AST Trust

Advancing Steam Traction

NEWSLETTER No. 20 - NOV 2022

Conference attendees paid a visit to the A1 Steam Trust's workshop to see the progress being made on the Trust's new-build P2 No. 2007 "Prince of Wales"

CONTENTS

ERRATA—Martin Johnson writes: "In Part 5 of "Some Comments on Locomotive Front End Design", I used Stanier's Coronations and Princesses as examples of engines with 8 exhaust beats to the revolution. My thanks to Chris Newman who pointed out that they only have 4 beats as the cranks were set at 90 degrees. Maunsell's Nelsons were the only UK class to have 8 beats. Interestingly, draughting on this class was not initially successful showing that Maunsell, like Stanier, may not have fully understood the implications of multi-cylinder engines."

CHAIRMAN'S PIECE
John Hind

Firstly, a personal note of thanks to Chris Newman for organising this year's conference. On top of the normal problems of finding venues, caterers and speakers, there was the additional and late complication that the Darlington Mercure cancelled our booking two weeks before the date! To say this is an inconvenience is an understatement as several of us were staying there and it was the venue for the conference dinner.

The Mercure found us an alternative hotel for accommodation and the conference dinner, albeit 5 miles out of town, which meant that anyone staying in Darlington now needed a lift to the dinner. The inconvenience was tempered, by the Mercure negotiating the same room rate and providing pre-dinner drinks. Sorting these arrangements out meant lots and lots of additional work. On top of this, illness meant that two of our speakers had to withdraw at short notice and our reserve speakers had to be called on. It was 'alright on the night' and an outsider observer would have thought there were no problems. Turning disaster into a success is all thanks to Chris's efforts.

What was pleasing was the numbers attending and it was good to see old friends and new faces, who we hope to see again. For the dinner on Saturday night, we had a private room and that was filled with a constant hubbub of chatter – a sign of a successful night. It was a real pleasure to meet our new members.

Jamie Keyte gave one of his ever-popular updates on Revolution and was able to bring along hardware to show progress (later in the newsletter Chris gives a more detailed progress update). It struck me that the locomotive is getting past the stage where it is easy to transport, very much like a baby outgrowing its pram! I needed to 'volunteer' 4 strong men to carry the frames into the meeting room. When the wheels and pony truck are assembled, we will need 6 strong men, so bringing it to any more events is going to be difficult.

When we started the project, ASTT agreed to provide kick start funding and a member donated £10,000 to it. That was to get us to the point where we can prove the frame and suspension concept. Jamie is nearing the point when the wheelsets can be assembled and then we can do some trials at Stapleford to prove the concept.

However, to complete the locomotive we are going to need more funding and it is something we hope our members can help with by either making one of lump sum donations, a regular monthly donation or even remembering us in a legacy. A separate appeal leaflet is in preparation and will come out separately. We are also looking at external publicity and a railway journalist is interested in finding out more about the locomotive.

MEMBERSHIP MATTERS

Chris Newman

We welcome four new members who have joined since our No 19 Newsletter was circulated:

Michael Lyons from NSW, Australia. Michael is a retired mechanical engineer who spent 34 years in the rail industry, working in rolling stock and traction, including dynamometer car work setting loads and conditions. He is also an air brake engineer.

Philip Blackham from Norfolk, UK. Philip has kindly signed up to make regular monthly donations towards the *Revolution* project.

Rob King from Norfolk, UK. Rob is Chief Mechanical Engineer on the Bure Valley Railway and has been responsible for implementing various performance-enhancing modifications to the railway's locomotives.

Giuseppe Pollone from Montcalieri, Italy. Giuseppe is a retired mechanical engineer who specialised in noise and vibration control and has volunteered in steam loco operation and maintenance at the Piedmont railway museum. He currently oversees steam loco overhauls at Lucarto Tecnica Co. Giuseppe is our first member from Italy.

Membership Numbers

Membership numbers are now:

Full Members:	27	UK members:	78
Associate Members:	71	EU:	14
Student Members:	11	USA	7
		Australasia:	8
Total Membership:	109	Asia:	2

PUBLICATIONS PAGE

Chris Newman

Book Sales

13 books have been sold in the three months since Newsletter No 19 was circulated, five of which went to a single buyer in America. The sales numbers are listed as follows:

Publisher	Author	Title	Sales since N/L 19	Total Sales
ASTT	L.D. Porta	Porta's Papers Vol 1	4	129
	L.D. Porta	Porta's Papers Vol 2	2	122
	L.D. Porta	Porta's Papers Vol 3	4	81
	C. Newman (Editor)	Porta's Centenary Compendium Vol 1	7	58
	Ian Gaylor	Lyn Design Calculations	2	102
	David Wardale	5AT FDCs	1	208
	Alan Fozard	5AT Feasibility Study	1	40
Camden	David Wardale	Red Devil and Other Tales ..	0	260
	Phil Girdlestone	Here be Dragons	0	33
	Jos Koopmans	The Fire Burns Better …	0	7
	L.D. Porta	Advanced Steam Design	0	5
Crimson Lake	Adrian Tester	A Defence of the MR/LMS 4F 0-6-0	2	31
	Adrian Tester	Introduction to Large Lap Valves	0	17

ASTT ANNUAL CONFERENCE

Chris Newman

Our 2022 conference turned out to be another successful event that seems to have been enjoyed by all who attended. There were 28 attendees, up 50% on 2021, but only a little more than half the number in 2019, due partly to travel uncertainty (rail strikes) and Covid concerns. Owen Jordan had to pull out a day or two before the conference when he came down with the dreaded virus.

Five of our speakers spoke on a range of new topics, while four expanded or updated on presentations from earlier conferences. Their presentations are summarised below:

Andrew Hartland presented the third part of his investigations into “Why Did BR Give Up on Steam?”. This year he covered freight locomotives in which he took the BR Class 56 Diesel Electric as the pinnacle of diesel freight in the 1970s to compare with the potential that then existed for steam technology. He concluded that a steam equivalent could have been developed but that it would have had to have had an adhesive weight higher than that of the conceptual 8AT and a geared jack-shaft drive to overcome steam’s limitation in terms of driving wheel diameter associated with the need to maintain high engine RPM.

Hendrik Kaptein presented a paper on the “Mechanical Efficiency of Reciprocating Steam Locomotives” in which he spelled out the problems of measuring mechanical losses (or mechanical resistance) and suggested some remedies to improve such measurements (e.g. resurrecting the use of a pendulum) and adopting tortional transmission (e.g. as used on the DR 19^{1001}).

Richard Pearson gave an introductory talk on the A1 Steam Trust’s new-build P2 locomotive which his audience were to inspect in the afternoon. He explained the extensive use of parts (including the boiler) that are common with the Trust’s A1 Pacific “Tornado”, and the design changes that have been made to overcome problems experienced with the prototype P2 - most notably the leading pony truck and the arrangement of poppet valves for the middle cylinder.

John Duncan presented a paper on “CPR Aylth Roundhouse and Diesel Depot” in which he described his experiences working as a machinist on the Calgary Division of the Canadian Pacific Railroad in the late 1950s.

Adrian Tester presented a paper on the “Physiology of the Locomotive Boiler” – a follow-up to the similarly titled paper that he presented to ASTT’s 2017 conference. Adrian has loaned the text of his talk to Chris Newman who will transcribe it and circulate it amongst those who attended the conference.

Steve Rapley (ASTT Member and CME of the General Steam Navigation Society) presented a paper on " Improving Performance & Efficiency of 35011 General Steam Navigation", focussing on the three principal deficiencies of the original design, namely the unbalanced crank axle; exhaust drifting, and low performance efficiency.

Ian Gaylor and **Rob King** (ASTT Member and CME of the Bure Valley Railway) gave a talk on the "Development of the Bure Valley ZB locomotives", describing improvements made to valves, ports, cylinders and steam chests that have transformed the performance of the railway’s two ZB-type locomotives.

John Hind & **Ian Gaylor** presented an update on ASTT’s involvement in "Trials and Research into Coal Substitutes, describing how they plan to seek funding to cover the significant costs of developing a commercial solid fuel alternative to coal.

Jamie Keyte gave an update on the work that he has been doing on "the design and construction of "*Revolution*". He brought with him the assembled main frame for the locomotive, together with the almost completed pony truck, coupling and connecting rods and a set of suspension and axle housing components.

Unfortunately no sound recordings of the presentations were made, but the nine PPT files have been uploaded to ASTT’s website in PDF format.

The 29 members who were in attendance are listed below:

Adrian Tester	Graham Shirley	John Hind	Richard Coleby
Alex Powell	Gwion Clark	Les Turner	Richard Mellish
Andrew Hartland	Hendrik Kaptein	Marcus Harriott	Steve Rapley
Chali Chaligha	Eelco de Bode	Mike Stockbridge	Terry McMenamin
Chris Newman	Ian Gaylor	Nigel Barnes	William Powell
Chris Parmenter	Jack Walker	Paul Winstone	
Dave Reynolds	Jamie Keyte	Pep Alemany	
Geoffrey Ayers	John Duncan	Rob King	

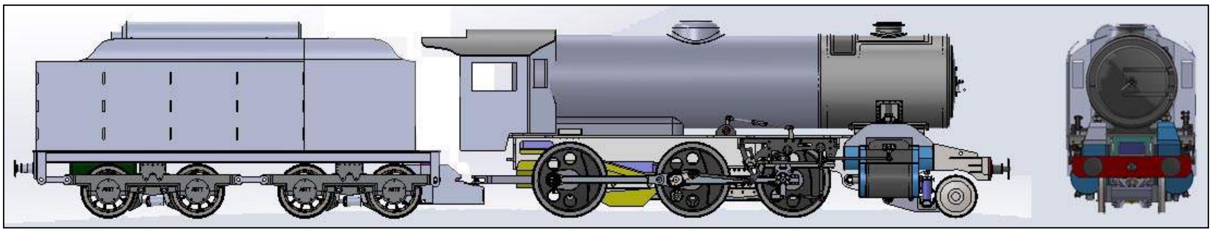
Apologies were received from Cedric Lodge, Mike Horne, Alan Barnes, David Nicholson, Doug Landau, Grant Soden, Iain Jack, Iain McCall, James Evans, Peter Lewis, and Owen Jordan who came down with Covid just before the conference.

2022 Conference Dinner at the Redworth Hall Hotel, Darlington, 15th Oct.

26 members attended the conference dinner at the Redworth Hall Hotel located five miles out of Darlington – see photos below.

REVOLUTION PROGRESS

Chris Newman



Those of you who attended the Darlington conference will have seen the progress that Jamie Keyte has been making on the *Revolution* project. Jamie brought with him the latest parts that he has manufactured, including:

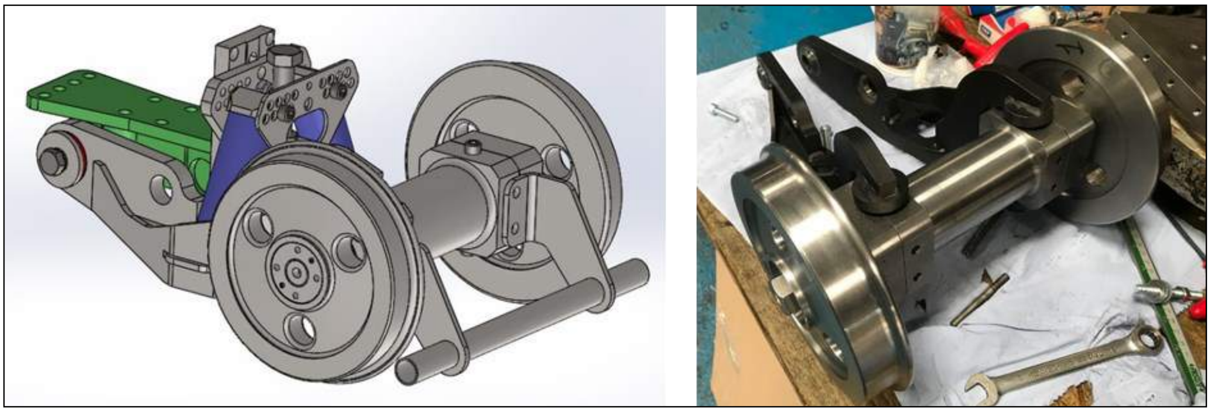
- The assembled frame,
- Suspension components,
- Coupling and connecting rods (manufactured from aluminium),
- Pony truck including axle and wheels.

