

Newsletter No. 7 September 2018

Editor: David A Nicholson

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EDITORIAL

I would also like to thank the members who have contributed to this issue. Although our membership is not as large as some societies we do have members with a vast amount of knowledge and experience and I would like to appeal to them to contribute to the Newsletter.

I hope that as many of you as possible will be attending the Autumn Conference in Bury at the end of the month. A very interesting program has been put together and it is important that we support the members who have put in a lot of effort to organise the event.

Thank you to James Evans for his article in this issue which we hope will produce some feedback either agreeing with or challenging his thoughts on a new narrow gauge steam locomotive build.

I am looking forward to seeing replica Baldwin 2-4-2 LYN running between Caernarfon and Waunfawr on the Welsh Highland Railway during the Super-Power Weekend on the 14th-16th September.



The first steaming of LYN in Alan Keefe's Yard on Saturday 8th July 2017.

(Photo: David A Nicholson)

September 2018

Chairman's Notes:

General Data Protection Regulations – thanks to all who completed the forms and sent them back to Chris. It was a task that none of us expected and I don't think we were the only organisation that had to react, but once again, thanks to Chris, successfully completed.

Locomotive Testing – for this newsletter, I had hoped to give a positive update, but once again the weather intervened, this time not the 'Beast from the East' but the heatwave during the summer. We had hoped to test one of the Churnet Valley Railway's two S160's to help the railway understand why they perform differently. One engine is now away on hire to the WSR for the season and the other returned to the CVR in June after loan periods on the Paignton and Dartmouth Railway and the Epping and Ongar Railway. It was then that the heatwave arrived and that put a stop on running with steam up the challenging gradients to Ipstones as the railway did not want to risk line side fires.

At time of writing the heatwave has broken and Rob Alcock from the CVR has just e-mailed with new proposals. Rob Alcock has joined ASTT as a member – welcome Rob and thanks for your help to-date.

As ever, we are dependant on the operational circumstances and goodwill, so progress can be frustratingly slow.

On a positive note, we did have the opportunity to do a days testing at the Kirklees Light Railway – this was so that we could test out a compound transducer - this can measure positive and negative pressures (vacuum). This was connected into the smokebox. All our other transducers measure either positive or negative pressure but not both. We saw some 'interesting' results, however, this was just on one engine, so we eagerly await the chance to try out it out on another locomotive.

Discussion Forum – after my attempt to stimulate interest in the Discussion Forum, Chris Corney and Martin Johnson had a look at the video I had posted and started a debate on exhaust systems, but we still lack critical mass in numbers of members joining in. So please take the plunge and have a look at the forum.

An alternative may be to have a 'letters page' in the Newsletter, in which case letters to David please.

Annual Conference: This year's conference is on the 29th/30th September at Bury

This is an anxious time for our conference organisers (Chris Newman and Mike Horne) as bookings come in. There are still places left, so if you have not booked already and are intending to come along please let Chris Newman know. It makes life easier, the sooner we know who is coming.

Last years event was a resounding success enjoyed by all. With your help we can make 2018's conference the same.

John Hind Chairman ASTT

!. Website updates

Chris Newman

The main changes to the website have been as follows:

- Six news items have been posted since the last newsletter.
- New pages include one each for Roger Waller and Nigel Day and a report on **ASTTs AGM** held on 17th March, with links to recordings of the afternoon's presentations.

Planned Website Updates still include two items listed in the last newsletter:

- A page listing **ASTS's current projects and activities** in the hope of encouraging others to participate.
- A new title will shortly be added to the **Book Sales page**, offering Ian Gaylor's "Steam Locomotive Design Specifications and Calculations for New Build Baldwin 2-4-2T 'LYN'" for sale. See also the "Book Sales" section of this newsletter.

The Forum section continues to be neglected by members. Feedback and suggestions for improving the forum are welcomed.

Members' feedback on the website, both constructive and critical, is always welcome. Members are also welcome to offer content for the site and/or to offer suggestions for new pages. The website is not just a shop-front for ASTT, but a communication channel for its membership.

2. Membership

Chris Newman

ASTT membership numbers continue to grow, five new members having joined since the April newsletter was distributed, bringing total membership to 58:

1. **Shawn Gray** from Australia.
2. **Hugh Odom** from the USA, a professional mechanical engineer well known for his Ultimate Steam website.
3. **Ralph Ingham** from Wakefield (West Yorkshire) who was a working member of the KVWR loco department for 50 years (recently retired).
4. **Phil Mortimer** from West Sussex, who has worked on rail-related projects in the UK and overseas, currently working on European R&D Projects. Joint owner of Phil Girdlestone's "Red Dragon" Garratt (NGG 141).
5. **Robert Alcock** from Macclesfield (Cheshire): involved with the Churnet Valley Railway MPD for 10 years; fireman for 9 years, owner of a Andrew Barclay 0-4-0 tank and part-owner of two Polish TKh 0-6-0 tanks.
6. **Jens Graefe** a software engineer from Lampertswalde, Germany.

The current membership base is distributed as follows:

Full Members: 13	UK: 48 members.
Associate Members: 40	EU: 6 (Spain, Germany, and the Netherlands).
Student Members: 6	USA: 3 members.
	Australia: 1 member.
Total Membership: 59	China: 1 member.

3. 2018 Autumn Conference

Chris Newman

An updated programme was sent out on 4th August including a menu selection for the conference dinner. Members who didn't receive it can download a copy from the website conference page at https://www.advanced-steam.org/members/2018-autumn-conference-bury/. A recent change to the programme has been the substitution of Richard Coleby who has kindly agreed to take over the last speaking slot on the Sunday afternoon in place of Mike Horne. Richard will present a paper titled "Walschaerts in a Box", describing his design for an enclosed Walschaerts valve gear. Mike believes that there has been insufficient progress on the testing and development of ASTT's electronic monitoring system to warrant an "update" presentation about it at this time.

So far we have received 35 expressions of interest in attending the conference, of which 30 have so far confirmed their intention of attending, though several have yet to pay their attendance fees. Members who haven't already done so are urged to confirm their attendance and pay their fees as soon as possible so that we can be assured of sufficient attendance to cover the conference costs and so that we won't have to be dealing with payments on the day.

Please note: members' wives are more than welcome to attend the conference dinner. At least one member's wife is planning to attend, so everyone else is encouraged to bring their wives along too.

Members are also requested to offer their services in helping to organize future events so as to ensure that ASTT's conferences continue on in future years.

4. Book Sales

Chris Newman

Book sales continue to be slow but continue to provide useful income to the Trust.

Sales since April have been as follows:

- **Defence of the MR/LMS Class 4 0-6-0** by Adrian Tester (pub. Crimson Lake): 0 sold (total sales 13);
- **Introduction to Large-Lap Valves** by Adrian Tester (pub. Crimson Lake): 1 sold (total sales 6);
- **5AT FDCs** (pub. ASTT): 0 sold (total sales 184);
- **5AT Feasibility Study** (pub. ASTT): 8 sold (total sales 42);
- **The Red Devil** by Dave Wardale (pub. Camden): 4 sold (total sales 20 + 233 sold by 5AT Group);
- **Advanced Steam Locomotive Development** by L.D. Porta (pub. Camden): 0 sold (total sales 3);
- **Here be Dragons** by Phil Girdlestone (pub. Camden): 2 sales (total sales 22);
- **The Fire burns much better …** by J.J. Koopmans (pub. Camden): 0 sales (total sales 2);

It is hoped that ASTT will soon be able to offer three new titles:

- **Design Calculations for "Lyn"** by Ian Gaylor (pub. ASTT): The e-Proof for this 604 page volume is currently awaiting a final check by the author. It is hoped to have it ready for sale in advance of the conference.
- **The Physiology of Locomotive Boilers** by Adrian Tester (pub. Crimson Lake): Adrian now expects that the first volume of his new book will be ready for publication at the end of 2018.

The task of proof reading is taking longer than he expected due to Adrian's day-job commitments.

- **Porta Papers**: We are still waiting for Shaun McMahon to finish proof-reading the drafts of Volumes 2 and 3, however he has just provided some editing notes covering Volume 1 which appear to be final, so we hope to be able to have it ready for the printers in time for the conference.
- **Porta Biography:** Work has begun on an additional supplementary volume to add to the three volumes of Porta papers that have been prepared for publication. It is intended that this volume take the form of a composite biography of Porta using material from various sources including:
    - an outline biography being prepared by Shaun McMahon;
    - paragraphs from Dave Wardale's "Red Devil" book describing his first meeting with Porta in 1976;
    - John Click's 1977 report on Porta's development plans for the Rio Turbio Railway (see below);
    - AST's current listing of Porta's 230+ papers;
    - anything else about Porta that may be found, suggested or recommended by ASTT members.

  Completion of the volume will depend on how quickly Shaun finishes his biography, the first few pages of which have been received. It is hoped that it might be possible to publish the volume by the end of the year.

