details I will begin with the most important, the mainframes. The original frames, with their large lightening holes, soon gave serious trouble from cracking. As early as 1929 a change was made to 12 in. circular holes as in front of the cylinders, first to new engines and then retrospectively. Finally in 1933, Gresley decided to delete all lightening holes save for that in front of the cylinders, though the programme lasted until 1962, after withdrawal had begun. Most of the trouble in my opinion was caused by the massive horn gaps in the frames, with no stress-reducing radii in the top corners, allied to fitted bolt fixing of the horns – much inferior to rivets in such an application.

The cylinders need not concern us unduly, for with the massive steam producing potential of the boiler, 1¾ in. bore has been adopted as almost representing 20 in. in full size, though in doing so it did mean the centre bore had to be displaced 1/16 in. off centre line and 1⅝ in. would have been better in this respect only. It is almost a waste of paper to record that official diagrams for the A1/A3 'Pacifics' showed cylinder bores which varied from 18¼ in. to 20 in., for this was a complete and utter myth. What really happened is that a new engine would enter service with cylinder bores conforming to diagram. As wear occurred, so the cylinder casting would be rebored in situ until it approached the limit of the machining allowance for the casting. It would then be bored out once more, if the general condition of the casting was satisfactory, and a cast iron liner was then fitted to bring the bore back to somewhere near original size, after which of course the liner too could be rebored; I do not remember ever fitting more than one new cylinder block at any refit. As wear is never the same in each of the cylinder bores, it was common to have one, linered, cylinder bore at 19 in., another at 19½ in. bore; the third and probably the inside one bored out to 20½ in. There was supposed to be some conformity in that both outside cylinders be of equal bore, but nobody in their right mind would take a brand new cylinder and bore out from 19 in. to 19½ in. just to match its partner. It has been said many times that 8 in. diameter piston valves were too small in relation to the cylinder bore, though no such restriction ever manifested itself at the chimney, which is the first indication of a 'constipated' front end. Anyhow, by careful design I am positive that the scale 11/16 in. diameter piston vales I was absolutely forced to adopt will pose not the slightest restriction, indeed they will very much enhance performance over any slide valve version.

Dr. Francis Burrows, whose theoretical outpourings met with fairly general approval from LLAS readers, though regretably not universally so, is actually a very practical man with crystal clear thoughts on Walschaerts valve gear, ones in which I am in total agreement, indeed they form the very basis of my design work. When considering the RUNNING of an engine fitted with Walschaerts valve gear, the crosshead component via the combination lever to the valve is all-important, to the virtual exclusion of the rest of the gear; this is why I put so much stress on 'lead' in miniature and will be doing so again for DONCASTER, in fact lap and lead were established very early in the design process to be .14 in. and .027 in. respectively. The rest of the valve gear only becomes important for STARTING and in my book there is no point in making provision to start, say 5 tons, if the boiler will then only generate sufficient steam to continuously haul 2½ tons; that basically is my whole philosophy on valve gears and why I reckon a cut-off of around 70% in full gear to be totally adequate. Of course it does not always work out that way as one cannot be too rigid in approach because of the differing geometry between the different valve gears, especially so for Joy gear, where what can be considered as excessive full gear cut-off is necessary to get the correct RUNNING characteristics. Verily it is an absorbing subject and I guess there will be more to be said when we reach that part in the series.

The inside connecting rod big end was a continual source of trouble over many years and I remember feeling very angry when the extremely light and effective pattern began to be replaced by huge and clumsy forked big ends. There was much discussion among us apprentices and I was of the opinion that the fault lay in the brasses rather than the rod itself, allied to poor lubrication. Therefore it was pleasing to learn that new brasses which consisted of a thin white metal shell extending all the way round, allied to felt oil pads which no longer went right across the bearing surface, largely solved the problem whilst retaining the original rod. Actually, this was the dawn of the 'plastic age' and one bright soul, Malcolm Crawley, suggested plastic coated bearing surfaces, water lubricated.

Talking of lubrication, the drive arrangement as shown on Sheet 1, to a pair of Wakefield mechanical lubricators, did not last long and the K3 arrangement with the drive arm on the expansion link being turned upwards was adopted, thus reducing the length of the drive levers to the lubricator ratchets; it also meant moving the rear axlebox lubricator, slightly ahead of the weighshaft. Some engines were initially fitted with hydrostatic cylinder lubrication, a point I will be returning to in the series.

One feature very deliberately omitted from my drawing is the front pair of guard irons that were attached to the mainframes just ahead of those on the bogie. They were a potential danger full size in that if they were damaged and knocked backwards they could interfere with and derail the bogie, a probability rather than a possibility in miniature, so no way will I specify same. Full size they were finally dispensed with 1952 – 1954.

DONCASTER was of course originally fitted with a round domed boiler pressed to 180 p.s.i.g., gained a 220 p.s.i.g. banjo domed version in May 1946 when she was reclassified as an A3, reverted to a round dome but at 220 p.s.i.g. in June 1947 for some 18 months, after which she remained with banjo dome until withdrawal.

The top, main boiler handrail was remarkably inconsistent in height between the different engines within the Class, something we had to watch as we stood on same when working on the dome or whistle. Generally they were supposed to have been lowered once it was realised that with cab height reduced to L.N.E.R. standard, they partly obscured the look-out, but nothing quite like that seems to have happened. Walking forward from the cab, one grabbed the lower handrail, passing along the firebox, found the step going up over the rear coupled wheel and reached upwards for the top handrail often with a heavy bag of tools in the other hand – that top handrail could be most elusive and a hot ejector exhaust pipe no substitute!

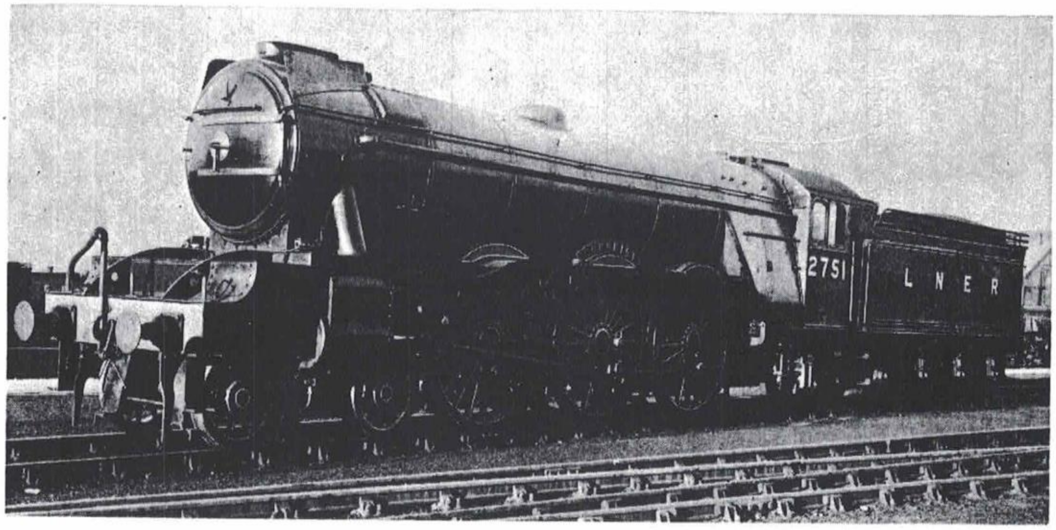
Very little happened to the cab in DONCASTER's lifetime, the main structural alteration being that the rear look-out in the cab sides was reduced in depth to match the tender, the vertical handrail being lengthened to match. Inside, the main change was in September 1952, when I assisted in her conversion from R.H. to L.H. drive; as I recall it we had some difficulty in getting the cut-off indicator on the backhead to agree with the actual position of the die block in the expansion links at mid-gear and the blacksmith had to shorten the reach rod. Actually, with the reach rod hard against the hot outer firebox, there must have been some discrepancy between working and indicated cut-off, though the experienced driver would rely more on sound than sight, at least until the advent of Kylchap draughting.

