

## Summary of Papers in order of appearance:

### Boilers:

**1 - Notes on the Responsiveness to Quick Load Changes of a certain Well-Known Type of Boiler when Burning Wood (1978):** Porta claimed that this paper was written following a visit to Sweden as a challenge to three Swedish boiler engineers to see if they could identify a wood-burning boiler that could: “reach full capacity for steaming in some 10 seconds, dropping instantaneously, letting some time pass, and then facing varying steam demands etc., without significant drop in the steam pressure, and all with reasonable efficiency”. Perhaps it was more likely written to illustrate what ordinary locomotive boilers could deliver in terms of flexibility and responsiveness as compared to the stationary boilers that the three engineers were familiar with. It includes a transcription of the British Transport Commission’s “Handbook for Railway Steam Locomotive Enginemen” Section 4: ‘The Boiler’.

*Historical context by Shaun McMahon: This paper was written hurriedly to drive home his point about the recuperative capabilities of firetube boilers. It is widely used today for the same purpose. Porta’s trip to the US and Europe was arranged by INTI at short notice at the end of 1978.*

*Boiler of loco No. 4674: this is of special interest because it is the first “demonstrator” that Porta rebuilt after joining INTI. It was effectively his first multi-fuel loco, a concept that he was to recreate on later occasions and which we continue to develop at INTI.*

*The appended letter is interesting as it refers to Dr, Peer Le Sueur and Dave Wardale. Le Sueur worked with Porta at INTI from Sep 1980 to Mar 1981 before moving to the SAR to work with Dave Wardale as one of his assistants on 3450, along with Roger Waller. After Wardale left SAR, Le Suerer modified class 25 3454 with double Lempor.*

### **2 - Improvements to Superheater Element Joints for Advanced Steam Locomotive Technology (1982):**

A study into the mechanism leading to leakage of superheater header-element joints and a proposed solution using displaceable washers and long bolts. It includes an appendix on “On Superheater Bolt Stretching due to Temperature Effects”.

### **3 - A New Superheater–Economizer Element for Advanced Steam Locomotive Technology (1980):**

Porta speculates on the possibilities of “a fin-tube detachable smokebox economizer which can easily be lifted up for repairs or access to the superheater”, comparing it to Chapelon’s integral economizer. Porta then goes on to consider how Chapelon’s integral economizer might be improved by incorporating finned superheater elements in the boiler section, and internally finned flues (“Serve” tubes) in the economizer section. An appendix has been added to help explain Porta’s calculations to readers.

*Historical context by Shaun McMahon: This paper was written for the ACE project not long after the Washington meeting of April 1980 when it was agreed that Porta would work full time for ACE starting later that year. However his arrival in the US was delayed by ACE, so he continued working at INTI until October 1982 by when he had turned 60, thus qualifying to retire on full pension. Preparation work for this paper had been carried out in 1978 in the TGS paper of that year.*

**4 - What Steam Pressure for Old Locomotive Boilers? (1999):** Written towards the end of Porta’s life, this paper was published by the Coalition for Sustainable Rail ([www.csrail.org](http://www.csrail.org)) in 2015 as part of their White Paper programme. This transcription includes sections of the paper

missed out in CSR's version, including the two Summaries and Section 5 "Legal Aspects". Some of the wording has also been changed back to (or closer to) the original.

**Historical context by Shaun McMahon:** *This paper was written at the time when I began working full-time in Argentina. Porta based the paper on what he had learnt and applied to locomotives in Cuba since 1992. He saw its subject as one that needed to be worked on as part of the then active Plaza Constitucion to Mar del Plata "modern steam" hauled train project that Tranex Turismo (former owners of FCAF) were working on, this project being the reason for my move to Argentina. The paper was effectively written for Phil Girdlestone and myself, to help us address problems that might arise when confronted with a need to increase a locomotive's boiler pressures. The project fell through due to political changes that occurred during the economic crash of 2001. The paper is still used at INTI as a reference for its projects.*

## **Fireboxes:**

**5 – Notes on the Flat Plate Stayed Firebox Construction for Locomotive Boilers working at 30 and 60 atm. Steam Pressure (1976):** This paper investigates the possibilities of increasing boiler pressures to 30 and 60 atm (440 and 880 psi) while retaining the traditional firebox form with water legs and flat stayed surfaces.

**Historical context by Shaun McMahon:** *The work described in this paper is related to the development of Third Generation Steam (TGS) that Porta was focusing on at the time. He and Dave Wardale presented a paper on the subject at the Pan American Rail Congress in 1978.*

**6 – On the Hudson-Orrok Heat Transfer Equation as applied to Locomotive Boiler (1977):** A 2-page rather academic paper written for David Wardale's benefit, describing a formula for heat transfer in boiler furnaces which Porta describes as "good for first preliminary calculations".