In addition, he has completed the six driving wheels ready for axle assembly.

Jamie presented a paper at the conference which described in detail the progress that he has made in the fabrication and assembly of components. His presentation can be viewed in PDF format at http://advanced-steam.org/astts-2022-conference-presentations-members-only/.

The project has reached the stage where additional funding will soon be required to progress it further, and an appeal will shortly be sent out to seek financial support from our members.

Some images from Jamie's presentation appear below.

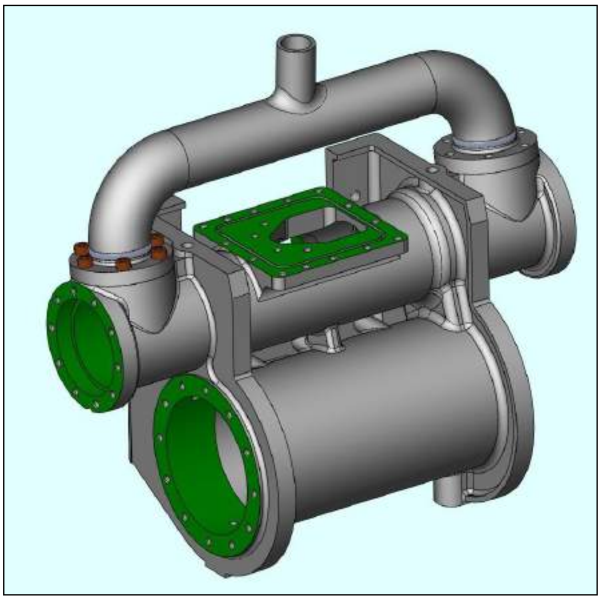


Above: Pony truck; Below: assembled frame and cast driving wheels.

Aluminium connecting and coupling rods fitted with roller bearings

Coupling rod connection detail

Suspension components



Cylinder and steamchest arrangement.

ALTERNATIVE FUELS

John Hind

ASTT Developed Fuel - by this newsletter I had hoped to give an update on the laboratory tests on the alternative fuel that Richard Coleby produced and we trialled at Stapleford in September 2021. While we got combustion performance curves, we were not able to get analysis of the products of combustion gases, which we feel is important in understanding the suitability of alternative fuels.

If anyone reading the newsletter knows of a laboratory that is capable of analysing combustion gases, please let us know especially if they will do it free of charge!

HRA Support - Ian Gaylor and I have supported the HRA by providing two 'Executive Summary' style documents in support of their submissions to

a) The National Heritage Lottery Fund who are reviewing what they fund from 2024 onwards. The result of the review is expected next year.

b) Railway 200 submission to the Government for funding for railway projects to celebrate 200 years of railways. September 2025 is the 200th anniversary of the Stockton and Darlington Railway opening and Government are looking to celebrate it by awarding grants for railway research projects. The submission to Government is in draft.

Of the two, I am more hopeful of the Railway 200 submission as it would be a ‘good news story’ for the Heritage Sector, particularly as the Stockton and Darlington Railway was built primarily to haul coal and an announcement on an alternative to coal would be good PR, though how funding would be awarded or managed remains an open question.

The opening paragraphs of each submission were slightly different to suit perceptions of the audience, but the paragraphs that outline the Development Programme are the same. The Development Programme uses a technique called ‘Structured Idea Management’ that is a methodology used to develop new products and has been successfully used by Ian.

Costings and timings are very much indicative at this stage and hopefully we will be asked to refine them at some stage in the future. Both submissions can be summarised as 'A three phase development programme with an indicative cost of £1.1 million over a 3-year timescale'

The first phase involves coal users in the heritage community, experts in combustion and chemistry and potential industrial partners, in a series of workshops and desk top studies to confirm needs, identify ideas – 100 or so and after desk top studies filter them down to 2 to 3 concepts that have a chance of success. This will be supplemented by locomotive testing using 21st Century tools and techniques to better understand current combustion conditions and define key functional success factors for a sustainable carbon neutral coal replacement.

The next stage is laboratory testing and small-scale trials prior to a final phase of large-scale manufacture of the fuel, testing and optimisation to ensure a viable product which meets the needs defined in the first phase.

Next Fuel Trials – together with the Bure Valley Railway we are working up a plan to do some more controlled testing in the spring of 2023 on other solid fuels that are being marketed as suitable for heritage steam. Over the late summer and autumn, a couple of trials on them have been conducted on other railways and testing at the BVR gives the chance to do true like for like comparisons in a controlled manner against all the other fuels tested since June 2022.

THE SHORT FLIGHT OF THE BATS

By Jean-Pierre Sentenbien, Thomas Hilge and Robin Garn via Chris Newman[1]

The first completed 4-8-4 locomotive (with provisional designation 242-1 and adorned with the French and Brazilian national flags) is presented on 4th July 1951 in the yard of the Batignolles works in Nantes.

Much has been said about the work of Andre Chapelon, with whom the author maintained a long exchange. But one of the last chapters of his extensive work as a French steam locomotive engineer remains less well known. It took place at a time when the swan song of the steam locomotive had long been intoned in Western industrialized countries. When his planned standard locomotives, which he had developed as chief engineer in the department for the development and construction of locomotives at SNCF, were no longer implemented due to the advancing electrification of the French railway network, and future projects such as those of his colleague Marc de Caso were shelved at the end of the 1940s, he was approached again to develop new steam locomotives, this time for a distant country — Brazil.

At that time, the rail network in Brazil stretched 36,700 km, of which 32,900 were meter gauge. Although the country had sufficient reserves of hydroelectric power, less than 1000 km were electrified, leaving most of the network the domain of steam traction. With the exception of a few small and insignificant private railways, the meter-gauge network, which is mainly located in the east, centre and south of the country, had no fewer than twelve different railway companies operating under the central administration of the "Departemento Nacional de Estrados de Ferro" (DNEF).

1—This article was first published in German in *EisenbahnKlassik* #2, by Nord Süd Express, Gröbenzell, Autumn 2021. Thomas Hilge is managing director of the publishing house Nord Süd Express and Robin Garn is editor of *EisenbahnKlassik*. David Wardale sent the original article to Chris Newman who translated it into English with the assistance of "Google Translate". The translation has been vetted by Robin Garn (one of the authors).

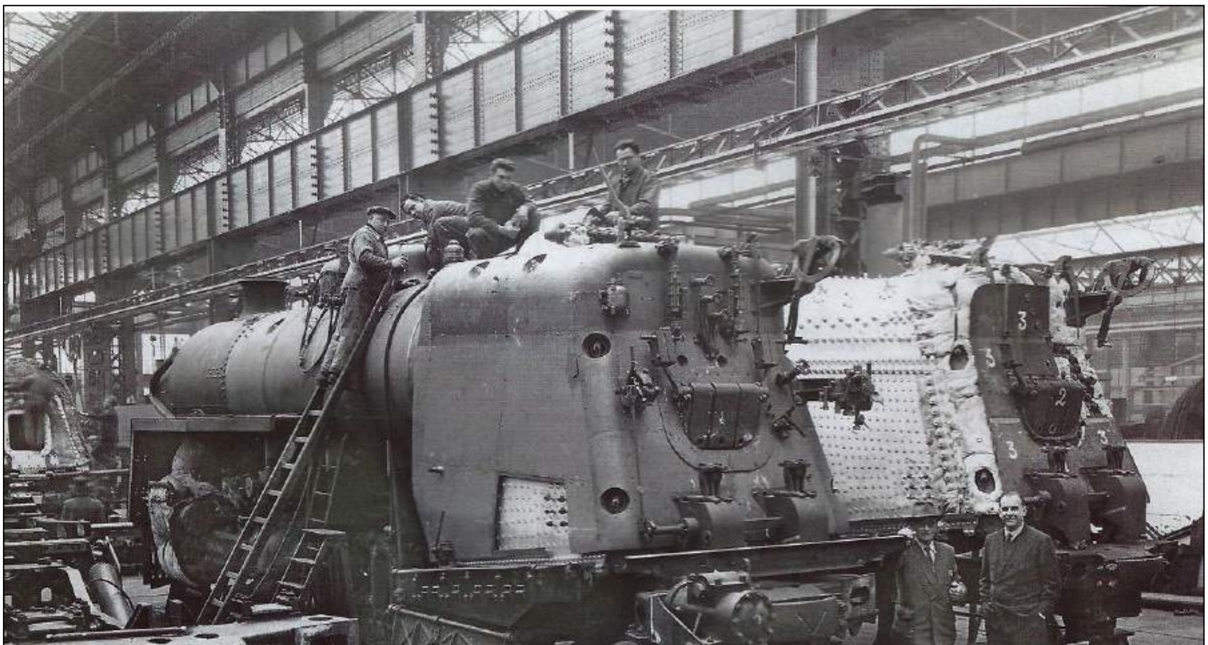
The locomotive stock was showing its age. In this respect, the then government under President Genilio Vargas, issued a tender for the procurement of new traction vehicles. Originally, the DNEF intended to order diesel-electric locomotives, however the choice fell on the "Groupement d'Exportation de Locomotives Sud-Amerique" (GELSA), a consortium of French manufacturers.

They were awarded ninety steam locomotives. Up until then, French steam locomotives had been the exception in South America, and later deliveries of European diesel locomotives were also limited to one-offs due to design flaws. Of all the suggestions, the GELSA concept was the most convincing. On the one hand, the high level of steam locomotive design in France promised a high level of locomotive performance. On the other hand, the GELSA offer promised burning of inexpensive Brazilian lignite.

In 1950, none other than Andre Chapelon was commissioned to manage the project. Two types of locomotives (wheel arrangement 2-8-4 and 4-8-4) were to be developed and supplied by the four manufacturers who belonged to the GELSA Group:

Batignolles Chatillod in Nantes
Societé Francaise de Constructions Mecaniques (Cail) in Denain/Valenciennes
Societé des Forges et Ateliers du Creusot (Schneider Works) in Le Creusot
Compagnie Fives-Lille in Lille (with which the Cail Works merged in 1958)

The contract signed between GELSA and DNEF on November 28, 1949 stipulated that the first machines should be delivered eighteen months after the order was placed, and the last after twenty-eight months. However, due to an extended test period and very detailed evaluations (as well as transport problems), the last locomotive did not reach the Brazilian port of Santos until January 1953.

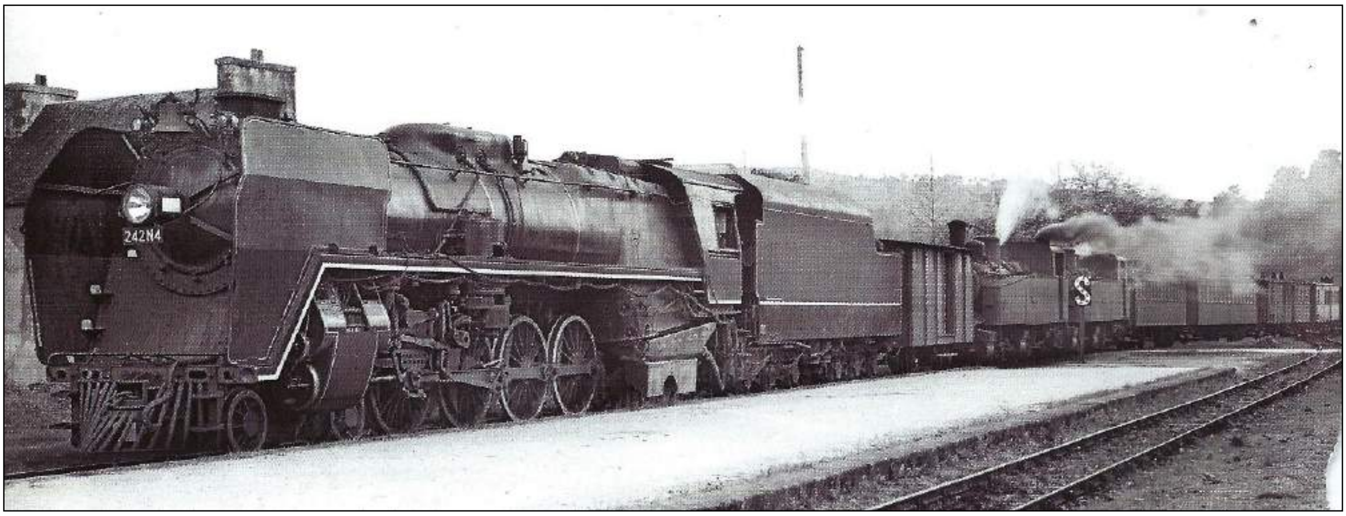


2-8-4 Locomotives (66 units): supplied by Cail, Schneider and Fives-Lille, intended for eleven rail networks. They had a manual firing system, driving wheels of 1270 mm diameter, a Belpaire firebox with a grate area of 4 m^2 with two Nicholson thermic siphons. The boiler pressure was 15 atm. They had a shaking grate and a Kylchap 1 K/T exhaust system of simple design. 16 machines had six-axle tenders with a capacity of 17 m^3 of water and 12 tons of coal. The other 50 had four-axle tenders with 14 m^3 of water and 7 tons of coal. (25 locomotives were equipped for wood firing without thermic siphons). Some were later converted to oil firing. Their design speed was 60 km/h.