At the head end, when 60048 was added as a cast numberplate to the smokebox door, the lamp iron had to be lifted, which meant that when headboards were fitted when working named trains, said boards projected quite dangerously above the front of the smokebox. I wonder what would have happened had an A3 had to be fitted with the huge New Zealand Steam Shipping Company headboard that every few months we had to get out and dust off at Eastleigh preparatory to one of our pair of 'Lord Nelsons' working a boat train. Later, on some engines but not apparently DONCASTER, the cast numberplate was moved to sit on the top hinge and the lamp iron reverted to its original position.

Allan Garraway has mentioned the vast superiority of the double chimney Kylchap draughted A4's from his experiences and I felt exactly the same from sampling HUMORIST, yet it was May 1959 before DONCASTER finally became a super-A3. Sadly, visibility was reduced through drifting smoke, so the final solution would have been a Giesl Ejector, so perhaps one day Dr. Giesl will show us his proposals for the A3's; he was very interested when I first mentioned the DONCASTER project to him and had a first copy of my boiler drawing. In the event, DONCASTER had to make do with trough deflectors, which were fitted in December 1961, and for that final indignity I am going to blame Tom Greaves – I must get one back on my critics somehow! Actually there is a little story behind that remark, for Tom very rightly castigated me for omitting the fine oval Works plate that adorned the smokebox sides as DONCASTER is depicted on my Sheet 1; I don't see them after the trough deflectors were fitted Tom.

The Gresley A1/A3 'Pacifics' were appropriately named after classic-winning thoroughbred racehorses, DONCASTER won the 1873 Derby, and in 5 in. gauge she will be both a classic and a winner, of both I am certain!

I could not resist inclusion of one shot of my favourite A3 HUMORIST, an engine always attached to a G.N. pattern Tender and by dint of the draughting experiments, unique for much of her career



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

by: DON YOUNG

Part 2 – A Second Introduction

Normal procedure for introducing a new DYD is to carry out the majority of the research ahead of putting pencil to paper, said research in several notable instances being carried out by good friends for me in large part, like for instance searches being made in Drawing Offices for old prints which had been hoarded for sentimental reasons. After several thousand hours spent on the drawing board and with that part of the process complete, patterns were then put in hand and castings from same duly arrived on shelf; only then was the design announced.

DONCASTER is proving the exception to the rule in many ways. First the necessity for research in depth was not appreciated at the outset, mainly because of my personal involvement with the Gresley A3 'Pacifics' at The Plant and vivid memories from working on them, though 30 years is a long interval and memory has proved fallible. I also knew that in the period 1962-72 the Drawing Office at Doncaster had contracted from 43 to just three 'skeleton' staff, so the hope of drawing information from that source was slim indeed, plus the tracings were in bundles at the National Railway Museum at York awaiting collation. I remained confident that through the kind assistance of John Bellwood, the Chief Mechanical Engineer at York, said drawing information would become available to me, but a Librarian was not appointed until October 1983 and to date, despite what I wrote earlier in anticipation, nothing has materialised from York as I pen these notes, though said comment is anything but a criticism of my good friends at the N.R.M. So the information available when I first put pencil to paper was a whole host of fond memories, supported by many published photographs of which a good selection had been provided me by B.R. in 1970 for my 'Doncaster Plant' series in M.E., plus Drawings No. Q90-N and R158-N loaned me by Brian Lee and covering the Class A1 Locomotive and flush sided non-corridor Tender. By August 1983 when the first DONCASTER article appeared in LLAS No. 16, I had prepared eight sheets of the drawings, five of which had been traced, and by the greatest of good fortune had taken a 'summer break' from the drawing board.

Publication of Part I brought forth a roar of approval, plus valuable addition to my 'team of critics', notably John Michael Foster and Doug Trivett, though many others made notable contributions. Not only did said two gentlemen indicate a need for more research, but they also supplied much of it for me – spoon fed again! By the end of September 1983 I had also acquired a number of, rather poorly reproduced, microfilm prints of Gresley 'Pacifics' from O.P.C./B.R. Joint Venture at Bournemouth, had covered the chassis amendments on Sheets 7 and 8, all Tender details being completely vindicated, and was ready to start on Sheet 9, covering on this some of the earlier modifications to DONCASTER apart from completing the rolling chassis and adding the side rods. Add to this the tender and boiler which had already been covered and progress was such that I could again stand back and take stock, though before doing so I had one further foray on the drawing board. This was to lay out the valve gear at twice full size and check out my earlier basic calculations. I was thrilled to find in less than two hours that I had a valve gear better than I had ever achieved before, one which Dr. Francis Burrows is going to verify for me, all being well, which bodes well for DONCASTER when she reaches the track.

Publication of Part I in advance of the DONCASTER series was vital in other respects too, for it acted as self-generating market research. From this it became apparent that most interest was in the single chimney A1/A3 of around 1933 vintage; there was some interest in the 1963 version and similarly for the Gresley A4 Class 'streamlined Pacifics'. My further research rather surprised me in that when at Doncaster I had considered the A3's and A4's as 'different engines'; by 1963 not only did they perform alike, but they

On May 2, 1981 FLYING SCOTSMAN comes up the incline off the Blackburn line and into Hellifield Station, going on to Carnforth. Photo by Mike Rea who has been waiting almost 3 years to see this shot in print had also moved closer together in constructional detail, so that with the main exception of the cylinders, they **were** alike. The myth that in 1935 Doncaster had designed a new engine, the A4, in a few months was finally exploded, for they had rather taken a fresh look at the last batch of A3's built in 1934, been finally freed from using the existing cylinder castings which could and should have been replaced at least seven years earlier, and put the whole in a fancy casing. That said changes were so minor is really a tribute to all the design progress made from A1 to A3, together with adoption of Chapelon principles in part, though not in full. By the beginning of October I had also loaded the major pattern work such as wheels and cylinders and knew their cost, another valuable piece of information, especially when applied to the initial reaction from you the readers to the introduction of DONCASTER.

One area I knew intimately on the A3's was the cylinders/smokebox saddle, particularly the jointing between the latter and the middle cylinder, which was complex. What was a difficult task in full size would become impossible in 5 in. gauge, where only fingers, not a whole body, could enter the smokebox to deal with the fixings. I determined early on to make said smokebox saddle simple and substantial, with particular attention to the exhaust passages, this at the expense of the middle cylinder. I am proud of my solution, though expense is the operative word for the middle cylinder block! But said expense is in producing the casting, for subsequent machining is very minimal, surprisingly so. I also decided at the outset that back covers on all cylinders would be cast integral with the blocks, as full size, which has received 100% approval. Of course, if any builder is put off by this, simply machine away the back covers and replace with separate ones, though I can verify from personal experience with my K1/1 'Mogul' that such an extreme step is not necessary. Anyhow, what really emerged was the sheer cost of the middle cylinder block meant it would be the sole example for my big Gresley engines.

There was of course no problem in arriving at the 1963 version of DONCASTER, for the changes were largely cosmetic, the double chimney and banjo dome being the only castings involved, but how to cater for the A4 fans economically? The tender, provided it remained non-corridor, merely required removal of the external coping, plus slight alteration to the front coal bulkhead; no problem with either. I then took the 1963 version of DONCASTER the engine and put it in a streamlined casing as at 1938 when MALLARD was built; and arrived at the result as depicted. Although said end result is rather a streamlined A3 than an A4, externally it does not offend my eyes, and remember that MALLARD will always remain very special to me, having been involved completely in one of her general refits in the early 1950's, which culminated in my driving her on trials, so I can commend my version to builders. As 99.9% of the DONCASTER description applies, there is no need for separate detail, though I will try to draw attention to those parts which need some modification to fit sweetly.