**7 – Note on Burnout Heat Transfer (1980):** Burnout occurs when the heat flux on the inside of a firebox exceeds the rate at which the coolant (water) can extract heat, resulting in an uncontrolled rise in plate temperature. From an empirical theory published by Bernard in a 1960 Chemical Engineers journal, Porta calculates that burnout should not occur at the maximum local heat flux that is likely to occur in a locomotive firebox ( $\sim 1 \text{ Gcal.m}^{-2}.\text{h}^{-1}$ ).

**8 – The Thermo-Mechanical Behaviour of the Steam Locomotive Boiler Firebox – an Overview (1984):** The paper reviews the development of firebox design with particular reference to innovations, particularly in the form of flexible stays, introduced by Von Dr. Ing. Arnold Tross in Germany in 1937, and parallel developments carried out in France during the early 1940s, necessitated by the substitution of steel for copper in the inner firebox. The necessity of eliminating scale and corrosion through effective water treatment is also emphasized. Two appendices are provided, spelling out methods of repair to damaged fireboxes, and on the design of thin (5/16") tube plates.

**Historical context by Shaun McMahon:** *This paper was written for the ACE project. Only Porta's name appears on the cover because of confidentiality clauses by ACE.*

**9 – The Worm Grate and Ash Disposal System (c.1976):** The paper presents Porta's bold imaginings of what could be done to improve the environmental impact of steam locomotives through the elimination of the ashpan by the automated removal of ashes from below the firebed and conveying them to a sealed container fitted between the bogies of the tender. His approach offers means of cleaning up the design of the grate/ashpan area and perhaps even lowering the level of the grate to allow a deeper firebed.

**10 - Note on the present status of Grate Design in connection with the Gas Producer Combustion System (1982):** This paper describes various proprietary US grate systems together with some of Porta's own designs (both tried and tested and conceptual) with particular emphasis on clinker break-up and disposal. It includes an innovative firebox and grate arrangement for his large MALLETT proposal for the Rio Turbio 750mm gauge line in Argentina.

*Historical context by Shaun McMahon: This paper was written for the ACE project, and (as for Paper 8) it has only Porta's name on the cover. This paper was extensively used by Dave Wardale in South Africa and later by Phil Girdestone, first when converting the Ffestiniog's "Linda" to GPCS and subsequently when modifying ACR's NGG16A. Porta went on to review and update the paper for use on his Cuban projects, especially on 1816. I have since used it for design work involving the Rio Turbio Advanced Santa Fe and then for designing the MVM (Máquina Vapor Moderna = modern steam machine) range of steam generators and on the modifications to ex FCGR Class 8A 2-6-2T No 3351 at Ayacucho (Buenos Aires province). I am also using it on the Tafi Viejo modified biomass locomotive project in Tucuman province.*

**11 - An essay on steam locomotive boiler tubeplate birdnesting (ash fouling) (1983):** The paper offers useful insights into the factors that contribute to ash fouling, and offers qualitative solutions for overcoming or minimising it.

*Historical context by Shaun McMahon: This is another paper written for the ACE project, and is based on work that Porta carried out while still at INTI, using the Rio Turbio locomotives during his final visits there between 1981 and 1982, just before travelling to the US.*

## **Combustion:**

**12 - Locomotive Boiler Combustion Calculations – The Heat Balance - A Criticism of the Lawford Fry Method (1974):** This was the most challenging of papers for the transcriber. The unusually rough nature of the manuscript suggests that Porta wrote it in a hurry and failed to proof-check it properly - or perhaps it was just a rough draft. However, in addition to identifying and correcting errors, it demanded an understanding of Fry's theories and of Porta's criticism of it, for which the transcriber was gratified to be able to call on the assistance of ASTT members Dr. Louis Wibberley, John Boutwood and especially Martin Johnson. Porta's criticism derived from Fry's assumption that composition of coal particles lost through the chimney are the same as for the "as fired" coal, whereas Porta believed that only char (unburned carbon) is lost after the hydrogen and volatiles in the coal have been combusted. Two appendices have been added: the first explains the idea behind the "Combustion Triangle" referred to by Porta and how to create it (based on advice by Martin Johnson; the second appendix, written by Martin Johnson, offers a commentary on various aspects of the paper.

**13 – Hand Firing in connection with the Gas Producer Combustion System (1976):** In fact this is three papers in one: Part 1 was written to advise David Wardale on converting the firebox of SAR 19D No. 2644 for GPCS operation; Part 2 contains more generalised advice on the hand-firing of GPCS fireboxes, while Part 3 offers advice on the design of the fire door for 2644. The three parts combine to form one of Porta's best illustrated papers, demonstrating his not-inconsiderable artistic skills.

**14 - Note on combustion efficiency of the Gas Producer Combustion System (1980):** Some of this short paper may not have been authored by Porta even though the second half is transcribed from Porta's hand-written manuscript. The first part – tabulated analyses of coal and ash - appears to derive from the UK National Coal Board's Coal Research establishment at Stoke Orchard, where samples carried back from Argentina by John Click were analysed, following his 1977 visit to the Rio Turbio Railway on a United Nations Industrial Development Organisation

(UNIDO) mission. Quite possibly the descriptive text following the tabulations was written by Click to emphasise the effectiveness of Porta's Gas Producer Combustion System when burning the high ash, high volatile Rio Turbio coal, and the very low particle emissions achieved despite its very small particle size.