4-8-4 locomotives (24 units): supplied by Batignolles-Chatillon in Nantes, intended for four railway networks. They had driving wheels with a diameter of 1500 mm, a grate area of 5.33 m^2(!), a Belpaire firebox with two Nicholson thermic siphons and a combustion chamber. The boiler pressure was 20 atm. They were equipped with a stoker, shaker grate and a double Kylchap exhaust system of type 1 K/T. The six-axle tender had a capacity of 22 m^3 of water and 18 tons of coal. They were designed for a top speed of 80 km/h.

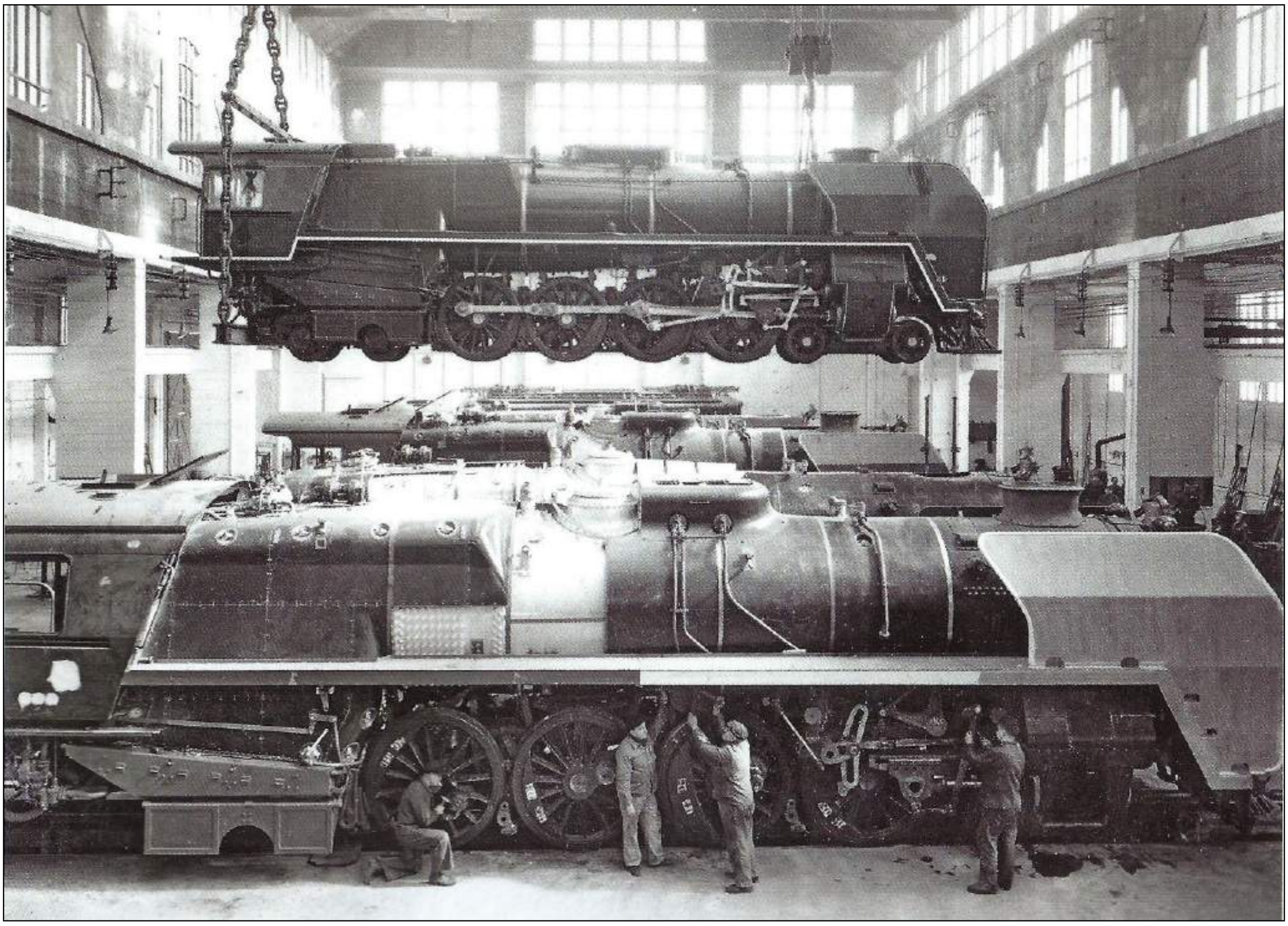
Test driven high-tech locomotives on a Breton narrow-gauge railway

The first machine, a 2'D2, was officially presented on July 4, 1951 at the Batignolles-Chatillon works in Nantes (see Fig 2). Road testing began in the autumn of the same year. The then extensive (300 km), meter-gauge network of Brittany was ideal for this, but not without certain restrictions: the maximum permitted axle load of 10 tons, and the track profile with many gradients and the numerous curves limited performance and speed. Of the two machines, 142 C 3 (2-8-4 Schneider) could only be tested briefly at 50 km/h and the 242 N 4 (4-8-4 Batignolles) at an even lower top speed. Very old CC (0-6-6-0) mallet locomotives were used as brake locomotives, or alternatively 2'C (4-6-0) machines with eight cars from the Breton meter gauge railway, one of which had been converted to a measuring car. Each test run lasted between 30 and 40 minutes with the throttle wide open[2] and constant speed, with Brazilian coal, which had been specially imported, being burned on the outward journey for comparison, and French fuel on the return journey. It turned out that the pyrite-containing Brazilian coal, which had barely half the calorific value and slagged relatively quickly regardless of whether it was hand- or stoker-fired, brought the same results in terms of evaporation performance, but a correspondingly higher consumption.

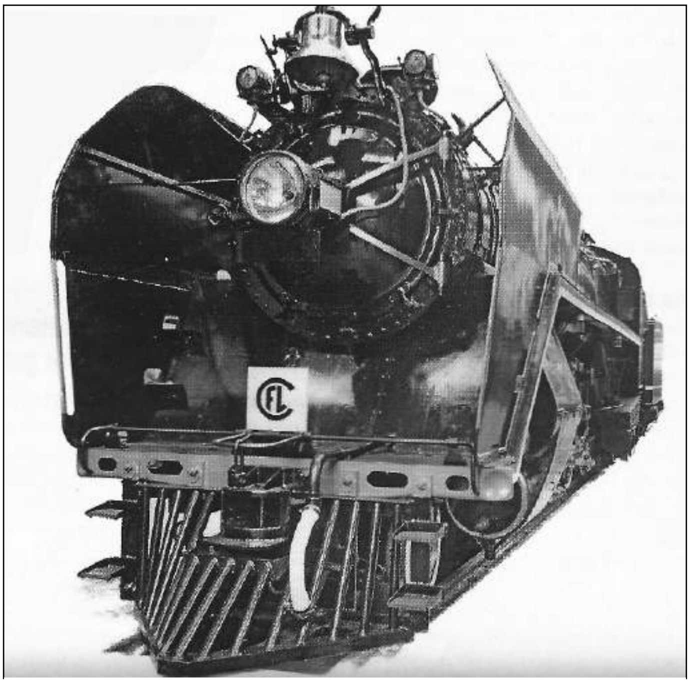


Test runs in Brittany. Test train hauled by 4-8-4' (242N4) traveling from Morlaix to Carhaix on the metre-gauge network of the Breton railways, after arriving at Scrignac-Berrien. Two powerful E-410 series CC mallets built in 1913/14 served as brake locomotives. At the destination, the new GELSA locomotive could not be turned around, so they travelled the entire way tender ahead.

2—A recommendation repeated over and over again by Andre Chapelon — also to the author: “Once underway, only use the reverser; keep the regulator fully open". *[Author]*



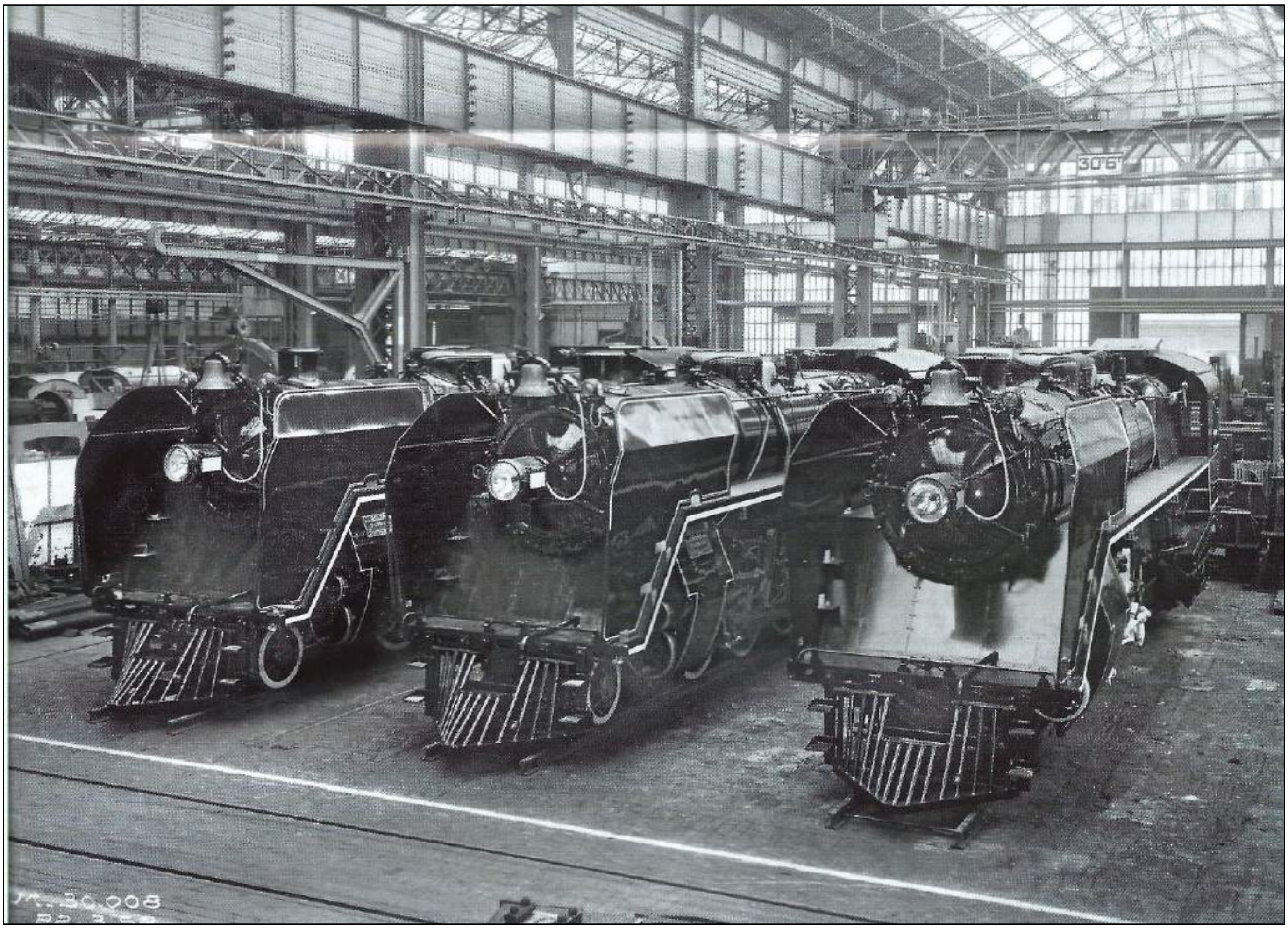
Erection hall of the 4-8-4 locomotives at the Batignolles works in Nantes. A machine that has just been completed is hanging on the crane.