  Post-script: Special thanks to **Jonas Nilender** (Student Member from North Carolina State University) who is continuing to transcribe some of Porta's manuscripts for future publication.

5. John Click Papers

Chris Newman

Having obtained a copy of the typescript of John Click's 1977 report on Porta's development plans for the Rio Turbio Railway and transcribed it into digital format, Chris Newman has spent a day at the NRM's research library looking through several boxes of papers listed in their catalogue pertaining to John Click. The purpose was to take copies of the illustrations appended to the Click report which were missing from the transcribed version.

As it turned out, these were quickly found and copied, so the remainder of the writer's five hours in the museum were spent looking through piles of correspondence most of which were typewritten or hand-written letters from Porta to Click spanning the period from 1977, prior to Click's visit to Argentina, and continuing on for at least five years after. Of perhaps greater I nterest was a small collection of Porta papers many of which were not in AST's collection and some not even listed in John Wright's catalogue of Porta papers. They include:

- Calculations for a Lempor Ejector for a 2-10-0 locomotive (1974) 11 pages manuscript;
- The cardinal points of modern and future steam locomotive design in the context of the Energy Crisis (1975) 36 pages typescript;
- A New Conception of the Compound Locomotive (1976) 18 pages manuscript;
- Progress on Steam Loco Technology carried out in Argentina since 1969 (1976) 18 pages manuscript;
- The Worm Grate and Ash Disposal System 1976 23 pages manuscript.
- The Steam Cycle in the case of a 3-cyl compound 2-10-0 (believed to be 1977) 6 pages manuscript;
- Notes on the Design of Garratt Locomotives (1977) 16 pages manuscript;

- Some Notes on the Design of Mallet Locomotives (1977) 12 pages manuscript;
- A system for coupling both Mallet engine units and its extension to other Articulated Locomotives (1977) 12 pages manuscript;
- A Feedwater Heating System suitable for SGS and TGS steam locomotives (1978) and a 1979 update 18 pages each manuscript;
- A note on a new approach to steam locomotive boiler water treatment (1978) 18 pages manuscript;
- Comments by LD Porta on a paper by G.G. Thurlow on Fluidised Bed Combustion (1978) 4 pages manuscript;
- Some notes on Large Steam Pipe Connections occurring in separable locomotive designs (1978) 10 pages manuscript;

These were all copied for future transcription and publication.

Copying Archives at the NRM: For those not familiar with NRM rules, archived documents can be copied using the NRM's photocopier/scanner (at a cost of 20p per A4 page, or more for A3 pages), or by using a camera without flash. It is not permitted to bring one's own scanner, nor is it permitted to use flash photography. It may be noted that readable copies of Porta's letters and manuscripts were obtained using a camera (without flash) and very much more speedily than would have been possible with any scanner.

Negotiating the NRM Archive: For others wanting to search the NRM archive, it may be helpful to be aware that their website has been updated recently making it harder to find archived records. A search using their normal Search Engine reveals nothing relating to John Click. Instead it is necessary to start at their Research and Archive page (through the link at the lower left from the NRM home page), thence to the Catalogues page at the bottom of which can be found a section titled "Archive Lists". A link to download a PDF copy of the John Click archive appears under the A-E heading. This chain of links may be useful to anyone else looking for information from the NRM.



New-build news:

Cedric C Lodge

Readers may recall a tail piece in Newsletter No. 5 referring to a number of new-build projects, aspirations if not actual work in progress. However, I am pleased to report that one of these aspirations has moved on a little: the Darjeeling B Class. Several important elements have coincided to start this project moving.

I am supporting Colin Rainsbury in his efforts to build a replica B Class, and through conversations with a number of other people, I am pleased to report we are no longer alone. From within ASTT, David Nicholson (our Editor) and Alex Powell have joined us. Earlier in the year whilst firing Linda up to Moelwyn Tunnel on the FR, I was joined on the footplate by Caleb Lovegrove. We got on very well, and it was a great pleasure to meet him again in the summer whilst he was on station duties at Harbour Station. He mentioned he would be starting an engineering course in the autumn, which would include CAD - which gave me an idea: would he like to make a start composing CAD drawings for a B Class loco? He jumped at the suggestion. I told him that all we had at this stage were a GA and Pipe Drawing, and it would be a hard slog, but he was not daunted. The following week I turned up copies of the drawings and passed them on to him. Caleb does not live far from me, so liaison should not be a problem.

One of my colleagues in the Darjeeling Himalayan Railway Society whilst at Tindharia a couple of years ago, came across a near complete set of original drawings for a B Class. It must have been akin to discovering the tomb of Tutankhamon! He arranged with Indian Railways to have them scanned, but instead, IR photocopied them-not as good as scanning, but better than nothing. He now has them on a DVD, a copy of which I hope to receive shortly. This will be of great assistance to Caleb with his CAD project.

Just before I passed the drawings over to Caleb, I received a copy of the book by David Churchill on the B Class: 'The incredible 'B' Class'. This is without doubt a monumental work, which will serve as the definitive work on the type for many years to come. As such, it will enable us to identify the origins of the drawings supplied to Caleb, and those on the DVD.

For a replica, I feel the design should incorporate such improvements to the design as can be fitted within the envelope. A new loco. offers a host of opportunities to show-case what is possible.

And in conclusion, may I invite those who support our aspirations to join us. My e mail is: janced@sky.com

Another area where an outreach function could seek to create partnerships is within the rail supply chain, as many of the larger companies train apprentices. As with the aforementioned students, there is a need to give apprentices interesting work which will challenge them.

The Great Dorset Steam Fair

Jamie Keyte

This year marked the 50th Anniversary of the GDSF. To commemorate the event the organisers got themselves a Guinness World Record by having over 500 full sized traction engines and steam rollers present.

There were plenty of things going on and the highlight for many was the heavy haulage arena. The GDSF bucks the trend of some rallies where steam is practically a static exhibit; owners are positively encouraged to spend the day chuffing round the arena towing one of the many loaded trailers should they wish. The youngest engine present was BR 5 73096 – looking in need of some TLC – on the back of a low loader, which provided an impressive load (well over 100 tons total). The sight of three road locomotives hauling it up the hill of the arena was quite stirring!



BR 5 No.73096 letting others take the strain for once!

Most of the steam was distinctly low tech by the standards of the AST. There were a couple of superheated road locomotives and compounding and piston valves were common on the younger models. There was a recently restored Aveling and Porter road locomotive which was truly massive, complete with a chime whistle the size of a dustbin which could be heard in Devon! I was fortunate to have a short ride on this beast – it was a long way up but the view was worth the climb.



6 ton A&P roller “Lord Jim” next to the massive road locomotive “Flame Lily”

At the very low tech end of the scale was our own Aveling & Porter agricultural tractor, back on the road for the first season in 13 years following heavy boiler repair. Built in 1884 this is currently the oldest steamable A&P engine in the world. Although rated at 6NHP we have applied a bit of modern computer analysis and calculated that on a recent road run we did manage to produce 29 IHP! Must get Mr Horne to fit up some instrumentation……..



A&P Traction engine No. 1995, built in 1884, in the evening sun.

Fun in the heavy haulage arena goes on until the light fades. Then everyone heads to one of the many beers tents for live music and……beer. The funfair runs late into the night and the line-up of showman's engines creates a wonderful atmosphere.



Evening entertainment in the heavy haulage arena.



Night at the GDSF – Engines as far as the eye can see.