The Tenders – Introduction

Every Gresley A1 'Pacific', as against the later Peppercorn A1's, was originally fitted with a G.N. pattern tender and although this type remained in the majority right until the end, I both abhor coal rails from practical experience in miniature, plus the flush sided non-corridor version for me is infinitely more attractive and a perfect match for the engine. So it was that after literally years of searching, I came upon DONCASTER illustrated on Page 120 of 'The Gresley Pacifics' by O. S. Nock and my joy knew no bounds. Unfortunately it must have been a case of auto-suggestion, something that stayed with me for a long while, for had I looked just that little bit closer then that flush sided tender would have resolved itself into a corridor one. Let me run through the tender history for DONCASTER as recorded in the R.C.T.S. 'Locomotives of the L.N.E.R. – Part 2'. Originally fitted with a G.N. type, the change to corridor was made in April 1928; reversion back to G.N. type was in July 1933. Then in December 1941 did DONCASTER first become attached to a flush sided non-corridor tender, went back to G.N. type in August 1952 and finally was reunited with a flush sided tender in August 1962 for her final fling. It means that to be absolutely accurate, we can only couple DONCASTER to a flush sided tender if depicted in the period 1941-52 or at the very end of her days, and though this came as rather a shock, it did mean reversal of my original decision of flush sided tender only and a G.N. tender body will appear in this series, the two chassis being identical to all intents and purposes.

If any builder wishes to be accurate in joining an A1 'Pacific' to a flush sided tender circa 1933, then the choice of engine narrows dramatically to just 2563 WILLIAM WHITELAW or 2466 LADAS, the former being renamed TAGALIE in July 1941 about 18 months ahead of conversion to A3; withdrawn in 1961 she was never fitted with trough deflectors. One other point about this unique pair of A1's is that they were built by North British Locomotive Co., Works Nos. 23101 and 23104 respectively.

Reverting to DONCASTER, although my choice of name was for obvious reaons, further research has shown she was of historical significance and very much a 'star' engine in her early career. For instance, she was the first Gresley 'Pacific' to be officially extended in the cause of increased speed, as against endurance, in February 1932 covering the 76.4 miles from Peterborough to Kings X in 66 minutes, with a maximum of 92 m.p.h. at New Barnet. It is perhaps noteworthy that an A1 was chosen for this trial, when by 1932 there were many supposedly superior A3's in service.

Just before we start construction there is one further feature to be mentioned, the 4th lamp iron on the bottom row at the back of the tender. This was a G.N. feature that was perpetuated into L.N.E.R. times and my drawing faithfully copies that for the flush sided tenders. It appears that the 'mistake' was not discovered until 1931, all flush sided tenders constructed before this being so fitted, plus all the G.N. ones, and it is a matter for conjecture as to when they were removed, for very few cameras were aimed at the back of tenders, except corridor ones, and the evidence I have gleaned thus far is totally inconclusive. One has to rely on memory, which can be very fickle at times as I have learnt to my cost!, but Allan Garraway brought the point up from his experience in changing lamps from tender to front end. I was never allowed to touch lamps on engines, hence I often tend to forget the essential lamp irons on my drawings, and I guess the reason why lamps were outside my experience was that if they went out on the journey, the train was very liable to be stopped – on dark, wet nights at the foot of a bank, such was not appreciated!

Tender Chassis

Now we have established that the tender chassis is identical for all three types, namely G.N., plain and streamlined flush sided non-corridor, I can advance description on a common front, and trust that the standard of my detailing will meet with general approval. I have concentrated exclusively on authentic detail, with no short cuts, though should any builder wish a 'plain' version rather than a SUPER DONCASTER, in the main it is a case of omitting some of the more exotic piece parts rather than a wholesale redesign.

Frames

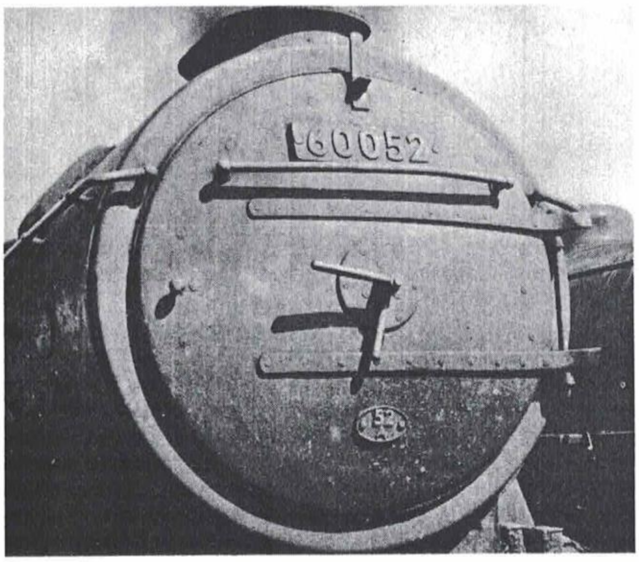
The frames are from $3\frac{1}{2}$ in. wide x $\frac{1}{8}$ in. or 3mm section mild steel and we require two lengths of around 2 ft. $1\frac{3}{4}$ in. First job is to establish a datum edge along the full length, which calls for careful filing and use of marking blue, a good first use for the lathe bed of your newly acquired Myford 254S! From said datum, mark out the frames, clamp to the second piece and drill about half a dozen 3/32 in. holes for copper or aluminium rivets. Now saw and file to line, then drill all the specified holes, separate and remove all burrs and sharp edges.

Draw and Drag Boxes

Already we meet our first steel fabrications, fairly simple ones that add greatly to the authenticity of the design. The idea with fabrications is to get them as close to drawing as possible so that subsequent machining is reduced to an absolute minimum, in this instance the side faces only to accept the frames. At the end of my six year stint with radar, LLAS reader John de Bank arranged that my parting gift be a vernier caliper gauge and although it took me some little time to learn to 'drive' it properly, nowadays it is a most cherished piece of equipment on the odd occasion when I can switch off the drawing board and switch on in the workshop. If any builder is not so lucky as I in this respect, then make up a frame gauge to be 6 in. between jaws, from 2 in. x $\frac{1}{8}$ in. or similar steel flat. Now it is a case of cutting out the individual plates to drawing, allowing only about 1/64 in. for machining the side faces, and joining the pieces together with just sufficient 8BA round head screws to arrive at a rigid assembly. Coat all the joints liberally with the appropriate flux, mixed to a very stiff paste so that it adheres rather than runs all over the place, heat as rapidly as possible and feed in spelter; speed is of the essence to minimise the risk of oxidation. Allow to cool, wash off in warm soapy water and use an old toothbrush to scrub away excess flux. File off the heads of those 8BA screws, generally polish up and then spray on zinc from an aerosol can to prevent rusting. Grip in the machine vice, on the vertical slide, and mill the end faces to 6 in. overall, not forgetting that $\frac{1}{16}$ in. spigot for the frames to butt against. Assemble the pieces made so far with cramps, sit on the lathe bed and check to be both square and flat on same. Although the permanent fixings can be applied at this stage, I prefer to wait until the chassis is wheeled as being the ultimate check that all is well.

Intermediate Stay

Because there are no inner frames on this particular tender chassis, we are already well advanced and can take another step forward by flanging up the intermediate stay from $\frac{3}{4}$ in. x $\frac{1}{8}$ in. steel flat, milling the end faces to 6 in. overall to gauge and then reducing the central portion as shown.



Outer Stiffener and Doubler Plate

There are no end beams as such on this tender, merely extensions from the draw and drag boxes, so let us attend to the latter next. Although the basis of the outer stiffener was assumed to be $1\frac{1}{4}$ in. x $1\frac{1}{4}$ in. x $\frac{1}{8}$ in. bright steel angle, I see from the current Reeves Catalogue that 32mm x 32mm x 4mm is more likely to be that available, which will suit our purpose equally well. Saw and square off in the 4 jaw chuck, two $1\frac{3}{8}$ in. lengths, then reduce one face to $1\frac{1}{16}$ in. width and the other to the shape shown. Cut the top flange and the two webs from 1.6mm sheet, fit wee spacers to arrive at their positions as shown, clamp firmly in place and braze up. Clean, zinc spray and check that the angle is still nice and square, getting back to this state by milling if indicated. Offer up to the frames, drill the No. 34 fixing holes, then cut out the doubler plates. Clamp these in place, drill for and fit the four $\frac{1}{16}$ in. snap head iron rivets, and we shall have to leave the buffer fixings to complete for the moment.