A "Little Gelsa" shows off its distinctly American face: with cowcatcher, spotlight and obligatory bell.

Despite the low driving speeds permitted in the Breton network and without exhausting the boiler output, 1560 psi steamchest pressure could be maintained with a 60% cut-off with the 2-8-4 and 1965 psi with the 4-8-4 (quite comparable to a coal-fired 44!). If one considers the small cylinders (434 mm diameter), the engines' boilers and drafting systems were very well designed.

With a view to simplifying production and maintenance (which, as we shall see, obviously did not go far enough), both locomotive types were designed as twins and were to a large extent standardized with one another. The use of the same cylinder and valve diameters allowed common pistons, piston valves, piston rods, stuffing boxes and crossheads. The cylinder castings differed essentially only in their stroke and were identical on the left and right, and according to the robust American model were not only bolted onto the frame cheeks, but also bolted together in the middle, so that they formed the smokebox saddle. However, this standardization required the boiler pressure to be increased from 15 atm on the 2-8-4 to 20 atm on the 4-8-4 — standard for French standard steam locomotives, but well above the norm in Brazil. Unlike in post-war Germany, in French steam locomotive boiler construction — as in the USA, by the way — the heavier riveted design was retained to the end. In both types, value was placed not only on a large firebox heating surface, but also on a significantly increased distance between the firebox top and the crown of the boiler in order to ensure a slow drop in steam pressure and a sufficiently high-water level without water carry-over when starting.



General view of three 2-8-4 machines ready for delivery in the assembly hall of the Fives Lille factory. The factory also produced 29 of 317 SNCF 141P steam locomotives up to 1950 (141P 259-288, serial nos. 5150-5179). The "Compaqnie Fives-Lille" merged with the Cail works in 1958 and with the Babcock-Atlantique in 1973. After its closure in 1997, the company was split into various companies: mechanical engineering, microelectronics, metal and bridge construction, building and urban planning...

Despite the low prescribed axle load of 10t (2-8-4) or 13t (4-8-4), the GELSA locomotives should have delivered a high performance and should also have been able to negotiate track curves with a radius of down to 80 metres. Until that time, a two-axle trailing truck (Delta type) was rather uncommon for similar heavy meter-gauge locomotives, but due to the large firebox, the "super-power" principle of the North American "Berkshire" and "Northern" was used here. The relatively poor calorific value of Brazilian coal necessitated generously dimensioned grate surfaces and large capacity boilers. Weight was saved where possible without sacrificing strength, for example on the driving wheel spokes, which were thinner and stiffened with webs[3].

3—Presumably the wheel spokes were of (or similar to) the SCOA-P configuration. [CJEN]

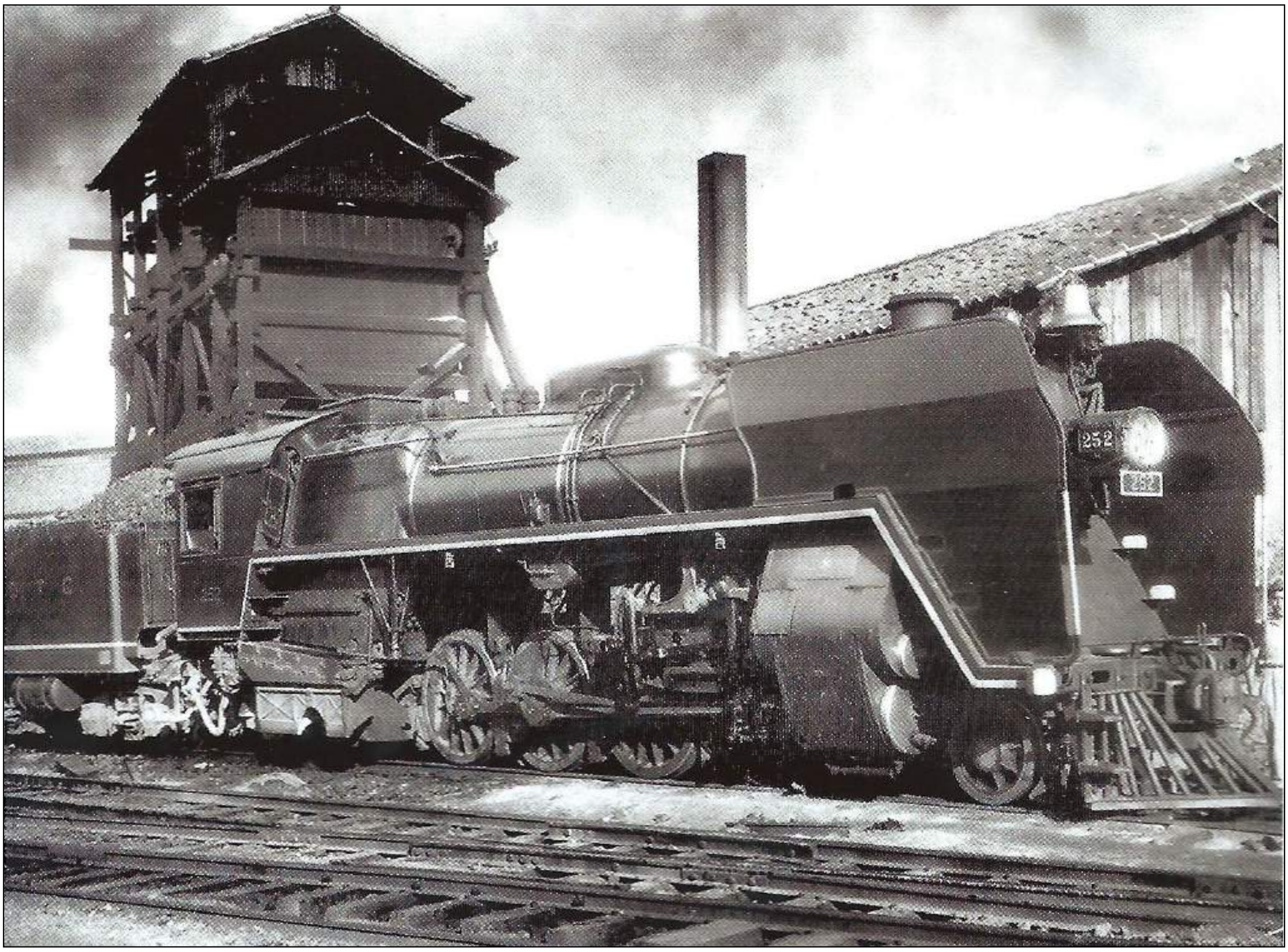
Heading an ore train in Brazil, "large Gelsa" No. 202 hauls freight instead of passengers. The proud 4-8-4 machines had to do much drudge work on tracks that severely restricted their performance: short light rails laid on a thin ballast - like a Formula 1 car driven on a dirt road.

The bar frames and slide bearings were graciously dimensioned and the axle bearing guides were equipped with automatic Franklin self-adjusting wedges in order to minimize engine and running gear wear. Depending on the route network, the machines were equipped with compressed air or vacuum brake systems, and the length of the four- or six-axle tenders was also adapted to the different turntable lengths depending on the railway company. Due to the different brake systems, the adjustment of the controls for both types of locomotives was carried out using a Franklin servo cylinder powered by steam instead of compressed air. The engines were based on the model of the SNCF twin locomotive 141 E 113 successfully converted by Chapelon in 1945 and equipped with large-lap valves, trapezoidal ports, reduced clearance volume and large steamchest - prerequisites for low [steam] consumption and high performance. In South Africa, three decades later, David Wardale again used these design features to successfully convert the SAR locomotive No. 3450 into the famous "*Red Devil*".

With its servo devices, multiple valve controls, comfortable seats with backrests and armrests as well as large sliding windows, the driver's cabs of the GELSA locomotives corresponded almost to US steam loco standards. Ultimately, the aim was to compete with the user-friendly diesel competition. At first the machines seemed strange to the Brazilian railway workers, especially the smoke deflectors which quickly earned the GELSA locomotives the nickname "bats".

In 1951, Andre Chapelon travelled to Brazil with representatives of the four manufacturing plants to witness the initial operation of the GELSA locomotives. The highlight of his stay was a 500 km round trip on the Porto Alegre - Santa Maria route with a GELSA type 2-8-4, both in the train and in the driver's cab, where he was impressed by the locomotive performance as well as by that of the crew. Representatives of the various railway companies as well as those of the Union of Brazilian Engineers also witnessed the trip. Overall, the GELSA locomotives were able to convince their customers in terms of performance and reliability. Chapelon also took the opportunity to give a series of lectures in Rio, Sao Paulo and Porto Alegre on how to improve older steam locomotives, many of which were still in existence from English and US suppliers.

Although Chapelon's stay in South America and the trial runs of the GELSA locomotives were extensively reported in the trade press, little information is available about their operation. Only a few operational networks are known here, including the "Leopoldina", "Noroeste" and "Dona Teresa-Cristina" railway networks.



Chapelon locomotive on the meter-gauge coal railway in the south of the country, the Estrada de Ferro Dona Teresa Cristina; here in the Tubarao depot (picture around 1960).

However, despite the initial promise and early successes, the GELSA locomotives were taken out of service early, contrary to all expectations.

There was a lot of speculation about the reasons, and above all a lot of falsehood and nonsense was said and written. The critics were, of course, the first to arrive. Some accused Chapelon of making mistakes, ignorance of Brazilian conditions, and even down to failure. Others felt that he had incorporated too many novelties, wanting to add as much refinement into the machines because he thought it his last chance to demonstrate his technology.

All nonsense. Anyone who knew him knows that he was indeed a very creative steam locomotive engineer, but above all a thorough pragmatist, and that, like all GELSA engineers, he strictly adhered to the specifications of the Brazilian DNEF. In principle, the locomotives were designed to be as robust and low-maintenance as possible using proven US construction principles (think of the successful SNCF series 141 R, for example). With regard to the workshop standard, expensive technology such as roller bearings in axles and rods were deliberately avoided, with the smaller 2-8-4 instead of feed water heaters and piston feed pumps, they were simply given two injectors. However, there is no information as to whether the TIA feedwater treatment, so successful in France, was practiced in Brazil.

In reality, however, there were three main reasons for the failure of the GELSA locomotives:

the dieselization, which was promoted early and massively for US interests;

the condition of the operational routes and the financial situation of the railway companies

the equipment and level of training in loco depots and of loco crews.

The wheel arrangement 2-8-4 and 4-8-4 characterized both types as powerful and useful locomotives, however their 10t or 13t starting tractive effort was limited by their low permitted axle loads, being criticized in operation as too low. Here, however, the DNEF, as the client, had to ask itself why the specifications did not require more traction and alternative axle configurations. There is no doubt that the poor condition of the routes used, with rails often weighing only 22 kg/m, generally did not allow the performance potential of the GELSA locomotives to be fully exploited, particularly as far as the 2'D'2s was concerned. Due to the poor track condition, they were unable to reach the prescribed maximum speed. Instead of 80 km/h, they could be safely operated at only half this speed, though the good springing, smooth running and high performance of the machines may have tempted some drivers to open the regulator a little too far.

In order to reduce tyre wear on bends, the leading coupled wheel were provided with side play. The leading axles and delta trailing trucks were also designed to be safe from derailment. Thus, the prescribed minimum radius of 80 m, at least for the 2-8-4 locomotives, was clearly undercut with 65 m. However, as was also reported about meter gauge locomotives (4-8-4) delivered to Brazil from the USA, derailments occurred again and again due to illegal use on routes with track radii of only 50 m (!), poor ballast and defective switches.