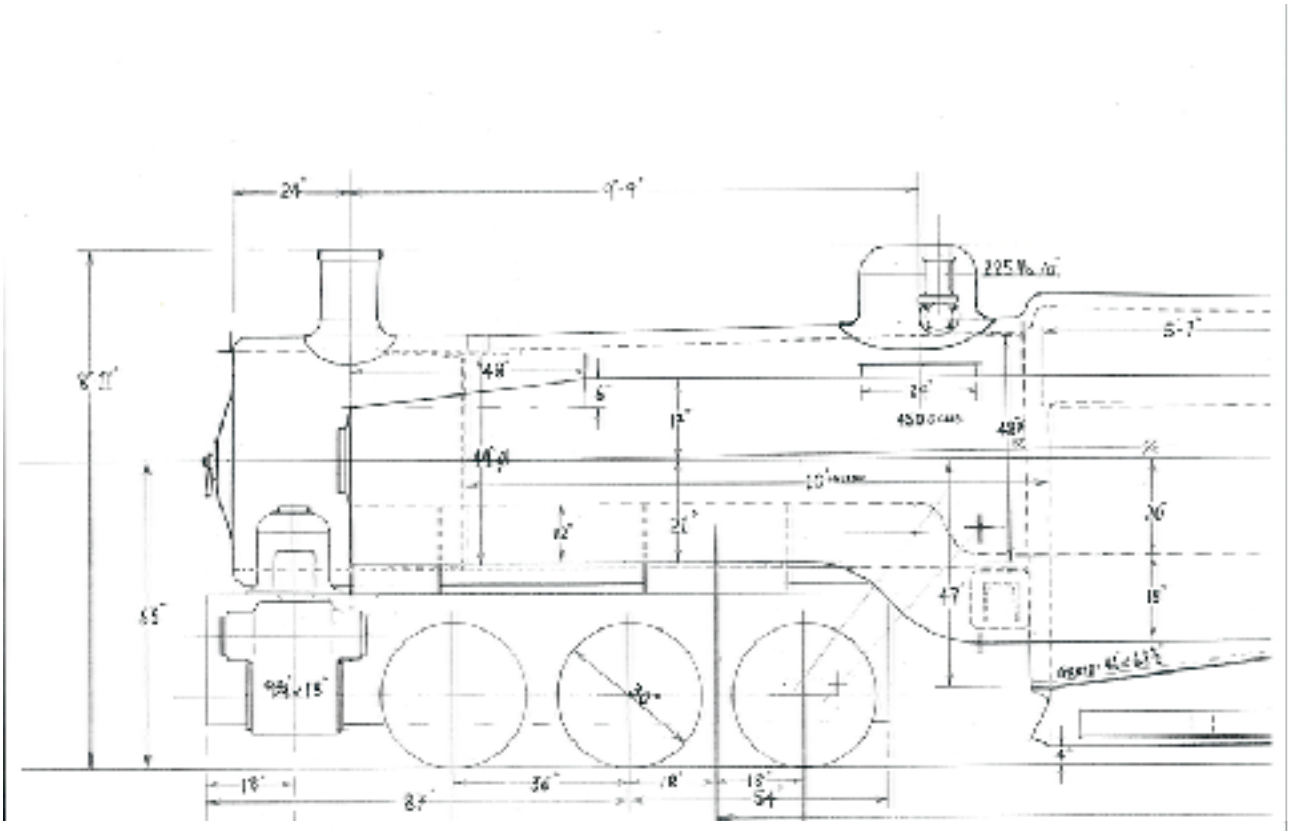
Although the technology on display isn't exactly cutting edge, the atmosphere is fantastic: There are steam engines from all over the world and if you stop by any engine you can be sure of a friendly conversation with someone with a passion for steam. Hard work, possibly a little too much beer, but well worth the effort.

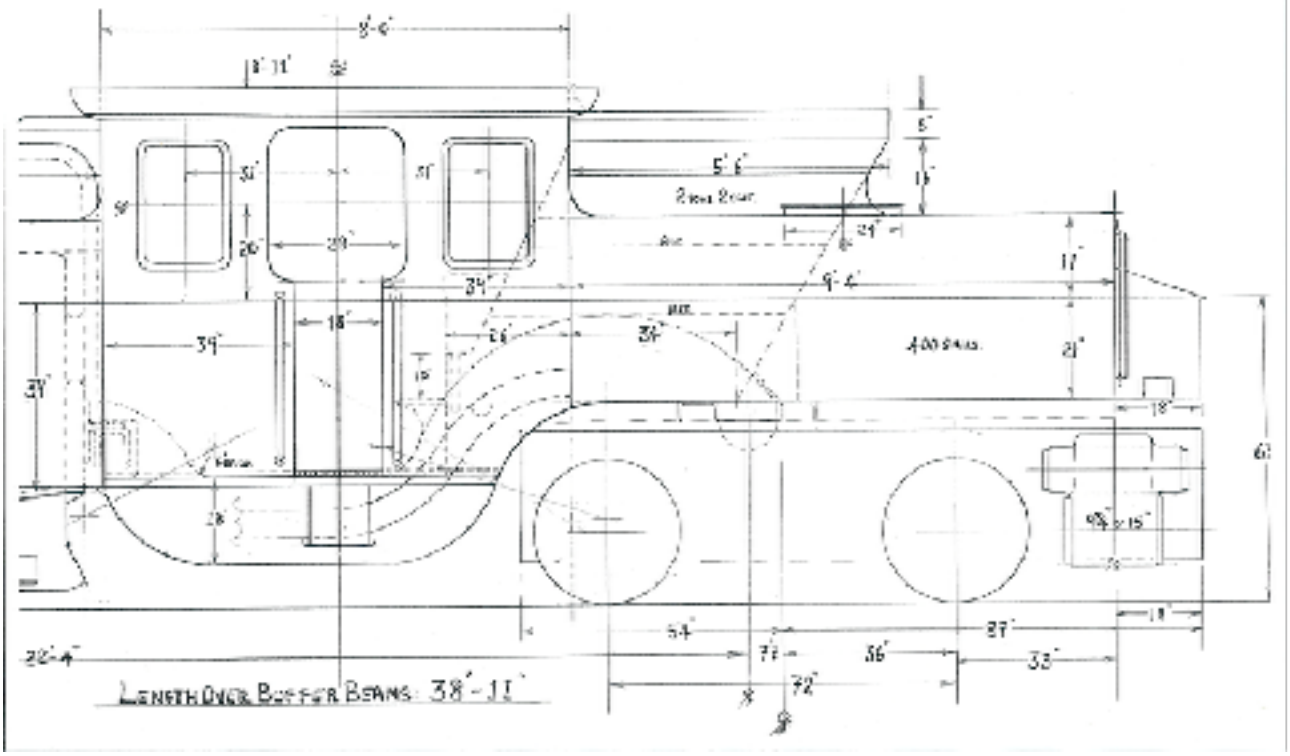


Cab view of LYN (Photo: David A Nicholson)

PROPOSED SUPER FAIRLIE TO FIT LOADING GAUGE OF THE LYNTON & BARNSTAPLE RAILWAY.

'EXMOOR' 0-6-4-0T DESCRIPTION OF ALL MAJOR DETAILS. Updated to December 2017





1. BOILER:-

Of generally flanged and welded all-steel construction, front tube plate, doublers and brackets riveted (as on LYD). Fire box side stays welded (fillet welds NOT full prep, tell-tail holes). The fire box to be of ample volume and longer than its width (long flame path), optimising combustion; (option of GPCS [but SEE NOTE AT END], secondary air would be admitted via vertical ducts in the front corners of the grate supplying an arched duct within the front end of the brick arch, air holes point down/back with separate front corner dampers, and through an adjustable vent under the fire hole door; the front middle and back dampers supply air via twin-walled sides to top of ash pan all round, including via three hollow fire bar supports. The grate two bars long, the back half rocking (possibly using standard WHR Garratt parts). The sides of the front section (short bars if GPCS air ducts fitted) are fixed, some middle (long bars) can be lowered at the back end to drop clinker. The air supply below the fire bed regulated by a screw operated damper (bar spacing to be chosen with regard to the type of coal, torrefied biomass, etc) and ducted under the grate so as to be unaffected by ash buildup, and cinder dropping made impossible. (GPCS:- A small proportion of the exhaust steam from the 0-4-0 power bogie to be routed to the ash pan via an adjustable regulating valve). Brick arch and air deflector. Grate slopes 8" to assist maintenance of the fire-bed, and ease removal of the ash pan (complete with grate etc). Spark proof ash doors each side of the ash pan (all stainless steel) which are not air dampers. See notes, and sketch. Ash pan drench.

The boiler barrel as large as possible consistent with a working pressure of 225 lbs./sq. in., plate thickness of 16mm., loading gauge and weight being the first considerations. 44" ID at the front end and tapering up to 48" with the bottom horizontal, and the throat plate inclined so as to be normal to the barrel centre line (front end 'worked' truly circular and butt welded to smokebox extension: all 16mm): this requires a girder stay across the front of the casing, riveted through the top and also through the sides, plus the external doubler for the casing cross stays. Tubes to be 10' maximum (1 3/4" diameter), free steaming and weight minimisation being more important than optimum heat exchange efficiency. Free gas area to be as large as possible. Shallow dome housing a twin horizontal multi- regulator (single body casting), fed by two s/s intake pipes; valves operated by a shaft with gland on c/l of dome base (RHS), gear and rack on backs of valves; body located on a circular ledge within the dome base, with the dry pipes bent upwards and clamped by through bolts (and olives) to the underneath. 0-4-0 pilot port opens fractionally in advance of 0-6-0 to clear condensate, main ports in unison; oil grooves under middle of sliding valves fed by pump (all within s/s enclosure). Small atomising ports open first: pipes run within boiler lagging. Look at possibility of centrifugal inlet to s/s outer housing.