Bracket and Rubbing Box

At the front end a simple folded bracket attaches to the frames to support the tender soleplate, the corner of which can be brazed up for the additional strength this provides.
For the rubbing box, start with the backplate, cutting a 1 in. x $\frac{5}{8}$ in. hole in the centre of same. Bend up the rubbing plate from $1\frac{1}{8}$ in. x $\frac{1}{8}$ in. flat to roughly the shape shown, then make top and bottom closing pieces to fit, trim the rubbing plate down to $\frac{7}{8}$ in. width at the sides, cut the $\frac{5}{8}$ in. x $\frac{7}{16}$ in. slot in the rubbing face, clamp the assembly together and braze up. Once again clean, zinc spray and the rubbing box can be fitted to the draw box, using either 8BA hexagon or round head screws, the latter with the slots filled in to represent rivets.

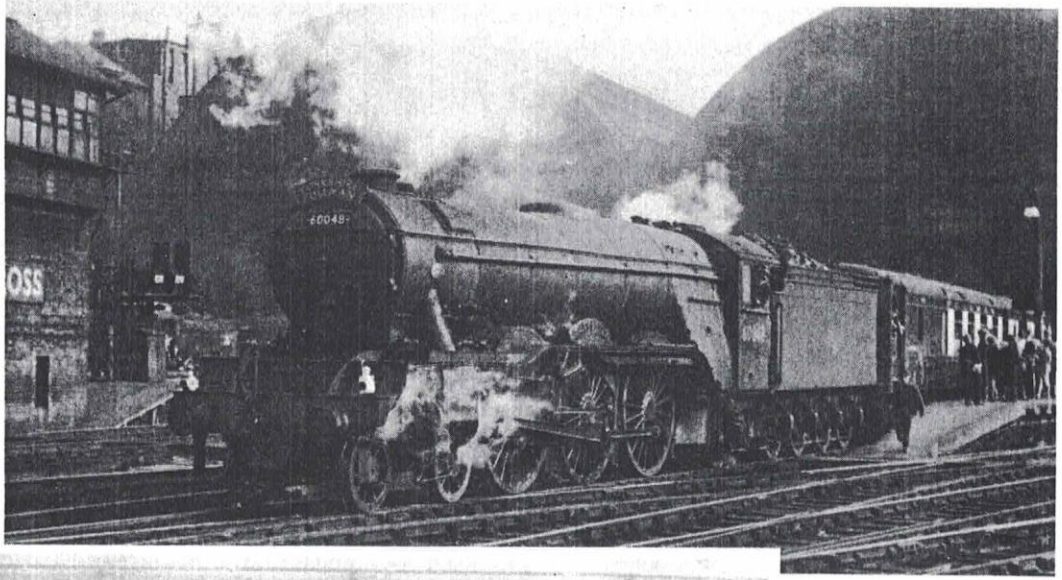
Axles

First square off four lengths of $\frac{3}{4}$ in. diameter steel bar to $7\frac{5}{8}$ in. overall and centre each end deeply, then mount between centres and carefully grip with the 4 jaw chuck. Reduce over about 4 in. length to 21/32 in. diameter, then with a round nose tool, form the journal to $\frac{1}{2}$ in. diameter, leaving the $\frac{1}{16}$ in. end spigot at $\frac{5}{8}$ in. diameter. Next deal with the wheel seat to the same $\frac{5}{8}$ in. diameter, either to be a press fit in the wheel or for securing with Loctite No. 601 – the choice is yours. Set the top slide over by 2 deg. and start forming the tapered portion at the centre of the axle, getting the length right in the first instance and then setting the top slide over a slight amount more to arrive at $\frac{1}{2}$ in. diameter at the centre of the axle; leave the top slide at this setting. Reverse in the lathe, reduce the remaining bar to 21/32 in. diameter and then deal with the tapered length before setting the top slide square once more to complete the axles.

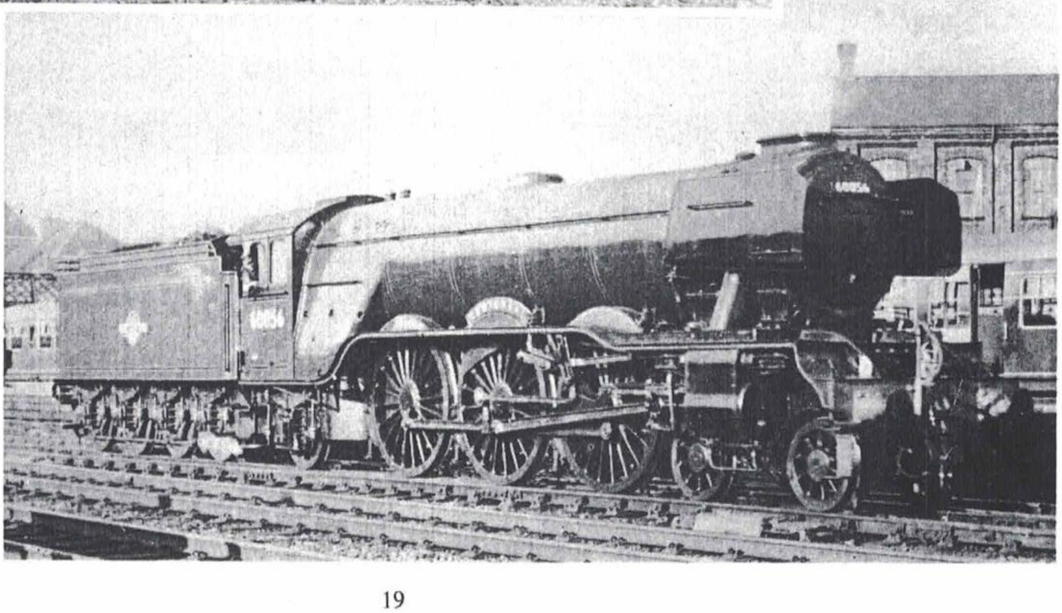
Horns and Axleboxes

The horns are cast in sticks of three as being the most convenient number to handle for machining and although this does mean a surplus of one of each type in conclusion, it is still felt to be the best solution. Grip each casting in turn in the machine vice and mill the rubbing surface as a first step, then sit this machined face on the bottom, fixed, jaw of the machine vice and with small pieces of packing between the cast webs, tighten the top jaw. For three of the castings, machine right across the bolting surface, on the other three take care to include the $\frac{1}{16}$ in. spigot as shown. Now it is simply a question of completing the rubbing surface to width and tidying up the frame fixing edge, when the sticks are cut into individual horns and squared off to length. Although the axle boxes could be fairly involved castings, setting them up would be a nightmare, so a plain cast stick of good quality gunmetal is much preferable, cheaper too. There is one decision to be made at the outset, whether those wee cover fixing bosses be integral with the casting or separately

The perfect action shot by Tom Greaves of DONCASTER pulling out of Kings X with the "Yorkshire Pullman"



Us apprentices even made A3 WOOLWINDER look untidy! No prizes for spotting yours truly, but Tom Greaves is standing 3rd from the left; for the story behind this photograph see Page 9



A3 'Pacific' 60056 CENTENARY in final form and captured at Doncaster by John Michael Foster in 1961 brazed on later, which decides if the material section be 1 15/64 in. x 1 in. or 1 15/64 in. x $\frac{15}{16}$ in., arrive at the chosen section. Saw into individual boxes and square off to length, remembering to make four each to 1 5/64 in. and 1 13/64 in. respectively.