The country's precarious financial situation, like that of the railway companies, has repeatedly led to cuts. The cancellation of funds for the procurement of spare parts had a particularly fatal effect, so that the first decommissioning became unavoidable after only a few years of use. The cost-cutting measures imposed nationwide also had a negative impact on staff training and equipment in the locomotive workshops, which until then had only dealt with simple, well-known steam locomotives on a daily basis.

US industry wooed financially weak railways with cheap diesel

The maintenance of the new GELSA locomotives quickly developed into a nightmare with their "on-board equipment" and unfamiliar working methods. In addition, due to insufficient training, the locomotive crews were not all capable of handling the new machines properly. Derailments have already been described as a result of incompetent service and inappropriate driving style, as well as from the other causes. In addition, there weren't even enough powerful cranes to rerail the locomotives, so that derailed machines were often left at the scene of an accident, blocking the track for days.

Now the question seems justified at this point: "Did the GELSA locomotives come at the wrong time because they were too modern for Brazil’s steam operations but already outdated compared to the growing diesel competition?", or to put it another way: " Were they just late?"

In 1953 a US-Brazilian commission presented a dieselization plan (of course in US interest) with the gradual replacement of steam locomotives. It was now possible to offer diesel locomotives that were more economical with the same performance. The first B12 diesel locomotives appeared a year later, and from 1957 the G8 and G12 from General Motors. This heralded the end of steam traction, as it did the "Bats".

From then on, the still young GELSA steam locomotives, generally referred to as the 450 (2-8-4) and 630 (4-8-4) series, migrated to colliery railways and branch lines as early as 1955, where lighter 1' D locomotives or Mikados of older design were sufficient, the use of which was inevitably more economical. Inadequate supply of spare parts did the rest, so that locomotives that were still operational, some after less than a year's service, had to be taken out of service and stored as spare parts donors. The remaining locomotives, which in the meantime had become unwelcome in some places, were just pushed aside. So, many of them ended up with small, insignificant railway companies, e.g. the "Goias" south-west of today's capital Brasilia or "Compania Mogiana" north of Sao Paulo, which insisted on first carrying out test runs either out of an excess of caution or more likely out of distrust. And not infrequently they left it at that.

Passed on like Hot Potatoes

Around 1960, three 2-8-4 (nos. 452, 454, 457) and seven 4-8-4 "bats" (nos. 631 to 637) arrived at the "Estrada de Ferro Noroeste", an early railway company founded 20th century with a more than 1600 km of route network, which connected Sao Paulo with the Bolivian border and where they could be used on a simple route profile, relatively flat and with few curves. They were also sent to the iron ore mines of Urucum in Mato Grosso, where they remained in service until 1962, when the "Noroeste" received delivery of 32 U5B diesel locomotives from the USA. These were not as powerful, but more economical. The GELSA locomotives were decommissioned, some being scrapped immediately.

So it came about that in the mid-1960s there were hardly any "bats" left in operation. At the end of the same decade, five "Leopoldina" machines were seen parked cold on a siding in Campos. In 1970 there were also a few 2-8-4s in the pilgrimage site of Senhor do Bonfim ("Lord of the Good End"!) in the state of Bahia.

The three small GELSA of the "Noroeste" fared differently: They and some discarded train sets were leased to the Bolivian "Empresa Nacional de Ferrocarril del Este" (ENFE) to build the newly built, 651 km long line from Corumba, a city near the Brazilian-Bolivian border, via Robore to Santa Cruz de la Sierra in the west of the country, which meant nothing more than an extension of the Brazilian "Noroeste" operation in the neighbouring country. An expansion to the Chilean Pazifilddiste was also planned, but the planning has remained the same to this day.

During their final years of service in Bolivia, the three locomotives lost almost all of their original lustre. Without smoke deflectors, with unsightly pipes and containers on the running plates, with a tender that was raised after the conversion to oil firing and apart from a generally unkempt condition, they looked strange, even pitiable.

Surprise in Robore, Bolivia, January 1976: Locomotive 556 has just helped a stranded diesel train with David Wardale on board out of its predicament and is now taking a break. Comparing this sight with photos of the Fives -Lille works reveals major changes to the locomotive: the smoke deflectors have been removed, the raised tender shows that it has been converted to oil firing, and the ugly compressed air tank complete with "cane salad" on the running plate completely disfigure this otherwise elegant machine.

The three locos, Nos. 555, 556, 557, were assigned to secondary services and were the last members of the GELSA family to remain in service even after the railway converted to diesel traction (locomotive no. 557 to 1974, no. 556 to 1976, while no. 555 was used as a source of spare parts). They were welcome when their more modern successors failed, and, as if by coincidence, in January 1976 none other than David Wardale was sitting in one of these broken-down diesel trains, which was rescued by the long-wingless "bat" No. 556. He immortalized it on celluloid immediately after the rescue operation.

Gradually entwined and recycled: In April 2017, what is left of locomotive 556 in Robore. Plunderers have stolen or cut out components, plates and pipes from the locomotive. The machine slowly blends into the environment, and in a few years it will become invisible.

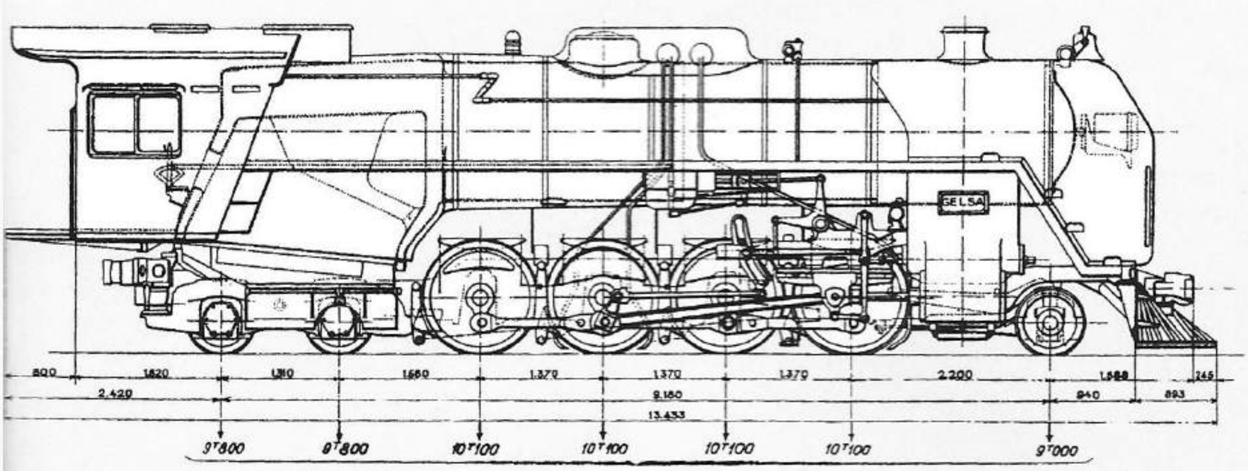
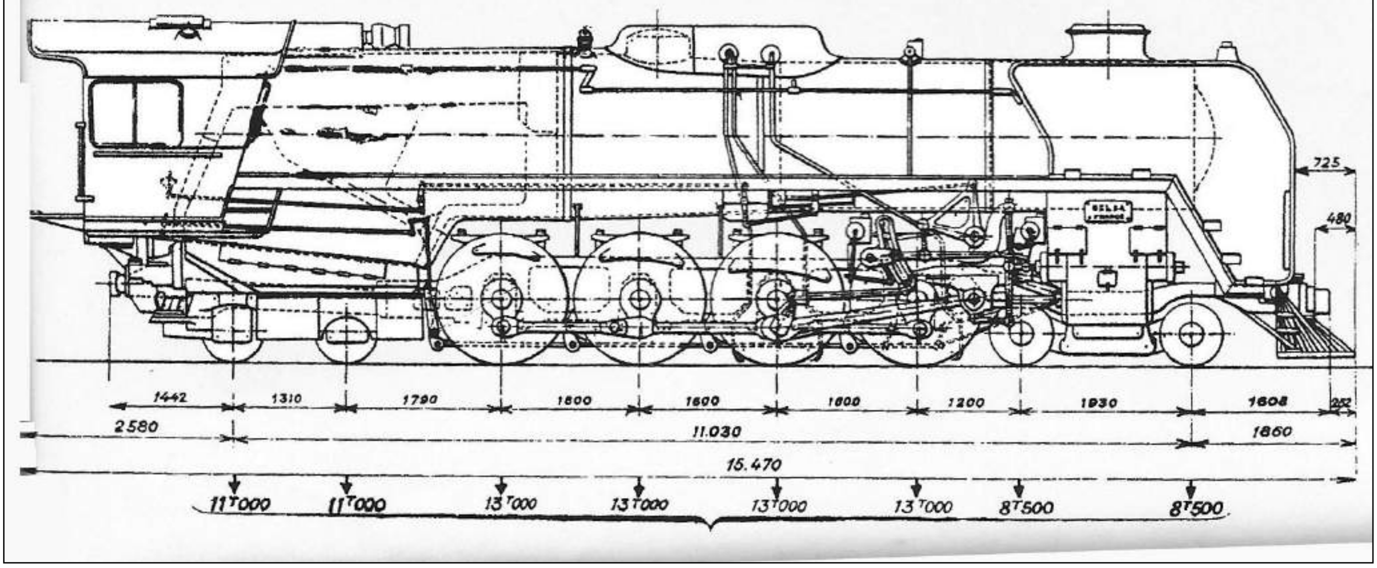


Diagramm der „kleinen“ 1’D2’- und „großen“ 2’D2’-GELSA-Lokomotive



The GELSA Locomotives (constructed 1951 — 1953)	2-8-4	4-8-4
Number built	66	24
Railway companies/deployment (Brazil) 1951-1962	11	4
Railway companies/deployment (Bolivia) 1962-1976	1	0
Length (without tender) (m)	13.453	15.470
Height (m)	3.712	3.920
Width (m)	2.700	2.700
Grate area (m2)	4.00	5.33
Stoker	No	Yes
Heating area, including firebox, combustion chamber and thermic siphons (m2)	19.70	27.60
Tube surface area (m2)	102.54	140.20
Total heating surface area (m2)	122.24	167.80
Superheat surface area (m2)	45.00	68.00
Boiler pressure (atm)	15	20
Cylinder diameter (mm)	434	434
Piston stroke (mm)	560	640
Driving wheel diameter (mm)	1270	1500
Carrying wheel diameter, front & rear (mm)	736	736
Adhesive weight (operating condition) (t)	40.40	52.00
Total weight (operating condition) (t)	69.00	91.00
Tractive effort at 85% cut-off (t)	10.58	13.65
Maximum speed (km/h)	60	80