Belpaire firebox (crown sloped 1/50); large steam space above water level (14 1/2" above working level); steam taken from a transverse perforated s/s pipe at the front of the casing (integrated with transverse casing girder stay, water spray deflector plate below). Direct- loaded NON-pop safety valves mounted each side of the dome base (independent of regulator valves in s/s box), allowing pressure to be kept near the 'red line' without wasteful and sudden blowing

off, or requiring unnecessary pressure reduction before closing: situated in the middle of the boiler. Internal steam pipes (2) from multi-regulator to 2 superheater headers, divided: 12 flues (RHS) 0-4-0 cylinders, and 12 for 0-6-0 cylinders, see note at end; plus anti-vacuum valves; concentric element superheater (LYD type), with 4 elements welded to each vertical sub-header, hot headers at the bottom. The main steam pipe to the trailing unit passes along the inner bottom edge of the right tank and down under the tank behind the pivot stretcher, under the cab floor (drip valve at low point). Low profile manifold within firebox top lagging between windows, with integral main stop valve and internal collector pipe. Two flooded injectors of modern design (larger on the drivers side, the other calculated to deliver the average boiler evaporation), to be mounted under the footplate with water drawn from the transfer pipe (transfer stop valve fitted next to back tank: to allow retention of water ballast, and to prevent tank overflow on 1:50 gradients). Each injector water valve precedes its in-line filter so that these can be cleaned easily if a blockage occurs. A feed pump driven by the 0-4-0 power bogie feeds via a heat exchanger (contra flow) conserving heat from the 0-4-0 exhaust steam, but normally only when there is steam chest pressure on that unit (allowing hot feed only: can be overridden). All clacks (3) to be back head mounted under crew control (for isolation) and pump delivery with a spring loaded relief valve, feed delivery to be via internal perforated pipes, above the water line at the front of the barrel (removable for cleaning). All cab pipework insulated and under steel cladding (removable for access to valves etc: R clips).

2. GENERAL CONSTRUCTION:-

The general construction of the locomotive frame is an all welded monocoque, and incorporates the front and back water tanks (all plates shot blasted and treated internally against corrosion after welding, using the best technology available: 'Fertan' and marine tank paint?), cab floor, cab sides and coal bunker. The welded cab front extends down to about the c/line and the lagged boiler back plate is outside the cab, with an allowance for expansion, there are cutouts as required for clacks etc. Part of the cab roof overhang may need to be bolted to allow the boiler to be fitted. The boiler bolted to a saddle at the smoke box, uniting the side tanks which are structural, and housing a centre-less roller which transfers some weight (small due to the overhung weight of the cylinders at the front end) to the 0-6-0 power bogie, and necessary because the main pivot, with load bearing oil immersed pads/rollers each side, is situated between axles 2 & 3. The inner side plate near the bottom of the tanks is thicker than the rest, and is braced horizontally to the outside and the bottom as required. The top of the tanks braced by a bolted tie plate over the top of the boiler barrel, and also at the smoke box, the former attached to a flange along the top inner edge of the tanks prevents water going down the back of the tanks. The extra long (self venting) tank filler lids are hinged on their inner edges, and open to just past vertical. Under the boiler barrel is the 0-6-0 unit pivot stretcher between the tanks: the boiler does NOT rest on this, and it does NOT transfer weight to the power bogie. This stretcher only locates the centre of rotation and transmits traction to the boiler/tanks structure: the pivot is lubricated by the centralised system, with a dust shield at the top. On the transverse centre line there is a load bearing pad (or roller, see note Z at end) each

side, with grooved faces and oil immersed, fed by the centralised system plus a shield to exclude dirt and water. At each location (3) there is a sliding clamp to provide security in the event of derailment. An adjustable hydraulic damper could be attached between the inner ends of each bogie and the tank/ framing (see further notes). Another stretcher between the front tanks in front of the firebox, and at the lowest point of the front tanks a transverse balance pipe (with flexibility?). The heavy sections (increased if required) near the bottom of the tanks pass alongside and close to the outer fire box, and cut-outs in the tanks themselves allow for the fire box and tapered barrel to be removed from the tank/ frame assembly. The RH cut out increased if required to accommodate the main steam pipe to the trailing bogie). Immediately behind the fire box there are cross members under the cab floor (all shot blasted and hot zinc sprayed) which is welded to them giving diagonal stiffness, and the raised front one supports the back plate of the boiler via a full width expansion bracket (lubricated bronze liner). There is a one inch space between the firebox casing and the frame members all round filled with insulation board, plus an allowance for expansion between the boiler and the cab front. At the back of the cab the main frame plates sweep upwards for their undersides to match those at the front end, with additional longitudinal members between them, and then become integrated with the back tank and bunker structure.The cab foot-plating lying outside the main frame plates is welded both to them and to the front and back tanks, and also to stiffening angles on their outer edges. The cab is 2” narrower than the tanks each side, and the cab sides (heavier gauge plate, bracing dropped framing under cab floor) have gangway grab handles which are within the overall tank width. Plate edges round doorways have half-round beadings, cab roof doubled at outer edges. The framing between the back tanks carries the load bearing and traction pivot for the 0-4-0 power bogie. The upper bearing being hemispherical and grooved for centralised lubrication, fits into a cast steel housing on the bogie with an outer shield to exclude dirt and water. Check straps maintain assembly in case of derailment. This pivot allows the trailing bogie to rock on both axises; the pivot centre is inboard of the centre line of the bogie, to be calculated to allow for the overhung weight of the cylinders (too close rather than too far apart, as ballast weight can be added at the cab end of the bogie framing).

Rollers (with sealed bearings) loaded by adjustable coil springs located between the double framing of the bogie and on the pivot centre line, accommodate track twist over the length of the locomotive whilst adding roll resistance to the locomotive as a whole, but allow load equalisation between the two axles (the axle box springs are stiffer and work independently). The rollers are set with a small preload but allowing minimal extension: the springs would neutralise each other.

The bunker is integral with the rearmost framing and with the back water tanks (with a triangular transfer passage between them). The machinery space behind the bunker, between the tanks, contains the main air reservoir, the heat exchanger (insulated), and all the control valves and equipment for the hot water feed, air and braking systems.

3. POWER BOGIES, GENERAL:-
Construction of both units as welded steel boxes, the lower part 'double

framed' (12.5mm or if possible 10mm plate) between the cylinders and the horn guides (full depth on 0-6-0 pivot centre line), with horn stays bolted for removal of the wheel sets (pulled upwards onto full width tapered seatings with two bolts/studs in each: wired together). Horn blocks to be part of the permanent welded structure and braced outside by the 'double frame' and ribs let-in on the centre line (locating/welding tongues through slots in both plates): pockets for 'Vesconite' pads if suitable, otherwise another dissimilar material (from manganese steel, and set in heavy duty adhesive to prevent fretting). Pockets machined at a single set-up after de-stressing the whole fabrication (horn stays fitted): facings to be a standard thickness giving a uniform set running clearance. NO taper wedges, grease lubricated (applied through middle of pads, and to centre of side thrust flanges).

Due to lack of depth available the top plate carrying the 0-6-0 pivot is not load bearing, but transmits traction to the main frames (tanks). Slide bar brackets (outer web set towards cylinders if required to allow removal of connecting rod on BDC) bolted into precision recesses machined in doubling pads rather than drive-in fitted bolts. Cylinder/frame flanges (machined) locate on welded pads at bottom and ends, and back face of cylinder casting bolted to a flange on outer frame plate, fixing exact distance to horn guides.

The 0-6-0 unit to have 6 foot wheel base with flange clasping brake blocks as on LYD, but with more room between the wheels (the centre wheel set can have thin flanges). Axles 2 and 3 to be leaf sprung and compensated (each side of main pivot). Springs on the outer faces of the box frames, wheels inside. The leading axle being at the extremity of the total wheel base coil sprung to allow it a long travel without undue change of load. A centre-less roller under the smokebox transfers some load to the bogie due to the pivot being off its centre (three point support), bottom track to have a liner, slightly inclined each side if required (gentle self-centering). The 0-4-0 unit also to have a 6 foot wheel base, so that all the motion and brake details will be identical except the coupling rods (and fly-crank balance weights if required). Leaf sprung on both axles, compensation not required due to the spherical design of the bogie pivot. Either unit could have a hydraulic damper at its inboard end attached to the main frame, not likely to be required especially on the 0-6-0.