Mark the journal centre very accurately on one box and scribe a circle to around $\frac{3}{4}$ in. diameter from same. Chuck this axlebox in the 4 jaw and with a scriber clamped under the toolpost, use this latter to get the circle running true; centre and bore through to $\frac{1}{2}$ in. diameter. We now have to open out the bore at each end to 21/32 in. diameter and form the radius at the shoulder, which we can accomplish in a single operation with a composite tool, a home made 'D' bit with the concave radius formed on the nose. If you can locate a source of 17mm silver steel rod then your task is all the simpler, otherwise use $\frac{3}{4}$ in. diameter and of course reduce. Deal with one end only for the moment, I recommend it be the back, then release two chuck jaws only, fit the next box and tighten the same two jaws, continuing until all boxes are at this state.

Next stage is the slots, so set up the machine vice and vertical slide then fit a suitable stop in one of the 'T' slots in the latter to act as a register for all the boxes. Deal with one slot to both width and depth, turn over and apply the same readings for the second slot; again there will be four boxes of each type. Before proceeding any further with machining the axleboxes, you can if you like assemble each with its pair of horns to the frames and use lengths of $\frac{1}{2}$ in. diameter bar to check alignment. If all is well, as it should be, then you can prolong the break from machining by rivetting the horns to the frames and then file relief at the ends of the slots so the axleboxes can be lifted independently by around $\frac{3}{16}$ in. without the, temporary, axles binding; of course maintaining the $\frac{1}{8}$ in. sideways movement of the intermediate boxes as this is vitally important for safe curving on what is otherwise a long fixed wheelbase.

Next rechuck each axlebox in the 4 jaw, with a length of $\frac{1}{2}$ in. rod in the bore and set this latter to run true with a d.t.i. With your special 'D' bit, open out the front end of the box to 21/32 in. diameter to leave $\frac{11}{16}$ in. between shoulders, only it is not easy to check this latter dimension, plus the axle will not enter the box at this stage, so leave over-long for finishing later on if in any doubt.

Back to the machine vice and vertical slide to mill out the large recess for the oil tray; drill a few pilot holes first if you like and use a large diameter end mill initially, but complete to drawing with one of $\frac{1}{8}$ in. diameter. Now you will be able to insert the axle, either returning to the 4 jaw to bring the shoulder to size, or staying with the machine vice and chucking the 'D' bit in the 3 jaw. With the latter set-up you can now mill the front of the box, the side flanges too if the cover bosses are integral, or form the latter separately and braze them on. Assemble with the proper axles to the frames, check that all is well, when we can add the finishing touches to the boxes to complete this session.

Oil Tray, Lid and Cover

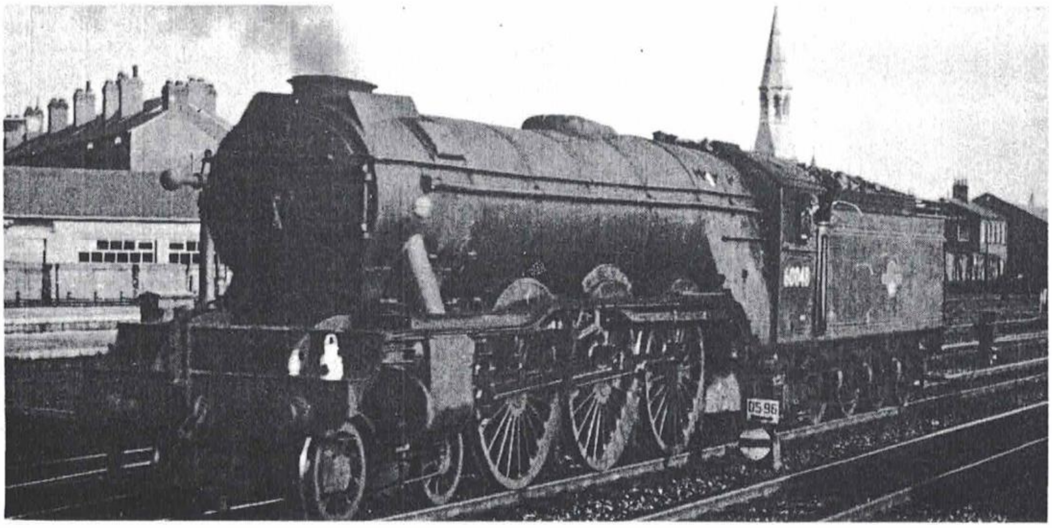
The oil trays are some of my favourite wee fabrications, one's I would simply make to place to fit the axleboxes, but anyone finding them a trifle difficult can knock up a simple metal or hardwood former and cut the tray from a single piece of 1.2mm brass sheet. Make the end blocks to which the lid fits from $\frac{5}{16}$ in. square brass bar, drilling the No. 41 oil hole first, then shaping to drawing; add the wee hinge as a separate piece part if you wish, then braze together. Scallop the inner wall of the tray to clear the axle, then cut pieces of felt to a neat fit in each tray, when we can proceed to the lid.

Chuck a length of 3/32 in. brass rod in the 3 jaw, face, centre and drill No. 56 to about $\frac{3}{4}$ in. depth; part off $\frac{1}{16}$ in. lengths and deepen the hole until you have eight of them. Braze these to the end of $\frac{3}{16}$ in. x 1.2mm brass strip, scalloping the latter slightly to arrive at the drawing detail so that the lid sits snug on the filler block, then shape the strip as shown, before gripping in the machine vice to complete the hinge with a slitting saw; assemble with 3/64 in. stainless steel pins.

The cover is from 2.5mm brass or steel to choice and I know of no better way to form the external radius than with a large flat file, after which mark out, profile, drill the fixing holes, then deal with the slot to accept the oil tray filler. Offer up to the axleboxes, drill and tap 10BA for the wee studs, turn up the latter and fit to complete. Actually there is one piece missing in this assembly, split pins which fit into the 3/64 in. diameter projections at the ends of the studs. Problem is that these would only be 1/64 in. diameter, which are very much non-commercial!, plus drilling the holes to accept same would also put a strain on the strongest nerve, so unfortunately they will have to be omitted.

Postscript

Just before I close, these notes were penned on Sunday 8th January, just 100 hours after I put down my pencil on completion of the DONCASTER Drawing set, though there remain a few details to be verified. At least this allows me to announce that the full set, which includes most of the modifications made over the years, comprises 16 Sheets, whilst Sheet 17 is devoted to the G.A. of MALLARD, so as these later sheets are traced so they can be released to builders. Quite a number of the castings should also be on shelf by the time this article is published, so I am winning – slowly!



The useless gull wing deflectors rather spoil the looks of DONCASTER at Doncaster. Photograph by John Michael Foster

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

by: **DON YOUNG**

Part 3 – Progressing the Tender

After spending literally days working out the tender axleboxes, particularly the intermediate ones to gain the very necessary side play, I still ended up with a foul between wheel boss and axlebox on the intermediate axles, discovered for me by builder Bill Holland; that did upset me! Bill simply machined $\frac{1}{16}$ in. off the inner face of his intermediate axleboxes, when all was well, though it is equally feasible to reduce the wheel boss by the same amount. At least no scrappage is involved, so I am going to leave it to DONCASTER builders to decide where to remove metal.

I was reading in 'Model Engineer' the other day how to machine wheels where the back was not cast concentric with the front and it made me sit up. For having spent around 50 hours at the beginning of the year cleaning up the master metal patterns for the driving, coupled, bogie and trailing wheels for DONCASTER, I was a little annoyed when the sample batches of those for the bogie and trailing showed a lack of concentricity on odd wheels and told the foundry so. Obviously an odd wheel will slip through the 'quality control net' as I cannot trial machine them all, but wheel patterns in particular take many hours to produce accurately and those for DONCASTER are really superb, so I only gain pleasure when the actual castings reflect the standard of the patterns – I will never tell my builders how to machine eccentric wheels!