REIDINGER ROTARY VALVE GEAR

G Shirley CEng,
Albert Reidinger CEng, Hugh Philips

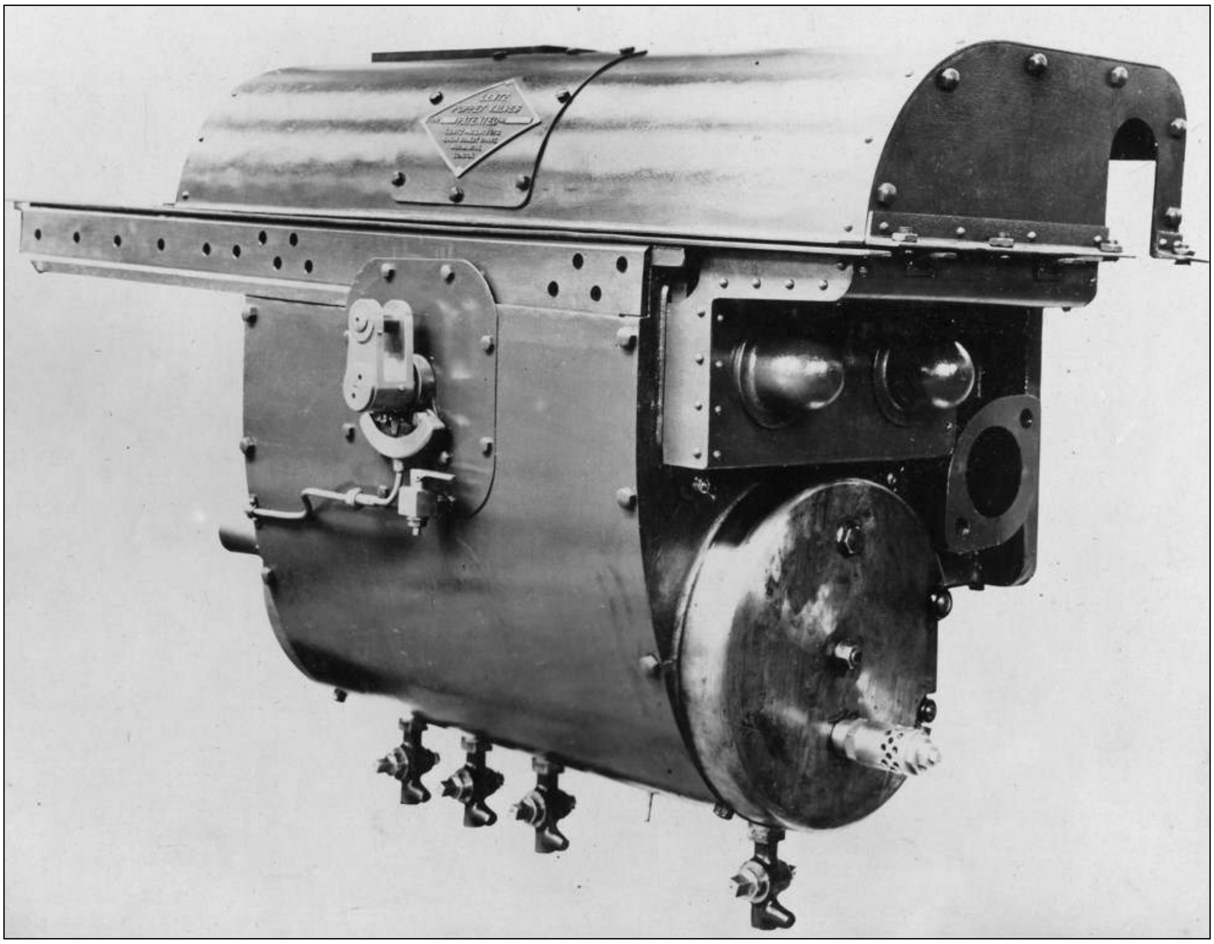


Figure 1 Oscillatory Cam Poppet Installation

The death of Albert Reidinger at the age of 90 in 1985 closed a chapter on the poppet valve gear supplier industry which blossomed in the days of steam locomotive construction and development in the twentieth century in Britain. Hugh Philips prepared an Obituary for his friend, but the editor of Steam Railway had too much news and it was never published. A compelling story, it is recreated here from the archive of documents left by Hugh at the Historical Model Railway Society. In the 1970s Albert Reidinger was asked how he felt that poppet gear development has gone over the years in the UK. His answer was "All Bungled".

Albert Reidinger served his apprenticeship with the Great Eastern Railway at Stratford works having been born in London and shortly after the 1st World War moved to Armstrong Whitworths on gun design and testing. Whilst with this company they diversified into locomotive building with the sudden downturn in munitions works following disarmament, Albert Reidinger transferred to London office on steam locomotive design. In 1921 he moved to Associated Equipment Company (AEC) and worked on the design of the 'NS' bus for London Transport (https://www.londonbusmuseum.com/museum-exhibits/double-deck-buses/aec-ns-ns-174/). This lighter engineering experience stood him in good stead later.

Dr. Ing. Hugo Lentz had a long association with poppet valves in Europe on marine, and stationary locomotives based on his own company in Austria but wanted to break into the British Empire trade with a collaboration with Paxmans. Hugo Lentz set up a UK operation but kept a firm hand on Lentz Patents Ltd and discouraged fresh thinking. Mr John Kupka was sent from Berlin, nominated by Lentz to come to the newly opened Lentz Patents office in London where he later specialised in the Dabeg and the USA connections. At the same time Albert Reidinger was handling all the British and Colonial business. Whilst Mr Kupka was involved with the continental business, he dealt with Dabeg and with Chapelon's desire to uprate his Pacifics. It was found that Chapelon wanted to do all his own design work. In practice the Oscillating Cam (OC) design system achieved was very little different to that in the UK. Mr Kupka had taken out one or two patents and had been forced to assign them to Herman Lindars (1899-1981 Composer, Halle Conductor, Industrialist & Inventor, also Director of LPL) and this alienated him so much that in 1934 he left and went to America. He later became involved again in the poppet gear business and worked in association with Dabeg and Franklin on various applications in the USA. This connection went on until about 1937-38 at least.

Originally the company had been set up as a wholly owned subsidiary to take over the licenced design and manufacture works being done by Paxmans of Colchester, UK. Mr Bertie Howe, who worked in the Lentz Patents office on temporary loan from Paxmans in the late 1920s, later became a Director of Paxmans. There was also a Mr Barnes who was the son of the Chief Designer at Paxmans in the 1920s. (https://www.paxmanhistory.org.uk/lentzloco.htm)

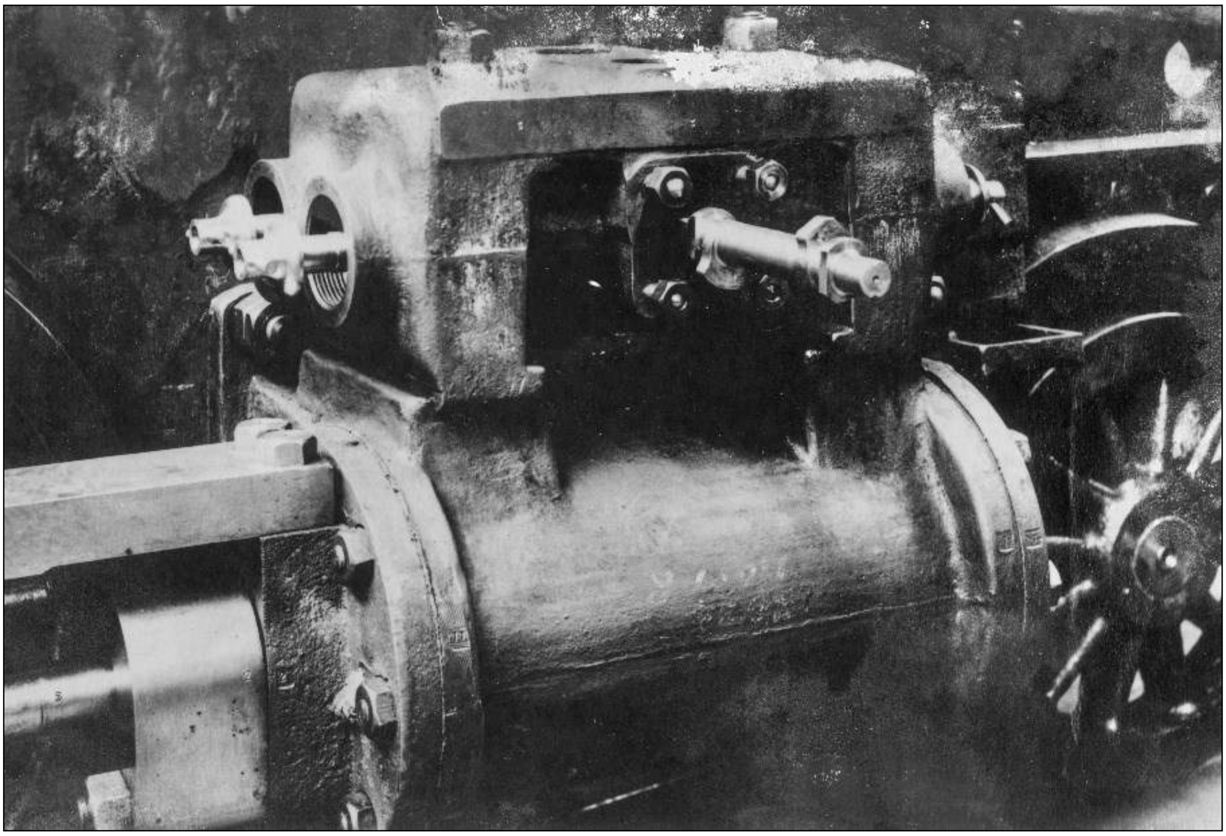


Figure 2 "River Esk" Poppet valve with cam shaft drawn forwards, and poppet valve ports either side on the same plane as the camshaft

The UK prelude to the technology of poppet valve gear was made by Paxman - Lentz with Henry Greenly's 2-8-2 "River Esk" application in 1923 on the Ravenglass & Eskdale Railway. It was a surprise to the LNER team on the J20 No 8280. It was an oscillatory cam system with poppet valves. The first application was not a success and rebuilt in 1928.

In 1922 Albert Reidinger moved to Sentinel at Shrewsbury to work on the design of that company's first railway vehicle under Mr Crombie, Chief of Design for Sentinel, a narrow-gauge tram type locomotive which appeared in 1924. (Patent US1603441A Self-propelled vehicle). The stepped cam system was well known and predated Sentinel, Foden or any other users. (see Wm Fairburn marine engine 1844). During this period Albert Reidinger had been introduced to Mr Poultney who was head of Lentz Patents Ltd (LPL). When they wanted a good technical man, they approached Albert. In March 1927 he joined Lentz Patents Ltd in London as a designer to engineer the application of the valve gear patents of Hugo Lentz of Vienna into the huge British locomotive building industry.