4. RUNNING GEAR:-
a. Cylinders:- The four cylinders to be identical castings and symmetrical about their transverse centre lines, castings to be of Grade 17 (+ Cu as on LYD) with sufficient wall thickness to allow for future fitting of liners after several re-bores: OR with 0-4-0 cylinders fitted with liners to reduce bore (see Weights & Factors of Adhesion). Alternatively: castings in Steel or SG Iron to save weight, and fitted with liners as above. The valve chests to be on the INNER top quarter, of ample volume (inside admission) provided by increasing the diameter between the valve liners and with large inlet pipe within casting, plus thick insulation all round. The ports to be straight

and short and with their width and thickness giving a uniform cross section. Flat piston heads with bevelled edges all round and fabricated to minimise weight and secure exact clearance dimensions. Port clearance machined from rib round cylinder end cover which locates in bore: Clupet rings. Separate large exhaust passages routed through the bottom corners of the mounting flange (with copper gaskets) before blending 'extractor manifold' fashion (all welded in heavy gauge pipe including to frame plates), exhaust from the two cylinders blend into the bottom flexible joint housing, leading to the blast pipe, NO exhaust through hollow piston valve to avoid heat loss from steam chest. Drain cocks (including steam chest at bottom of inlet pipe) to have electric operation.

b. Axles:- Design based on FfR best practice: stepped wheel seats for press fitting.

c. Wheels:- Cast steel disc style with the cast-in balance weights, supplemented as required by fly-crank weights (cranks cast steel with pins integral), and fitted to axles with taper-locking bushes and keys). Particular attention to be paid to minimising reciprocating weigh and balancing to minimise bogie hunting. Hydraulic damping could be provided. Tyres to 'Porta high adhesion profile' with oil thrower lip and extended-turning tread.

d. Axle Boxes:- Cast steel with pairs of spherical roller bearings (provisionally: 200mm/ 120mm/ 62mm) and sealed to allow oil lubrication, top-up via flexible pipes and slide-on nipples, with level/overflow/vent drillings from horizontal centre line; inner flanges ONLY and relieved to allow for axle cant. Pockets machined in box faces for Manganese steel wear plates of uniform thickness. Wheel bosses recessed on outside if required to maximise axle-box width, and increased inwards to allow for flange thrust taken through axle from remote side.

e. Motion:- Coupling and connecting rods of modern design: all rod ends to have spherical roller bearings (oil lubricated and sealed on the 'excavator track idler principle'), except Little Ends which have standard PLAIN spherical bearings (oil lubricated: syphon) and special design gudgeon pins with no heads (saving width). The main crank pins fitted with side thrust washers between the rod ends to keep all rods aligned and sealed; coupled crank pins allow twist. Valve gear to use roller and needle roller bearings, and hardened steel bushes and pins (Exmoor S/R pattern): all grease lubricated, except expansion links (and cross head slides).

f. Valves:- Inside admission 5" diameter, long lap, 4 narrow rings per head (or modified Clupet rings?) Ring control of events, tapered end lands. Head spacer hollow but NOT through-ported (see Design Notes). No sight holes for valve setting, but marker groove in valve spindles combined with tight tolerances for valves and liners, plus reference markers attached to valve chest back covers. Valve spindles supported by long bushes BOTH ends, and lubricated by pump. Tail rod hollow and enclosed.

g. Valve Gear:- Compact arrangement of Walschaerts' gear (to achieve good geometry

and keep components clear below tanks). Box type expansion link, four feed oil box to the die block; sliding lift-block behind expansion link (oil lubricated), on arm pivoted at the same centre. Short individual rods (sealed joints) to weigh shaft through each bogie. Bi-directional electric motors (with limit switches) drive crank-arms via worm reducing gears (c1000/1) and connected to the weigh shaft arms by links with sealed spherical ends: indication back to cab by flexible steel cables (provision for emergency cranking by portable 'air wrench' motor). Return crank of small throw, to give good geometry and minimise inertia in gear. Combination lever carried on a rocking lever with a ratio of 6/10 (and not on the valve spindle), which produces the required long valve travel. Rocker pivot (roller+needle roller bearings) situated between piston rod and top slide bar, levers each side of slide bars, inner one may need recess in bar (in addition to thickness of cross head) to clear leading crank pin. Connection to valve spindle extension by link, and tail guide (oil lubricated) attached to top slide bar, vernier adjustment as on LYD. Valve 'middle position' groove on valve spindle.

h. Brake Gear:- Blocks flange clasping, air cylinders for graduated independent brakes (optional electronic 'Traction Control'), also linked proportionally to train vacuum system. The 'Parking' brake is APPLIED by a pair of compression coil springs (each bogie) and are held OFF by a pair of air cylinders with pressure reducing valve set to just neutralise the spring pressure; a second pair of air cylinders controlled by a 4RE valve and supplied from a local reservoir actuate the graduated brake on each unit.

This arrangement would save the 'half a ton' of expensive engineering required if trying to operate the brakes on two articulated power bogies mechanically from the cab, especially with a very large boiler in the way. Main air reservoir can be charged by external connection (in Works), by onboard battery electric compressor, and normally by mechanically driven bi-directional pump when the locomotive is running (unloader on pump when fully charged). Brakes can be locked OFF (in Works or failure in service) using special release 'nuts'. Control of air brakes by vacuum AND independent graduated controls in PARALLEL (see sketch plan). All brake rigging pins to be fitted in Vesconite bushes as trialled at FfR. if successful.

5. AUXILIARIES:-
These mounted above and driven by the 0-4-0 unit and comprise:-

a. Vacuum Pump:- Rotary vane type to maintain the train pipe vacuum under normal running: pump driven via one-way clutches from a bevel gear reversing box. Large and small ejectors also provided.

b. An Air Compressor (bi-directional) and main reservoir:- To work the graduated brakes on each unit (non-return check valves, safety valve and isolating valves). An electric air compressor (backup) plus an external workshop connection. Moisture separators and drip valves, off-take for auxiliary 'tools' eg cranking of valve gear in case of electrical failure.....

c. A Boiler Feed Pump (bi-directional, triple ram 'CAT'):- Circulating water constantly from the lowest point in the transfer pipe from the front tanks (outside left frame plate) and ahead of the stop valve that prevent water from flowing end-to-end on steep gradients, and also allows adhesive weight to be maintained on the 0-4-0 whenever possible. The pump only feeds the boiler (via the heat exchanger) when a bypass valve closes automatically, when steam chest pressure rises on the 0-4-0 unit (only hot feed and matching feed to steam consumption), this can be manually 'screwed down' to force feed, and a manual bypass cuts all feed.

d. Twin heavy duty 24v alternators and charging circuits with ammeters in cab. An inverter could produce 110v AC if more suitable for motor selections.....
Full lighting system in cab, powerful head lights plus red tail lights.

e. Heat Exchanger (lagged):- Mounted between the back tanks and behind the bunker, through which exhaust steam from the 0-4-0 unit passes to a vent. Some exhaust steam can be diverted to below fire bars (full GPCS) or as required for clinker control only. Condensate gravitates to the ash pan (dust & oil contamination control). Feed passes through tube bundles compartmentalised in a contra flow arrangement. Frost drain taps as required. The 'exhaust chimney' could be fitted with a gravity loaded flap, though not sealed allowing a vacuum.

f. Centralised Lubrication Pump for main pivots/pads.

Drive for auxiliaries:-
A large split sprocket clamped (4 bolts, no keyway) onto the inner (driving) axle and drives an industrial 90 degree bevel gear, speed increasing unit attached to the framing, via a horizontal duplex self oiling roller chain. This drives an inclined agricultural type drive shaft (with easily detachable splined attachments), which passes up into the machinery locker on the loco centre-line and close to the bogie pivot. Another gear box drives a cross shaft fitted with appropriate pulleys/sprockets to drive each auxiliary.

6. GENERAL DETAILS:
a. Draw Gear:- Similar to that on LYD (centre-less, and single sprung for draw and buff), mounted on the bogies.
b. Sanding Gear:- Gravity with electric rotated screw feed (leading and trailing). Ornamental cast iron leading sand boxes for 0-6-0 (rigid delivery pipes, pass just behind incoming main steam pipes). Middle boxes built into the space above bunker shovelling plate, these can be used in

either direction to supplement sand dropped by whichever boxes are leading: mechanical sand valves and flexible pipes attached to inner end of 0-4-0 unit. Trailing boxes (0-4-0) located in the middle section of the “tool box” at the trailing end of the loco; 24v batteries left side, tools right side.
c. Boiler Lagging:- The barrel to have eccentric lagging if required to allow bogie clearance; 2” thick at the bottom, and at the sides to maximise the tanks; 3” at the top where most heat would be lost; otherwise all 3” thick. The latter is additionally enclosed by an outer steel plate which ties the top of the tanks, preventing ingress of water between the tanks and the boiler. The throat plate and the back-head 3” lagging. 1” insulation board round the lower firebox sides. Insulation on smoke box. Built in chimney lid: see sketch.
d. Water Tanks:- All welded construction. The heavy section, structural part of the front tanks inner plate and bottom, to be braced as required, also in the area of foot plating between the front and back tanks. A duct down the back of the front tanks for steam pipes to ejectors mounted under the back end of the R/H tank, blower etc.. Storage compartment inside top of the L/H tank for fire irons. Lengthened filler openings to ease “spotting”, plus additional fillers on the back tanks (all near middle of tank length). All filler lids hinged on their inner edges to just over vertical only, and arranged to allow venting of those not opened during filling. The back tanks transverse passage to be of triangular cross section and part of the steel fabrication. Flexible joints in pipe front to back tanks, and between front tanks, and a quarter turn stop valve (and indicator: open/shut) fitted next to the back tank to prevent surge on 1:50 gradients causing overflow at either end, this also enables water to be retained in the back tanks to maintain adhesion (or excluded to reduce axle load). Front and back tanks to have level gauges in the cab.

e. Other Cab Details:- The floor non-slip timber covered, and the roof with four sliding ventilators. The coal shovelling plate to have a drain gutter inside the bunker (covered by a removable perforated plate) to catch rain/coal damping water, slide down door between two hinged side doors to prevent coal and dust getting into the cab when fuelling, the latter form sides for shovelling plate when open: sand boxes above, with sand pipes dividing coal outlet into three. A coal watering spray pipe fitted across the front of the bunker and a flexible spray pipe are fed from a manifold off the fireman’s side injector feed. The fixed side windows are LYD pattern, the front and back spectacles shaped to fit the spaces, mounted in strong ‘brass’ frames and fixed. The shoveling plate to be very little lower than the fire hole, and both at a comfortable height above the floor. Doors to provide crew safety and protection from the elements slide back back against the cab sides. RHS: a glazed (inner) shutter can be slid forward to prevent rain/snow blowing through the cab, and the leading side window slides back for the seated driver to look out when running backwards.