Disc Wheels

I will run quickly through the operations to produce the tender wheels, which can then be followed for the remainder on the engine. Chuck by the tread in the 3 jaw, after assessing the machining allowances provided, face the back of the tyre, move the tool back $\frac{1}{8}$ in. and face the boss. Turn the tyre flange to $4\frac{3}{4}$ in. diameter and radius the corner, then centre, drill and ream through the boss to $\frac{5}{8}$ in. diameter. Next mark off and drill the two $\frac{3}{16}$ in. holes in the wheel centre; full size these have no other purpose than to stop the wheel 'ringing', though we shall find them useful in a moment.

Saw the flutes from an $\frac{11}{16}$ in. drill with taper to suit your headstock mandrel; tap it home and turn down to a good fit in the wheel bosses. Fit the faceplate, offer up the first wheel, packing off the faceplate so that the centre boss does not do the supporting, then put 2BA bolts through those $\frac{3}{16}$ in. holes and nut to the faceplate. Face off the front of the wheel to thickness, remembering about the centre boss on the four intermediate ones if removal of metal here is your choice, then cut back 3/64 in. or $\frac{1}{16}$ in. to $3\frac{11}{16}$ in. diameter to represent the tyre, as shown. Next, with a round nose tool, concentrate on the tread to about 4.45 in. diameter, getting all wheels to this stage, dealing the root radius and the other corner of the flange. Leave the last wheel in place, take a final cut to bring the tread to size, and at this setting deal

Jim Sarney sent in this magnificent shot of 60052 PRINCE PALATINE approaching Aylesbury with an up Manchester-Marylebone express in 1949 with the other seven wheels. Complete by setting the top slide over 30 deg. and producing the chamfer as a separate operation. Secure the wheels to the axles, either press fit or use of Loctite and we have a rolling chassis.

Spring Gear

An 8 wheel tender produces a fair number of parts and where sufficient of them are identical it is worth making up a 'master', case hardening it and then using as a drilling and filing jig for the remainder; the sixteen spring hanger brackets are a good start in this direction.

For the spring hangers, chuck a length of $\frac{1}{2}$ in. x $\frac{3}{8}$ in. BMS bar truly in the 4 jaw, face and turn down for $\frac{5}{8}$ in. length to $\frac{3}{16}$ in. diameter, screwing 2BA. Reduce the screwed length to $\frac{9}{16}$ in. as per drawing, then turn the next $\frac{7}{8}$ in. down to 5/32 in. diameter, using a round nose tool, and start forming the 'gripper' end. Cross drill No. 30 then you will have to complete fashioning with saw and files.

The spring plates can either be machined from solid, or fabricated, and on reflection I now favour the latter method. Start with 1 in. x $\frac{1}{8}$ in. BMS flat, mark off and saw out, then complete by milling or filing to an easy fit between a pair of horns. The collar to accept the spring buckle end is plain turning; braze together and then clean out the bottom of the recess with a $\frac{5}{16}$ in. 'D' bit.

For the spring buckle, first produce a length of BMS bar to the required $\frac{9}{16}$ in. x $\frac{3}{8}$ in. section from the nearest available stock. Chuck truly in the 4 jaw, face and turn down for $\frac{1}{8}$ in. to $\frac{5}{16}$ in. diameter, a nice fit in the spring plate. Centre and drill No. 34 to $\frac{5}{16}$ in. depth, tapping 4BA, then cross drill at around 13/32 in. diameter to start forming the slot for the spring. You will have to complete said slot by filing, using the actual spring material as your gauge; when satisfied, rechuck in the 4 jaw and part off to length.

Of all the things I was taught at Doncaster Technical College, the solution of leaf springs stuck firmest in my memory, laying the leaves side by side to form a diamond, supported of course at its end corners and with load applied in the middle; even my brain could absorb such a simple technique. When I first changed from coil to leaf springs in miniature, by making each leaf only .010/.012 in. thick and using three of them to represent each full size leaf, it was a matter of solving three diamonds, and of course with such thin and flexible material, everything could be made from spring steel. This meant that for engines like JERSEY LILY I could specify springs of a known rate. However, another faction preferred using spring leaves of scale thickness, using a mixture of spring steel and 'Tufnol' to obtain the necessary flexibility, and being more realistic this type of spring is now much in favour, hence my adoption. It does mean though that no longer can I establish its characteristics by calculation, it is a matter of trial and error, though I suppose it is a small price to pay for the extra realism, especially where springs are so exposed as on our tender.

For the top leaf, use a sharp chisel to mark both faces of a $3\frac{13}{16}$ in. length of $\frac{7}{16}$ in. x .028 in. spring steel strip, snap off and grind the edge. Part off $\frac{7}{16}$ in. lengths from $\frac{1}{8}$ in. steel rod, poke the leaf through a large potato with only $\frac{1}{16}$ in. stand-out, sit the $\frac{1}{8}$ in. rod on this projection and braze up; the potato will cook a bit, but save the spring leaf losing its temper. Tap the bottom face of the leaf with a ball pein hammer to stretch the metal to arrive at the required $\frac{1}{4}$ in. camber; deal with the spring steel leaves likewise.

Both spring steel and tufnol of the requisite section is obtainable from Reeves; coil the latter inside a tobacco tin and boil in a saucepan for about 20 minutes, or less time in a pressure cooker if you have one; more importantly can gain domestic approval for use of same in this way. Cut to length, build up the spring and secure with a 4BA cup point socket grub screw.

Shock absorbers are a very prominent feature on LNER engines and tenders, so despite the sixteen called for on this drawing, we do in fact require a total of no less than 32, so may as well tackle them all in a single batch. Grip a length of $\frac{3}{4}$ in. x $\frac{1}{2}$ in. BMS or brass bar in the machine vice, on the vertical slide, face across with an end mill, find the centre by the 'X' method and drill No. 10 to about 1 in. depth. Reeves do not list an 11/32 in. end mill, which is hardly surprising, but they do have this size in slot drills, so first mill out a $\frac{5}{16}$ in. slot to $\frac{9}{16}$ in. length and 7/32 in. depth, completing with the slot drill to around 19/32 in. length. Saw off a $\frac{7}{16}$ in. length of bar and mill the top face to start forming the spigot which sits in the recess provided in the spring hanger bracket, then I can think of no other way but to complete with files, rather a tedious task, but the end result will be well worth the effort.

Thus far I have failed to locate a source of $\frac{3}{16}$ in. thick rubber, or neoprene, for the shock absorber itself, though something a bit thinner is no problem and of course can easily be bonded together to build up to $\frac{3}{16}$ in. thickness; cut to a close fit in the cup and punch the $\frac{3}{16}$ in. hole. The retainer is of course a very much 'make to place' item; erect the piece made so far, making the nut at the end of the spring hanger from 4BA hexagon bar. Cut the locking plates, offer up to the retainers, drill and tap for the 10BA studs to complete. Actually there should be a split pin to act as a further safety precaution for the 10BA nut, but I know of no way to produce 1/64 in. split pins, they not being a commercial item. Just one more point whilst we are in this area; if the spring end tends to move sideways out of its spring hanger 'gripper', then do as shown in the photograph full size and fit a 10BA dowel bolt, filing a local flat on the $\frac{1}{8}$ in. rod at the spring end; it will add that final touch of class.

Buffers and Guard Irons

Our buffers must be self-contained in that the springs cannot extend beyond the buffer beam in the usual, miniature, way. The stock can be machined either from $1\frac{3}{4}$ in. diameter or $1\frac{1}{4}$ in. square steel bar to choice, first being turned to drawing and then the flange tidied up to size; mark off and drill the four No. 44 fixing holes. The buffer head is again plain turning; deal with the shank first, setting the top slide over 10 deg. to machine the back of the head, then drill and 'D' bit $\frac{1}{2}$ in. diameter for the spring and tap 4BA for the retaining screw. Part off, reverse in the chuck and complete the head, I suggest a metal or plastic template, so that both heads are identical in conclusion. The socket again is simple turning; fit the head to the stock, slip in the spring, followed by the socket, and secure with the 4BA cap screw to complete. I should mention that for these buffers to be of any use in service, it should be impossible to fully compress them by hand.