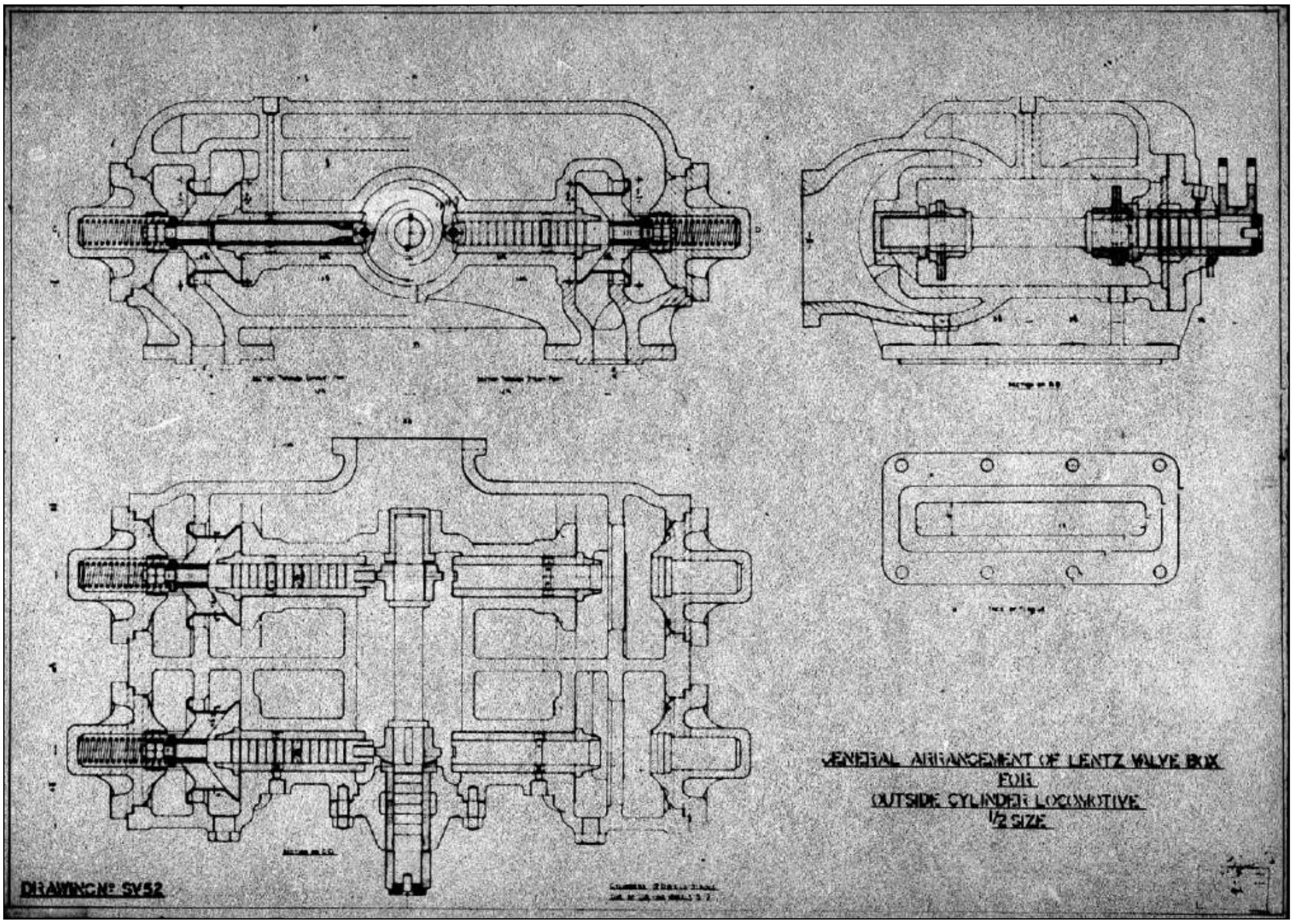


Figure 3 Lentz Valve Gear Layout

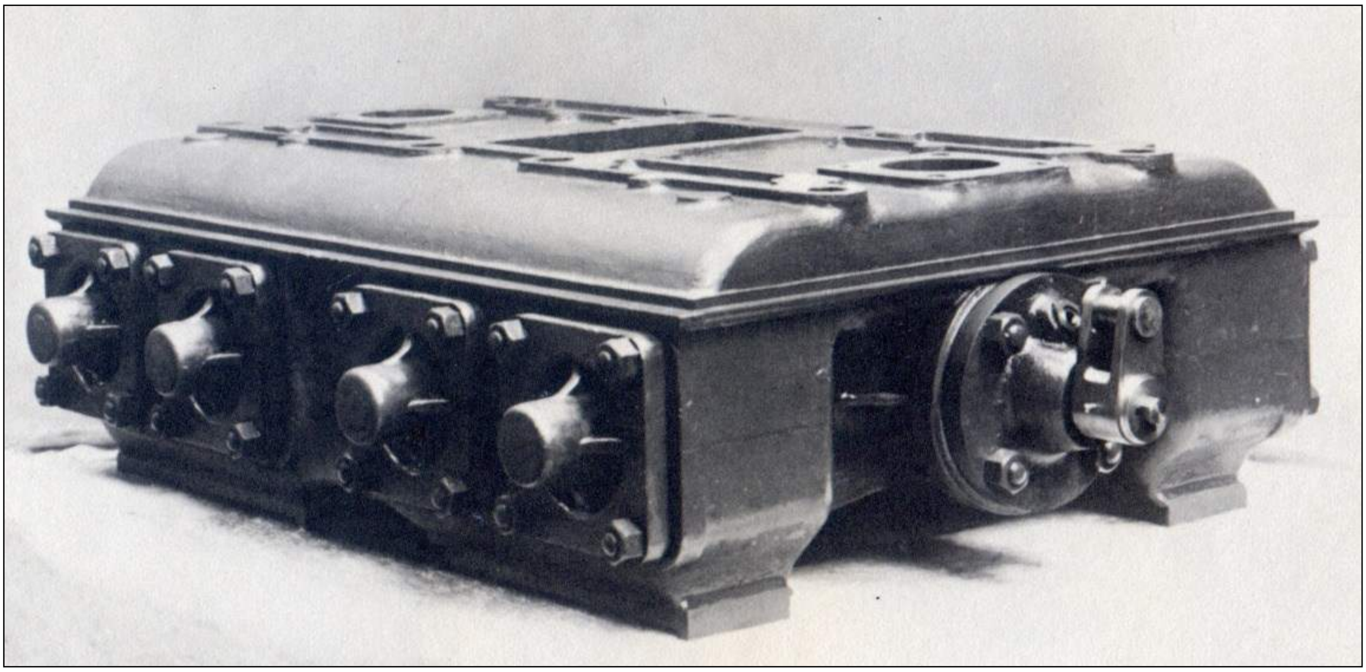


Figure 4 Lentz Valve Monoblock

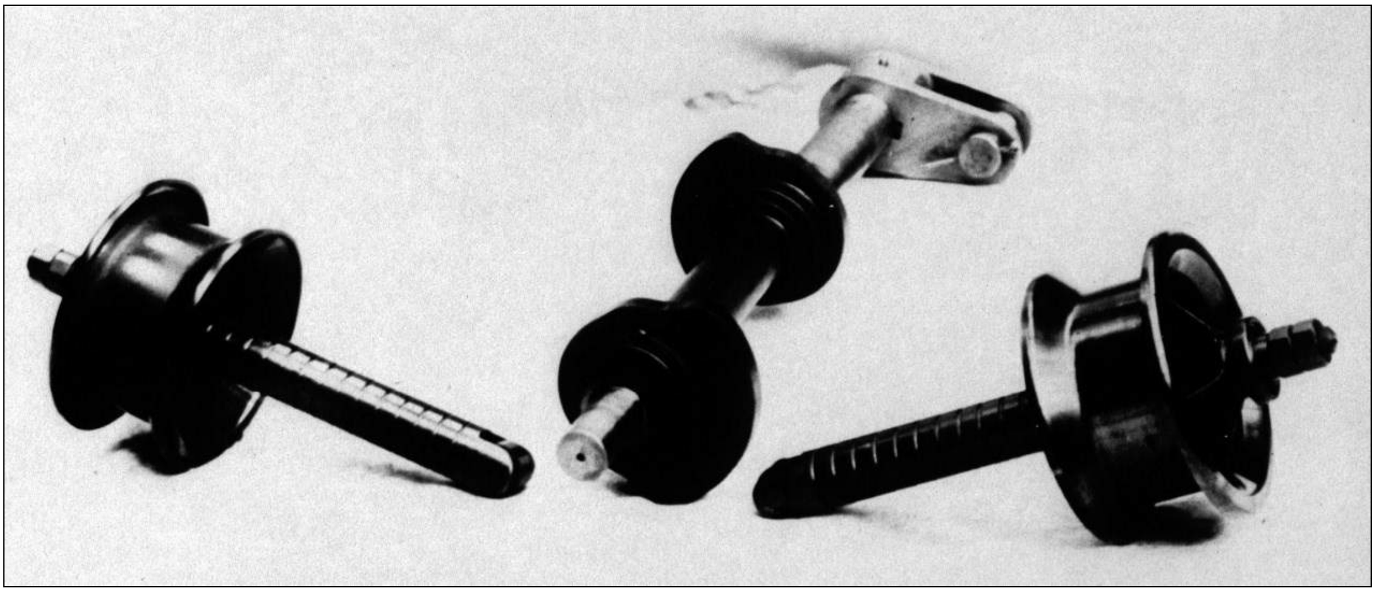


Figure 5 OC Cam shaft and Lentz Valves

Gresley on the Great Eastern Railway fitted tender locomotive oscillating cam (OC) direct gear on No 8280 of the D81 type 0-6-0 with the cambox being supplied by Paxton. This was followed by an order in 1926 from Rhodesian Railways for 10 mountain class loco type 4-8-2. Paxman made the cam boxes and supplied them to North British Locomotive who built the locomotives.

This was followed in 1926 by the LNER with one set of OC direct cam gear for class B12 type 4-6-0 and a further 5 sets in 1928. In 1929 Albert Reidinger supervised the fitting of 10 new LNER B13 type 4-6-0 at Beyer Peacock with OC poppet gear. This was the time manufacture switched from Paxman to North British.

Up to 1928 Paxman had been making many parts. i.e. valve spindles, cams, rollers, etc from Firths SHB steel which was an air hardening material. This was not regarded by Albert Reidinger as a very acceptable material for these applications, he wanted a Nickel Chrome steel specified. Herman Lindar, who had big interests in Dumford & Elliot the steel makers (https://www.gracesguide.co.uk/Dunford_and_Elliott), was quite happy to go along with this as having no technical knowledge of the argument progressing, he backed Albert. This alienated Paxman and their attitude became “If you specify Nickel Chrome, we don’t want any more to do with it”. This suited Lindar and as he had good relationships with Sir Hugh Reid, Chairman of North British Locomotive, NBL were approached and they reacted with enthusiasm as it was the sort of business they were anxious to become involved with, but with one exception they made all OC and rotary cam (RC) gears from then on. The exception was the 16 sets for the Bengal Nagpur Railway FT Class 2-6-4T with oscillating cams in 1928-29. Due to a capacity problem at NBL, AEC of Southall made these gears via Albert’s connections for the business until parts were made at Associated Locomotive Equipment (ALE), a division of Heenan & Froude, Worcester after the Second World War.

At that time the only valve gear sold was the Direct Drive type of oscillating cam where a link valve gear provided the motion to rock a cam shaft which directly opened and closed the horizontal poppet valves. This valve gear was a result of the direct influence of Hugo Lentz. With the demands of higher power and faster running locomotives the Direct Drive type gear had limitations, so a pendulum lever was introduced to reduce the loadings on the cam shaft. This annoyed Hugo Lentz and relationships became strained.

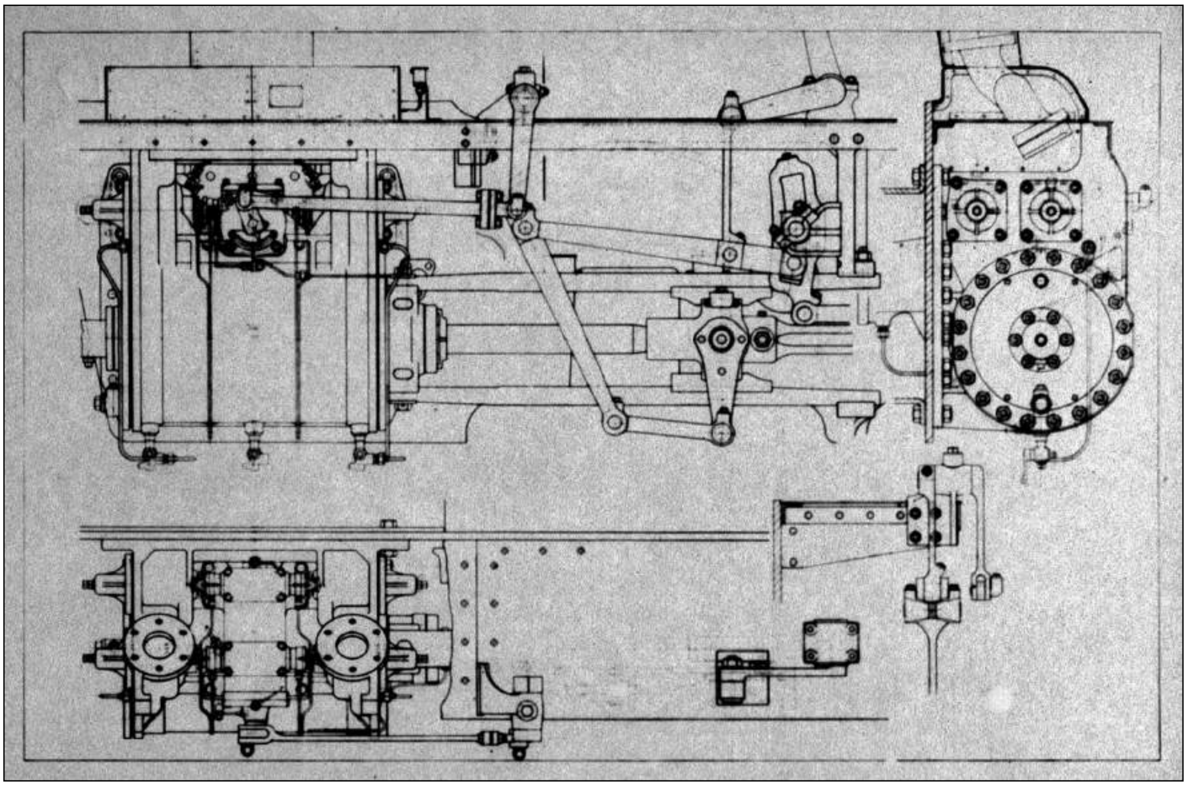


Figure 6 Incorporation of Pendulum link

With Albert Reidinger having experienced at Sentinel the automotive type of enclosed rotating cams operating within a clean lubricated environment he was directed to prepare a design of fully rotary valve gear which could be driven without the need of link valve gear. This resulted in a complete break from Hugo Lentz. This meant the death of Direct Drive cam operated gear and hence forth only the pendulum lever (OC) and the rotating cam (RC) gears were sold. Neither had anything to do with Lentz systems patented in Austria. (Patent GB411536A)