DRIVING, right side:-
Upholstered swivel seat rotates round main control pillar (see sketch) towards RHS of cab, with backrest and footrest (driver can face direction of travel whilst sitting), height adjustable to suit

sight line of driver. Main console (rotates with seat) located at top of column: 2 steam chest, 3 brake gauges, 2 steam temp. (at steam chests), speedometer; 2 air/1 vacuum brake valves mounted below. Fixed console on RH cab-side: large ejector (push/pull), small ejector (1/4 turn) and duplicated blower (1/4 turn). Reversing gear (two small self centering levers and mechanical cable operated indicators; ammeters, main air reservoir, air pump switch, etc. Regulator handle above middle of side console when half open, suspended from roof; handle bent horizontally and with ratchet release on back (push/pull forward to shut), and drifting position (with stop on ratchet, Note:- $$) minimum for atomizing steam when drifting; rod to regulator valves passes through cab front (follows firebox top lagging) to upwards lever on c/l of dome, clear of safety valve. Reversing levers control worm geared electric motors driving cranks linked to arms on the weigh shafts, (provision for portable air winding in case of failure). Vacuum limiting valve accessible for adjustment/cleaning; release valve for 'dummy' reservoir; Two independent graduated air brake controls.

'Parking Brake':-

Fail-safe to ON due to spring application (twin compression springs) and air release, and an air pressure gauge for each unit shows:- 'Brakes ON/Brakes OFF'; other gauges grouped as above: duplex vacuum, speedometer, two steam chest gauges (that for the 0-4-0 unit marked with a green line showing the minimum pressure required to close the water pump bypass valve). Drain cocks (electric operation). Sanding gear controls for forward and backwards (buttons mounted directly on the regulator handle on the appropriate side): electric/gravity operation, plus middle boxes have mechanical control (fireman operation). Air reservoir pressure gauge; lubricator rotation (4 green lamps illuminated continuously, with passing contacts on pump spindles to maintain at normal line speed); master battery switch and charge/discharge dual ammeters; feed pump delivery temperature. Whistle chain (duplicated). Other 'driver' controls:- Main manifold stop valve (on c/l). Large/small ejectors stop and service valves, and blower valve (quick action and duplicated as on LYD). Stop valve handles protrude through cab front/floor and steam pipes from manifold pass down ducts in back of front tanks, just clear of front windows. Service valves worked remotely from RH console. Front tank water level, and back tank gauge on front of R/H tank. Large injector water valve (on right side of fire hole door).

FIRING, left side:- Whistle chain (duplicated). Front and back screw dampers (primary air); [GPCS front corner dampers for brick arch air, diverter valve for exhaust from 0-4-0 to ash pan (from feed water heater), and optional live steam]; blower with FINE control (needle valve, duplicated: quick action). Three back-head clacks with isolators (as on LYD) and two injector steam stop valves, and quick action service valves (the steam and feed pipes pass through the cab floor just outside the main framing: all covered, see notes), pump feed to have a sprung relief valve in-line; feed pump manual by-pass AND automatic bypass (steam chest pressure controlled) with manual override. Small injector water valve (large: to RHS of fire hole doors); air operated fire hole door (hinged horizontally at the top and opening inwards), sight hole and shielded cooling/ top air holes. Adjustable auxiliary air vent cast into door ring protector. Door assembly lifts off fire hole back plate to allow firebox access. Boiler Pressure Gauge and isolating cock; two Water

Gauges (heavy duty, reflex type) with separate top and bottom cocks (ie NOT linked), marked at the side with WORKING LEVEL and MIN./MAX. for 1:50 gradients in either direction (the L&BR was almost unique in the UK in providing this information for their locomotive crews); Steam Temperatures (at steam chest, each unit). Footplate wash-down pipe and stop valve, fed from fireman's injector, plus change over valve to coal bunker and ash pan water sprays. Seat (LHS) with oil bottle locker under. Rocking grate, (and dump section outside cab, on ash pan), lever/s with lock plates. Emergency vacuum brake application valve. Cab, gauges and running lights switches. Fire iron storage inside top of L/H front tank. Mechanical operation of middle sand boxes. Fire hole door air valve (foot pedal, left of door), isolating valve and separate handle for manual operation in the event of air failure. NB Some of the above arranged to be visible from the DRIVING side.

f. Mechanical Lubricators:- Mounting brackets on back end of each steam chest and driven by rods from top of expansion links, via holes in slide bar brackets. Multi point feed to valve liners (2) and mid point at bottom of cylinder (1); INNER gland guide bushes (2: piston rod and valve spindle); also atomised to steam-chest inlet (1) with live steam from small ports in the main regulators in dome and piped within the boiler lagging, forward and back (to keep them hot). Front valve spindle support bush (1). One extra feed to oil groove under multi-regulator valve. All feeds have spring loaded check valves at points of delivery. g/. Centralised 'chassis' lubrication by multiple pump, driven from the countershaft above the 0-4-0, to all major items (main pivots/pads) not conveniently greased or trimming fed. h/. Draughting:- The 0-6-0 unit's exhaust passes to a high efficiency blast pipe and chimney liner of 'state of the art' design. The 0-4-0 exhaust passes to a feed water heater (contra flow) thence to an auxiliary vent, condensate drain to ash pan damping. Option to divert part of this exhaust steam under the grate for clinker control or full GPCS.
i. Ash Pan:- Stainless steel, side emptying with spark proof doors. Main damper(s) for primary air, with screw control: air is ducted up close under the fire bars (via hollow fire bar supports/slots in sides) so that flow is not affected by the build up of ash, and dropping of cinders is prevented. Sides double skinned to prevent warping, and form air ducts (see further notes at end). Optional: Top air to the brick arch is ducted (spark-proof) from front corner dampers. Rocking and dump grate gear is all part of the ash pan assembly, which can be lowered complete and removed sideways at rail level. 4" rail clearance (3" when tyres fully worn). Ash pan wider than outer firebox to allow for double skin, and bolted to extension angles.
j. Blow Down Valve:- FfR standard 'Valtaco' with locking.
k. Powerful 24v head lights and tail lights each end plus full cab lighting system (gauges and interior). AC inverter for other systems if appropriate.

Note regarding release of Parking Brake when reservoirs are discharged:-
1. In works or in service (failure) by use of on-board 24v battery-electric air pump. 2. In works by

use of compressed air line to external feed-in connection.
3. In works or in service (failure) by use of cranking handle (see note 4 h. above).

GENERAL NOTES:-
Double Framing, the reasons for:-
Normal plate frames need to be quite thick (with wheels inside) due to the impossibility of sufficient internal cross bracing at the bottom, and certainly require axle boxes with double flanges to share the sideways bending forces on the frames between the two sides of the locomotive. Bar frames have a similar difficulty but additionally the springs have to be either above or below and on the frame centre line: the latter not feasible with small diameter wheels. Springs above are not possible in the case of an articulated power bogie mounted under side tanks, and with a minimal loading gauge height limit. Double framing allows the horn blocks to be supported on their inner AND outer edges (in this case as part of an all welded fabrication); the springs can kept low down clear of the side tanks, between the frame plates and made accessible from outside for inspection/replacement. The double framing is also very rigid from sideways bending due to a ladder form in plan view, especially with a rib on the longitudinal centre line they provide very rigid connection between the cylinders and the horn blocks. The double framing at the sides of the pivot centres also allows the load from the boiler/tanks assembly to be uniformly distributed to the bogie framing. Due to the requirement of providing sufficient space between the double frames for the springs (also for welded construction details), and because of the loading gauge width constraint and the need for sufficient bearing width, it is necessary to have the twin plates as far apart as possible. Thus, due to the rigidity of the double framing, it is possible to have axle boxes with inside flanges only: the wheel flange thrust being taken through the axles to the axle boxes on the opposite side (also adds width for crank seating). The axle boxes would be steel castings (flanges relieved to allow for axle cant), and the horn blocks being part of the fabrication made of mild steel. Wearing of the inner edges of the blocks easily restored by welding.