Most guard irons in miniature are a complete waste of time, for as soon as they attempt to carry out their function, bolts shear and they get knocked back out of the way. This pair, however, are rather more robust than usual, though perhaps with this in mind I have made them too robust and 3/32 in. or 2.5mm thickness would be better.

Brake Gear

We can only go so far with the brake gear in this session a the means of operation appears on Sheet 4, though there i plenty to be going on with! The gear is also a remarkabl mixture of simple and complex parts, so let us ease our wa in by starting with the intermediate brake hanger brackets.

Chuck a length of $\frac{3}{4}$ in. diameter steel bar in the 3 jaw, fac and turn down to 23/32 in. diameter over a $\frac{1}{2}$ in. lengtl Centre and drill No. 22 to $\frac{1}{2}$ in. depth, following up with $\frac{3}{8}$ in. 'D' bit to 7/32 in. depth; part off at a full $\frac{5}{16}$ in., revers and clean up. Grip in the machine vice, on the vertical slide, to first mill away to arrive at the 3/16 in. dimension, then use a 3/8 in. end mill to complete the recess. Offer up to the frames, locate through the No. 22 hole. clamp in place, drill for and secure with four 1/16 in. rivets.

I recommend the front brake hanger brackets be fabrications, in five pieces. First cut the base from 1.6mm steel; mark off and drill the No. 22 hole in the centre. Next cut a 5/8 in. length from 5/16 in. x 1/8 in. BMS flat, clamp to the base and drill the No. 22 hole, followed by the same operation on a 5/8 in. length of 5/16 in. x 3/32 in. flat. The final pieces are two 1/4 in. lengths of 5/16 in. x 3/32 in. flat, to complete forming the slot. Select a particularly rusty length of 5/32 in. steel rod so that the spelter will not adhere, screw 3BA for about 3/16 in. at each end, and use this to firmly grip all the pieces together for brazing. Clean up, apply a coat of zinc from an aerosol to prevent rusting, offer up to the frames and secure with 1/16 in. rivets. Brake shoe and hanger pins are plain turning, though I would turn up the heads as wee collars and braze them to plain pins, so let us move on to the brake hangers.

For the rear and intermediate hangers we require a simple jig, so take a 4 in. length of, say, 3/4 in. x 1/4 in. BMS bar, mark off the three hole centres as specified on the hangers, drill one at No. 23 and the other two at No. 31, pressing in 1 in. lengths of 5/32 in. and 1/8 in. rod respectively. Concentrating on the rear hangers first, chuck a length of 1/4 in. steel rod, face, centre, drill No. 30 to 3/4 in. depth and part off a 5/8 in. slice; drop this over the bottom pin of the jig, then repeat for a 9/32 in. sleeve and drop this over the middle pin. Change to 5/16 in. rod, face, centre, drill No. 22 to about 1 in. depth and part off 7/32 in. and 1/4 in. sleeves; drop these over the top pin in that order. Now cut the central portion of the hanger from 1/2 in. x 1/8 in. steel flat, drill the No. 30 brake shoe pin hole and then fashion the ends until they match the end bosses; braze up. Now you can complete profiling the hanger to blend in with the end bosses as per drawing detail.

For the intermediate hangers, at the bottom we require 9/16 in. long bosses; for the top make five bosses each 7/32 in. long, the fifth being an additional spacer to cater for the offset. Bend up the 1/2 in. x 1/8 in. flat to give the required 5/32 in. offset, drill the No. 30 brake shoe pin hole, then fashion as for the back pair before brazing up and completing the profile.

Press the bottom, 1/8 in., pin out of the jig and drill a fresh pair for the front brake hangers, pressing in 1/8 in. and 5/32 pins. Drill No. 30 and No. 22 holes in a block of 3/4 in. x 5/16 in. BMS bar, part off to 9/16 in. length and then fashion this, bottom, block to drawing. The rest is as before, not forgetting to revert to the original spacer at the top.

For the brake shoes, take a length of 1 in. x 3/8 in. BMS bar and square off eight 1 3/8 in. lengths. Mark off and drill the No. 30 hole, then profile to drawing. Grip in the machine vice, on the vertical slide and mill the 1/8 in. slot, the 3/16 in. dimension being fairly critical so that the shoe cannot 'trip' when the brakes are fully released and make the wheels seize – it has happened!

Erect all the pieces made thus far, set the axles at their nominal working height and clamp the brake shoes firmly to the wheels; measure the pull rod centres, produce these from 1/4 in. x 1/16 in. steel strip and erect with 1/8 in. pins. Unfortunately for me the brake beam ends are detailed on Sheet 4, so I will have to assume for now they are in place for the 3rd and 4th axles. Make up the wee fork ends from 7/32 in. x 5/32 in. steel bar and pin these to the rod ends, then cut the 3/32 in. rod 'beam' to a close fit between; remove, braze up then complete the transition point to drawing.

The front brake beam is both detailed and conventional, so cut a 4 5/8 in. length from 1/2 in. x 1/8 in. BMS flat. Chuck in the 4 jaw with an end running true, face across, centre and drill No. 43 to about 5/32 in. depth. Reverse, face off to 4 9/16 in. overall, centre and drill this end too. Chuck a length of 1/4 in. steel rod in the 3 jaw and turn down over an 11/16 in. length to 5/32 in. diameter, an easy fit in the front brake hanger; part off at a full 7/8 in. overall. Reverse in the chuck and reduce to 3/32 in. diameter, a press fit in the No. 43 hole in the beam, to leave a 1/16 in. collar of the 1/4 in. material; braze up and clean. To complete, fashion the ends of the beam itself to suit the collars and drill the pair of No. 30 holes.

The brake shaft was a one-piece forging in full size, though replaceable steel bushes were pressed into all the pin holes; our problem though is in reproducing the 'forged look' and for this I think it is best if we start from 1/2 in. diameter steel bar. Chuck a full 6 in. length in the 3 jaw, face, centre and turn down the first 5/16 in. length to 1/4 in. diameter. Reverse, face off to 6 in. overall, centre and turn on the second journal. Mount between centres, set the top slide over a bare 4 deg. and turn on the taper portion with a round nose tool. Leave 3/32 in. for the first collar, then machine for 5/32 in. length to 7/16 in. diameter, another 3/32 in. collar and then 17/64 in. to the first brake arm. Leave 1/4 in., then go on to the centre of the shaft, before reversing and repeating to arrive at a complete shaft, less arms of course.

The main arms are milled from 3 1/2 in. lengths of 3/4 in. x 1/4 in. BMS flat. Drill two No. 30 holes at 2 7/8 in. centres, followed by the 5/16 in. hole as specified, then bolt to a length of bright steel angle, bolt this in turn to the vertical slide and mill one face down by 3/64 in.; reverse, pack up and repeat. Now it is a question of producing the profile, I suggest as a pair, this to drawing and to suit the shaft. The pull rod arms are from 1/2 in. x 3/32 in. steel strip, 3/4 in. lengths of same, drilled first at No. 30, bolted together and then finish profiled. Use lengths of 5BA studding to locate axially on the shaft, through the No. 30 holes, then braze up, clean and spray with zinc.

Only the front pull rods and adjusters remain from the details on Sheet 3, so on we go. Functionally the adjusters should be provided with R. and L.H. threads, but it will suit our purpose better if both ends are conventionally R.H., when it is only a matter of knocking out a brake gear pin to achieve adjustment. Chuck a length of 1/4 in. A/F steel hexagon bar in the 3 jaw, face and turn down to 3/16 in. diameter over a 5/32 in. length. Centre, drill No. 29 to about 7/16 in. depth and tap 5/32 x 32T before parting off at a full 1/4 in. overall; reverse, face off and run the tap through again, then repeat for a second adjuster end. Screw a length of 5/32 in. rod at 32T and fit the ends to be 15/16 in. overall as per drawing detail; now take a 3/4 in. length of 1/8 in. rod and set over both ends to leave a 3/8 in. straight portion in the middle. With a 3/16 in. round file, scallop the sloping end pieces to match the end fittings; repeat for a second piece, clamp over the pair and braze up.