**Historical context by Shaun McMahon:** *This is effectively an internal INTI memo referring to work that was then taking place in conjunction with Rio Turbio.*

**15 - The Gas Producer Combustion System as an answer to coal-derived pollution from steam locomotives (1990):** Perhaps best described as an update on Porta's earlier papers, it focuses on the reduction in chimney emissions achieved by the adoption of his Gas Producer Combustion System. However it includes descriptions of environmental control of ash disposal and reducing lubricant losses. It includes a 2½ page appendix listing "Items Included in a Typical Locomotive Modernisation".

**Historical context by Shaun McMahon:** *This paper was a state of the art review of the GPCS and its usefulness, written at the time when Porta was working at the Donha Teresa Cristina Railway in Brazil. It brought together his experience there with Phil Girdlestone's experience at the ACR on Garratts Nos. 141 and 155. Porta had been to the Ffestiniog Railway in Wales that same year (when I first met him); he was shocked by the lack of knowledge and negative attitude within the UK towards such novelties as the GPCS. It was this negativity that inspired him to write this paper.*

**16 – Locomotive-type Boiler for Bagasse, Peat, and Wood Refuse Burning (1983, revised 1992):** The title reveals that this paper is about locomotive-type boilers rather than locomotive boilers *per-se*. It is nevertheless interesting in that it offers insights into drying and combustion of biomass fuels, and speculates on how a locomotive-type boiler might improve the performance and/or reduce the size and cost of normal stationary biofuel boilers.

**Historical context by Shaun McMahon:** *This paper was written after Porta began work on the ACE project. He had been working part time and unpaid from Argentina on ACE matters since May 1980. He moved with his wife Ana to live in the US on 12th October 1982 from when he worked full time for ACE.*

*The paper derives from work that Porta undertook in the development of a stationary plant in Argentina. This was a clever design due to the drying of the fuel in power station style. I have used this quite extensively on stand-alone generator work in recent years here.*

*The Nobel reference arose in 1983 from US staff working on the ACE project when someone suggested that he be nominated for a Nobel prize. This represented a very different attitude towards his work than what he had experienced in Argentina. Note: Porta wrote his Buenos Aires address on the cover of the manuscript when in fact he was in the US at the time. Most likely he added the address when he revised the paper in 1992, forgetting that he'd been away in Feb 1983.*

*The accompanying letter (in Spanish) written to Ing. Llorens in Cuba at the very start of the Cuban project, i.e. when Porta was considering taking up the offer after his initial visit there in early 1992. The issue was finally settled in September 1992 during a later visit. In the meantime, there was a lot of correspondence between Porta and the Cuban government and submission of papers etc.*

**17 - Application of the Gas Producer Combustion System to the 141R - An Exercise (1998):** A most interesting paper describing how a (US-built) French 141R might be converted to incorporate a Gas Producer Combustion firebox. It was written immediately following the

publication of David Wardale's "Red Devil and Other Tales from the Age of Steam" in which Wardale described the difficulties he experienced achieving success with the GPCS firebox in his Class 26 4-8-4 "The Red Devil". Clearly Porta wanted to demonstrate how such a retrofit might be more successfully undertaken. Appendix 2 is titled "Combustion of Biomass by the GPCS".

**Historical context by Shaun McMahon:** *This paper was presented by Porta as a full presentation at the ECOVAPOR conference in Cuba on July 8th 1999 in the presence of Dave Wardale and myself.*

**18 - Comments on a paper by G.G. Thurlow on fluidised bed combustion (c.1978):**

Two pages of comments and calculations expressing Porta's skepticism about the potential use of fluidized beds for locomotive combustion, saying that the evaporations quoted in Thurlow's 1978 paper were "same as for GOSS's ninety years old 55 lb/ft<sup>2</sup>/h of firebox heating surface of 1890s locomotives".

**19 - A note on the Gas Producer Combustion System with fluidized bed conditions (1980):**

Written two years after Thurlow's paper, this appears to have been an intellectual exercise in which Porta speculated about what experimentation might be tried (as opposed to a serious research proposal). The concluding paragraph contains a strong hint that he was responding to pressure from a Fluid Bed Combustion lobby, and that he considered the exercise one of futility – even at "chicken-feed" expense.

The paper offers a glimpse of Porta's mindset when undertaking work for INTI that had no direct connection to locomotives. Notwithstanding, he couldn't resist putting forward the suggestion that, if a trial was to be conducted, it should be undertaken by adapting a locomotive to handle an amalgam of GPCS and Fluid Bed Combustion technologies.

**Historical context by Shaun McMahon:** *To prove his point in this paper, Porta went ahead in 1981 to produce a fluidised firebed on a Rio Turbio locomotive. The locomotive was 113 of the second batch which Porta used as his test-bed during his later visits to the RFIRT (between 1977 and 1982).*