Fitting and adjusting coil springs between double framing for leading axle:-
The spring hanger, with top and bottom spring mounting plates, spring and bottom adjusting nut, is installed by partially compressing the spring using the nut, so that the assembly can be inserted at the front or back of the location. The square bottom plate fits between the double frame plates and prevents it turning, and a central boss fits snugly inside the spring. The bottom ‘nut’ is tubular and has a 3/4” square drive at the bottom, and accessible through a hole in the framing bottom flange for spring adjustment. Once installed the bottom nut is released so that the spring hanger can be raised and attached to the top beam connecting the springs to the axle box. When adjusted the correct clearance can be checked between the bottom mounting plate and the frame mid-rib via the circular hole in the outer frame plate, and must be at least the maximum rebound distance between the axle box and the horn stay. The top mounting plate also has a central boss to locate inside the spring, and bridges the slot provided in the top mounting bracket to allow fitting.

Regarding Superheat:-
It is appreciated that the proposed boiler would only provide 'moderate' superheat, but the efficiency per square foot of the concentric elements appears to be higher than the return bend type, relative to the space they occupy. The slightly increased efficiency which would be possible with a larger boiler capable of containing a 'high degree' superheater would be offset, in 'this application', by its extra weight, requiring the provision of carrying axles and thus a heavier locomotive (defeating the first object of optimizing the power to weight ratio); plus the higher first cost and increased maintenance costs. "This application" being specifically: within the narrow gauge load/envelope of the Lynton and Barnstaple Railway, and where full power is only required for part of each round trip when the increased efficiency would be beneficial.

The lower maintenance requirements of 'moderate superheat' would be a positive advantage, and maximizing theoretical thermal efficiency by small increments is NOT the first priority in 'this proposal'.

Working Pressure (225psi.) is maximized relative to the barrel diameter (limited by the loading gauge), and 16mm. plate thickness gives 6/700% factor of safety. Also, above this pressure boiler maintenance increases disproportionately.

Routing live steam pipes from manifold on firebox top to ejectors (under RH cab floor), and back-head clacks to/from injectors (under RH/LH cab floor):-
So as to increase safety, reduce copper polishing time and minimize heat loss, pipes from right angle stop valves on the back of the manifold pass down a space in the back ends of the front water tanks (cut away at the top to allow pipes to clear front cab windows) to the ejectors etc.. The injectors mounted on swinging brackets so that the steam pipes are not flexed: feed pipes individually lagged and under metal casings retained by R clips. They pass through elongated cutouts in the floor just outside the main frame up-sweep at front of cab, follow the back plate clear of the fire-hole door mechanism. The injectors aligned to allow removal of cones for inspection. All screwed/bolted couplings in steam pipes to be easily accessed with spanners.

The manifold is entirely outside the cab, under a removable cover and the front overhang of the cab roof.

Fabrication of Bogies and tank/cab unit:- All steel plates to be profile cut with locating tongues and slots to allow accurate assembly and clamping of all major components before welding. This applies particularly to the longitudinal rib on the axle centre line, where frequent protruding tongues can be welded around rather than using plug welds. After tack welding all welds to be completed in a balanced sequence to minimise local heat build up and distortion. The side sheets of the cab, being structural and set 2" inboard

of the tank sides, are heavy gauge and welded to a thickened area of the tank tops with generous radii.

Overall Thick Lagging:- Cladding sheets over dome, manifolds, clacks, etc formed as boxes and not fitted until the boiler has been cycled over a period of time, so that all studs/ bolts remain accessible to be fully re-tightened before covering. (Those over the clack valves and elsewhere to allow access for maintenance, located on dowels with R clips).

Presentation:- Paintwork obviously to the highest standard, Midland Red or perhaps Caledonian Blue for 'blue sky thinking', GWR green would be nice but no copper cap! Smokebox black and insulated. A 21st century design but 19th century standard of presentation. Bright work to be nickel plated (or satin chrome) for the side rods, motion, cab windows and whistles etc., stainless steel for hand rails etc. and sheet stainless steel for highlights eg. lagging bands and dome/manifold covers. Yellow brass for works plates \name plates in FfR style, ie. flat with sunken lettering (easier to clean). Any exposed cold water pipes left polished copper where convenient for cleaning.

Traction Control and Superheaters:-
Independent regulator valves in dome but ONE operating lever. (ie. if one unit slips the steam pressure is NOT allowed to fall in the other unit, the independent graduated air brakes are used for control, NOT shutting regulator (driver guided by steam chest pressure gauges), plus option of using the independent control of cutoff; electronic AIR BRAKE TRACTION CONTROL would be possible. The 0-4-0 unit has three vertical rows of four superheater flues on the LHS, and those on the RHS serve the 0-6-0 unit (12No. each).

Centre-less Roller under the front of the smoke box could have its lower track (liner) inclined upwards each side to provide gentle self-centering of the bogie if required (an alternative to the optional hydraulic damper for hunting control).

Leading Sand Box Lids to have recessed handles to allow them to be stepped on.
Small tool boxes and oil feeder storage in space above coal shoveling plate (cab hand tools, red flag, detonators etc.).
Main tool box at RHS trailing end of loco: Special wash-out nozzle for back plugs in foundation ring. Air wrench and air line for emergency 'winding'. General tool kit.
Battery box at LHS trailing end of loco, sand boxes middle section.
Lids (including sand boxes and battery box) to have internal brass hinges and arranged to prevent the lids fouling the paintwork on the tanks, and provided with internal props to keep them open. Also arranged to shed rainwater all round: drain holes provided.

Boiler Fittings to be made of materials compatible with 'Porta' water treatment, if desired.
Special attention to be paid in boiler design to water space and ligament width at firebox tube plate as applied experimentally in LYD (assuming that this arrangement has proved successful

over time):- Use of stay tubes, monel stays and NO palm stays (as on LYD); tubes and flues swaged down for 3” length to increase water circulation AND thicken metal at back ends of tubes (annealed before expanding into tube holes); all ends beaded over in firebox. Additionally in the light of further research:- All tubes and flues to be sand blasted externally (to descale) before fitting.

Brake Gear: cross shaft, application springs and air cylinders to be mounted on the OUTSIDE of the inner ends of each unit, and arranged to clear the tanks/main framing at maximum swing.

Use of standard castings:-
Cab side windows (LYD)
Clacks (LYD) Machined larger internally, or new castings? Fire bars (Garratt/FfR Fairlie?)
Draw Gear (LYD)
Oil Boxes

Brick Arch to have cut-away adjacent to lowest row of tubes, to prevent ash build-up and to ensure sufficient gas flow through them.

Washout Plugs:- 4no. in circumference of front tube plate;
3no. above tube bundle, to allow withdrawal of feed pipes;

2no. top/sides front end of barrel, for washing tubes below feed pipes; 4no. in shoulders of belpaire casing, for washing crown plate; 4 no.inback-head “ “ “ “ ;
2no. in foundation ring of back-head, half way between c/l and sides; 2no. in “ “ front corners, at 45 degrees.

Blow Down Valve:- Foundation ring at the front middle.
Fire Irons to include a rake suitable for pulling back clinker for dropping.

Paint: cab floor area to be hot zinc sprayed and two pack
painted before fitting wood flooring.
Bodywork to be sand blasted, phosphate’d before zinc phosphate priming.....

Regulator will push or pull forward to SHUT (spring loaded ratchet) up to the ‘stop’ but will only go further to shut atomiser if the trigger rod is pulled down
fully, ie further than the trigger actuates. Regulator can NOT be OPENED till trigger is squeezed, and for all subsequent increases.....

Possibly arrange s/s feed pipes to enter regulator housing forming a centrifugal water separator, ie part of s/s sheet steel box enclosure.

Ash Pan wider and longer than the foundation ring and bolted to extension plates fixed to the underneath of the foundation ring. This allows plenty of room for the double skinned sides through which primary air is ducted under the grate all round, and above the build up of ash;

also plenty of ash capacity. The side ash doors pass through the double wall and are top hinged, the bottom edges close against a full length stop to make a spark proof seal; each has two top pivoted catches that swing down through slots in the bottom plate, and a hook is arranged to keep the door open when clearing ash. All constructed in stainless steel.

Rocking Grate mechanism is operated by a lever in the cab floor, but the grate opening mechanism is operated from the fireman's side of the ash pan with an extension bar.

Machinery space: top access, lid hinged at the front edge and includes the top half of the back sheet, rain-proof edges turned down all round; contains heat exchanger, air reservoir, all auxiliaries and valves.
Bevel gear box and driveshaft/pulleys for pumps: rotary vane vacuum pump (with uni-directional drive using one-way clutches), CAT boiler feed pump, air pump, twin alternators, centralised lubrication pump, etc.. Space in middle for FITTER!