The rear portion of the front pull rod is so short that it can be made in a single piece from 1/4 in. square bar. Chuck truly in the 4 jaw, turn down for 19/32 in. length to 5/32 in. diameter and screw 32T, then reduce the next 3/32 in. to 1/8 in. diameter with a round nose tool. Drill the No. 30 brake pin hole, then turn over and at the 5/16 in. dimension shown, drill another No. 30 hole at the end of the slot. Saw away, then deal with the slot, before radiusing the end over a mandrel with an end mill; complete the profile at the base of the fork.

For the front portion, chuck a length of 5/32 in. steel rod and turn the first 3/32 in. down to 3/32 in. diameter. Now in increments of around 1/2 in., turn the next 4 3/8 in., a bare dimension, down to 1/8 in. diameter, then part off to leave 1/2 in. at the original 5/32 in. diameter; reverse in the chuck and screw the latter at 32T. Produce a section 9/32 in. x 5/32 in. over a 7/8 in. length of steel flat, mark off and drill the four holes at No. 30, then radius the ends before drilling one of them to accept the 3/32 in. spigot on the rod end; braze up, when we reach the end of the brake gear for this session.

Outrigger

The outriggers are clever little fellows, for apart from supporting the tender body, they also provide a measure of restraint to a spring should the top leaf break; making them though is not so clever! As the top inner corner is hidden by the $\frac{1}{4}$ in. brass angle that runs all along the top edge of the frames, save for interruptions, the top and back can be bent up in a single piece from $\frac{1}{2}$ in. x $\frac{1}{16}$ in. strip, shaped as shown. The bottom piece tapers from $\frac{3}{8}$ in. down to $\frac{1}{4}$ in. over its $\frac{11}{16}$ in. length, with of course the 3/32 in. 'curl' at its outer end; now it is a question of cutting and shaping the web to suit, clamping together and brazing up. I suggest the lightening hole be left until after brazing, when the outriggers can then be offered up to the frames, the $\frac{1}{16}$ in. holes drilled and rivets fitted to secure.

Tender Body

There is no way that I am going to give a 'blow-by-blow' description for construction of this tender body – most builders will be able to tell me how it should be done! I will, however, run over the major features in case my detailing is not 100% clear, something that is not unknown. Brass or steel for construction – the former if at all possible for the long service life it provides. If steel has to be your choice then use a zinc coated one such as 'zintec' and coat the inside with epoxy resin containing white pigment to both seal and show up any 'foreign bodies'.

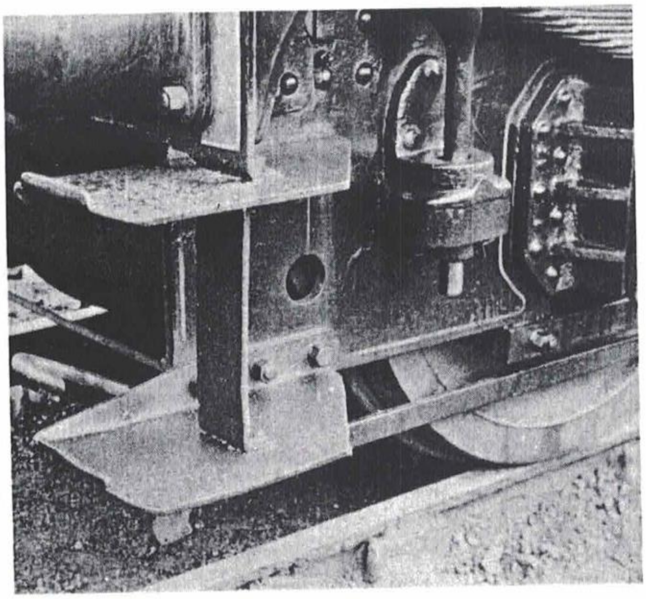
The soleplate is a massive 26 in. x $9\frac{5}{16}$ in. from 1.6mm material, though it still requires a great deal of attention to complete. Cut the $15\frac{11}{16}$ in. x $4\frac{1}{4}$ in. opening to accept the sump, followed by eight slots approximately $2\frac{9}{16}$ in. x $\frac{7}{8}$ in. for the wheel splashers, sitting on the frames to check the latter give good clearance over the wheels, I doubt if any builder has bending rolls 16 in. long, so cut a piece $15\frac{7}{8}$ in. x 7 in. from the 1.6mm material. Scribe the two bend lines on at $2\frac{3}{8}$ in. centre, grip over a length of $1\frac{1}{2}$ in. diameter bar, or tube, in the bench vice and start bending a little at a time, using hand pressure backed up by a soft faced mallet. In conclusion the well should be a 'spring fit' in its opening in the soleplate, cutting away the corners to achieve this; now make up the end plates to fit.

The splasher tops can easily be rolled, or pulled over a piece of 5 in. o.d. or so tube, the sides being made to fit, when the parts made thus far are best silver soldered together. It will cause some distortion, but this can fairly readily be removed by careful use of a mallet, when we have a nice stiff building base on which to proceed. Although gauze can simply be spread over the well opening and tacked in place with a few blobs of soft solder, it is well worth making up a 1.6mm frame to a tight fit between the splashers and tacking the gauze to said frame, when the complete screen can be removed for, annual, spring cleaning.

Apart from the curves at top and front, the side plates are simply large areas of 1.6mm sheet; the back a simple piece of the sheet material. Join the three pieces together with $\frac{1}{4}$ in. brass angle, rivetting together, add more $\frac{1}{4}$ in. angle around the bottom and use 8BA countersunk screws to secure to the soleplate. Cut out another piece identical to the back for the front coal bulkhead, cutting out the centre as shown for the coal opening and doors; erect this in the position shown with more $\frac{1}{4}$ in. brass angle.

The water space really is remarkably simple and by the same token makes a very rigid structure, one that it is feasible to sit upon for driving, a thought for anyone as short armed as yours truly. Cut two pieces each $10\frac{7}{8}$ in. x 7 in. from the 1.6mm material and fold up as shown on the 'View looking forward onto front coal bulkhead (L.H. side)', securing to said bulkhead with yet more $\frac{1}{4}$ in. brass angle. Now comes the tricky bit, filling in the centre portion between these two 'wing tanks' with the combined tank top/sloping base of the coal space. For this, make up a cardboard template and only when satisfied, transfer to 1.6mm sheet, remembering that the plate extends $1\frac{1}{8}$ in. through the front coal bulkhead to come flush with the locker fronts, though said extension may be a separate piece as it continues right across the tender body. Talking of locker fronts, we will now concentrate our attention at the front end.

The locker front is $8\frac{3}{8}$ in. wide x $3\frac{7}{8}$ in. high with a $2\frac{1}{2}$ in. deep x $2\frac{3}{8}$ in. wide cut-out $\frac{1}{8}$ in. displaced from the centre line as the coal opening. Both top and bottom coal doors open inwards, so they are sort of 'fail-safe' as they cannot inadvertently be opened against the weight of coal behind them, though full size this did mean a fireman could be in serious trouble if a big lump of coal did get stuck in the opening, as Frank Mayes related in his '20 years on the Footplate' series. What this means now to builders is that the inside wall of the lockers do not come flush with the coal opening, but are recessed as per drawing, so perhaps we should leave them until the bottom coal door has been made and tried in place. The locker tops do, however, extend to the opening and are held in place with $\frac{1}{4}$ in. brass angle, this time visibly so. With the arrangement shown, there is water space



A selection from the John Michael Foster album of the Tender fitted to FLYING SCOTSMAN; note the different style of step on the L.H. view