Reference-only Vacuum Reservoir (under cab floor) is required for the graduated linkage between the 'train' vacuum system and the independent air systems on each power bogie, see sketch plan of system.

Smokebox to be clad and insulated which, combined with a built-in chimney lid will conserve heat at night, and increase safety when climbing onto the tanks.

Gas Producer:-
Experience gained on the Ffestiniog Railway suggests that the firing skills required to operate this system are not sufficiently consistent amongst volunteer crews, and that any hold-ups at departure time can seriously affect a prepared fire. Standard gauge locomotives performing regular duties with regular crews and consistent supplies of fuel, appear to have been reasonably satisfactory, but this is not directly transferable to narrow gauge tourist railway practice. However, work by Prof. John Sharpe (experience gained with River Esk) suggests that shredded waste (excluding medical) can be successfully burnt on a GPCS system using the 'brick arch air vent' as proposed here, but the development of standardised briquettes of 'torrefied' waste would be ideal.

Grate Oversized relative to the free gas area is intended to produce a fire bed where inferior (smoky) coal can be burnt with a modest gas flow velocity avoiding small/light fuel carry-over. Torrefied biomass should not present a problem with volatiles, but may require the exhaust steam to lower combustion temperature at the grate. The long brick arch and low velocity would ensure good secondary combustion. Deep bed GPCS was conceived with a view to clean combustion/clinker prevention with inferior coal, but also maximising combustion rates/power outputs from relatively small grates, this proposal is for a relatively large grate and modest rate of combustion.

Tube Length/Internal Diameter Ratios:-

Bowman's Analogy.

This ratio is like a bird's digestive tract, if it was longer digestion would be more efficient BUT the bird would not be able to fly because of the weight. Longer tubes increase heating surface and to a point heat exchange efficiency, but the extra weight of the longer boiler (and more water) plus the higher gas flow resistance, are not justified or possible within the size/weight limitations of a narrow gauge locomotive aiming at a maximum power to weight ratio. The same reasoning applies to tube diameter being relatively large, ie freer steaming (more effective use of the tube length), with the added advantage of reducing gas friction (easier drafting, less back pressure on steam exhaust).

Experience: smokeboxes need painting more often!

Access to Pipework, and cables under rotating console:-

When the drivers seat is in the backwards driving position (ie against the boiler) a panel can be removed from the opposite side of the rotating outer column (R clips) exposing and opening in the inner fixed column, and giving access for maintenance.

Boiler almost entirely outside cab: safety and draught proof cab.

Axle Loads and bogie support systems:-

The 0-6-0 bogie effectively supports the boiler and front tank structure via three points, pads/ rollers each side of the pivot (between axles 2 and 3 which are compensated), and a third loose roller under the smokebox (runs in guide tracks, one of which can be inclined slightly each side to damp hunting: not necessary or applicable if side pads are used instead of tapered rollers). The leading axle has long independent coil springs. Maximum axle load c. 8 tons reducing to about 7 tons when the tanks are empty.

The 0-4-0 bogie carries part of the weight of the boiler/front tanks, the cab, bunker, back tanks and the auxiliary equipment and drive mechanism, plus the contents of the tanks and bunker. This bogie is mounted on a spherical seating allowing movement in all directions (roll being controlled by coil springs each side of the pivot), whilst it has a maximum axle load of c. 9 tons the spherical seating ensures full compensation, and as the bunker/tanks empty axle load will reduce to about 6 1/2 tons. The back tank can be left empty when suitable water stops are available. This bogie may need a hydraulic damper to limit hunting because of its low rotational friction.....

Note 'Z' re Rollers on 0-6-0 bogie:-

Rollers would have the advantage of reduced friction, thus reducing flange wear entering curves but hunting could nullify this advantage? Pads would add damping but could increase wear due to resisting entry into curves? An independent hydraulic damper can be fitted between the locomotive framing and each bogie if required.....

Rollers would be tapered and at least 6" long and located on the c/l in the bottom casting (oil

bath), with each end fitted with a spherical roller bearing. These bearings would be pressed into square ‘die blocks’ allowed to slide vertically in recesses in the housing.

Excess weight beyond that required for adequate adhesion, other than ballast weights for fine adjustments of weight distribution (0-4-0 unit only in this case), equates to a loss of overall locomotive efficiency?

Provisional routing of main steam pipes:-

From the bottom (hot) headers of the superheaters the pipes head forwards (with ‘easy- cut’ bolted flanges), and in the front half of the smokebox ahead of the saddle uniting the front tanks, 180 degree bends pass through air tight glands in the smokebox sides, and above the level of the saddle. On the LHS a rigid pipe (lagged and with provision for expansion) runs back in the space between the tank and the barrel with its back end bracketed off the front of the main pivot stretcher. A (? swivelling) 180 degree bend passes down through an oval cutout in the bogie top plate (corrugated over the wheels), and a lagged pipe with flexible joints (?) connects to a Y splitting manifold, low down between the cylinders: then ducted within the casting up to the steam chest (drain at this point). Trailing unit similar but steam pipe on RHS and dips down after the leading pivot stretcher to follow the bottom of the side tank. Drip valve at lowest point.

POP SAFETY VALVES:-
Questions regarding pointless ‘pop’ safety valves:-
Unnecessary steam wastage from the violent opening of pop safety valves, where the pressure has to be brought down considerably before they close, must partly negate some of the thermal advantage resulting from design improvements in the ‘steam circuit’?
When locomotive crews have varying levels of skill in maintaining ideal amounts of fire/ water/ steam, surely direct loaded safety valves must be more ‘user friendly’ (for the public too) and less wasteful of fuel? What is the actual advantage of pop safety valves in narrow gauge locomotive applications?

The Story:-
It may be apocryphal and there are variations.....
An American railroad director was standing next to a locomotive that was blowing off furiously, and he noticed that the pressure gauge was reading somewhat above the ‘red line’. He mentioned this perceived danger to his friend who owned a precision engineering workshop, and the latter promised to ‘fix it’. Thus was invented the Pop Safety Valve, a clever solution to a non-existent engineering problem. Boilers are of course designed with a considerable margin of safety, often between five and seven times stronger when new than dictated by their normal working pressure, and a boiler would have to be on its last legs to explode when five or even ten

percent above normal. See:- W A Tuplin, D.Sc., F.I.Mech.E. The Steam Locomotive, pages 35/36.....

Practical Considerations:-
The makers of Pop valves were excessively diligent in their marketing and made much of weight and space saving, as well as the reduced 'over pressure' risk of course. Interestingly 'Wikipedia' suggests that a 'feather' of steam from the safety valves was a sign of a fireman's "virility", and that with the introduction of the Pop valve they "tried to avoid noisy blowing off, especially around stations". Neither of these statements is quite true: a 'feather' at the safety valve simply showed that the pressure was just approaching maximum (which kept any driver happy) and the loss of steam was kept minimal as no fireman wished to shovel any more coal than necessary. As far as TRYING to avoid noisy blowing off is concerned, crews were INSTRUCTED not to allow their engines to blow off in stations because the noise terrified passengers! In reality there is absolutely no disadvantage in carefully designed directly loaded safety valves in a narrow gauge application, especially where station stops are frequent and crews are of varying abilities . They are 'user friendly' for the crew, giving gentle warning when the pressure is approaching the 'mark', customer friendly in that whilst noisy they do not 'explode' suddenly, and fuel friendly in that corrective action can often be taken before a full-bore blow off. Also, unlike the Pop safety valve the pressure does not need to be reduced BELOW working pressure before the valve shuts (often quite a lot). The latter not only

wastes fuel, but when working 'full regulator' the pressure drop may lead the driver to lengthen cutoff, using more steam and requiring more fuel to redress the situation. Comments based on many years of personal experience.
In redesigning the Ramsbottom safety valves for LYD (I was told that she would have to be fitted with Pop safety valves) due to the increased working pressure, I not only changed from tension spring to compression spring with external adjustment (plus collar), but also chose narrow flat seats (and phosphor bronze valves) to gain their superior discharge characteristics. If direct loaded non-pop safety valves were good enough for the Great Western Railway they are good enough for me!

FINALLY THE ESSENTIALS:-
1. Maximised power to weigh ratio, 100% adhesion, locomotive equivalent 'power' to TWO 'LYD type' Manning Wardles AND about ONE carriage LIGHTER.

2. Clean combustion with low grade fuel: large, long firebox (traditional ratios for grate area/free gas area do not apply, moderate rate of combustion to avoid particle carry-over).

3. Minimised labour requirements: daily prep., maintenance and overhaul.

4. Free steaming: tubes short for their diameter (not traditional standard gauge ratios).

5. Wear and tear minimised: boiler pressure not more than 225lbs/sq.in., moderate superheat, use of current best materials, and appropriate lubrication systems.

6. Maximised safety and crew comfort.

James Evans