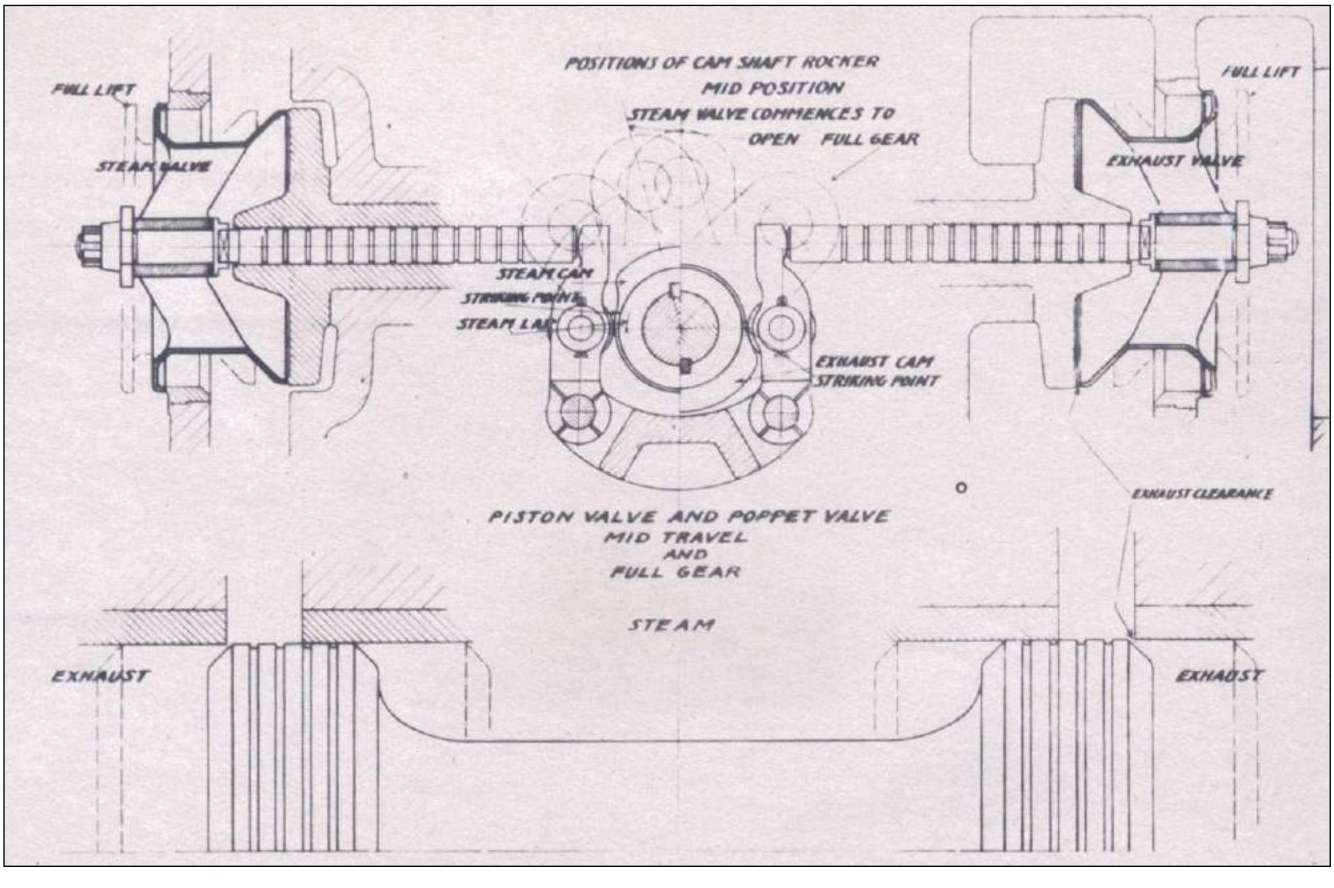


Figure 7 Poppet valve compared to piston valve.

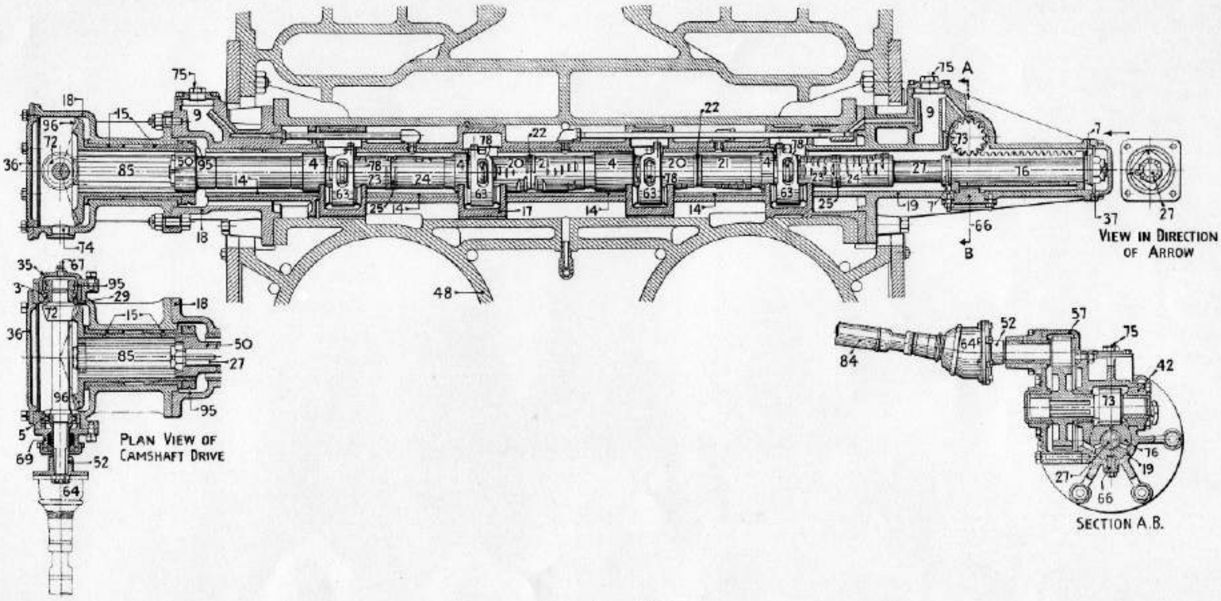


FIG. 19.

3. Bearing—Ball.
4. Bearing—Block.
5. Bearing—Roller.
7. Bearing—Thrust.
9. Boxes—Oil.
14. Bush—Bearing Block.
15. Bush—Driving Shank.
17. Cage.
18. Cage—Driving Section.
19. Cage—Reversing Section.
20. Cams—Exhaust Forward.
21. Cams—Exhaust Backward.
22. Cams—Exhaust Bye-Pass.
23. Cams—Steam Forward.
24. Cams—Steam Backward.
25. Cams—Steam Bye-Pass.
27. Camshaft.
29. Chip Shield.
35. Cover—Bevel Pinion.
36. Cover—Cage Driving Section.
37. Cover—Cage Reversing Section.
42. Cover—Rack Pinion.
48. Cylinder.
50. Driving Dog.
52. Flange—Companion.
57. Gearbox—Reduction Reversing.
63. Intermediate Lever.
64. Joint—Universal.
66. Key—Reversing Rack.
67. Nipple—Grease.
69. Packing.
72. Pinion—Bevel.
73. Pinion—Reversing Rack.
74. Plug—Drain.
75. Plug—Filler.
76. Rack—Reversing.
78. Roller.
84. Shaft—Tubular.
85. Shank—Driving.
95. Wire—Locking.
96. Wheel—Bevel.

Figure 8 RC Gear section through cam shaft for 2 inside cylinder locomotive

The RC gear is shown in the cross section, with parts identified. The cam shaft is shifted from left to right to change the cams in operation enabling change in locomotive direction and steam cut off.

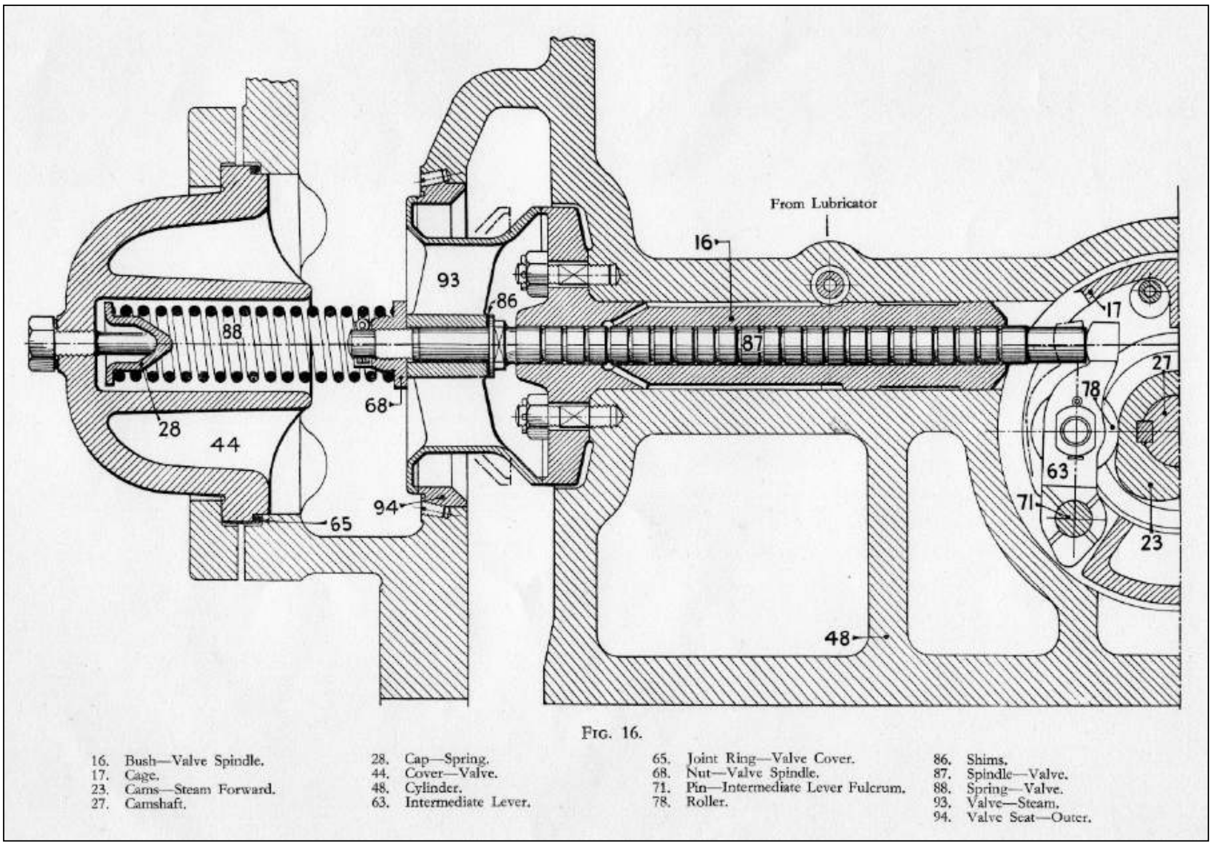


Figure 9 RC Gear Steam valve

The novelty of Kupka's patent GB260332A for Rotary Cam lay in the use of the intermediate lever (63) to multiply the valve lift and in the method of drive using the return crank gearbox and rotating shafts Patent GB294950A.

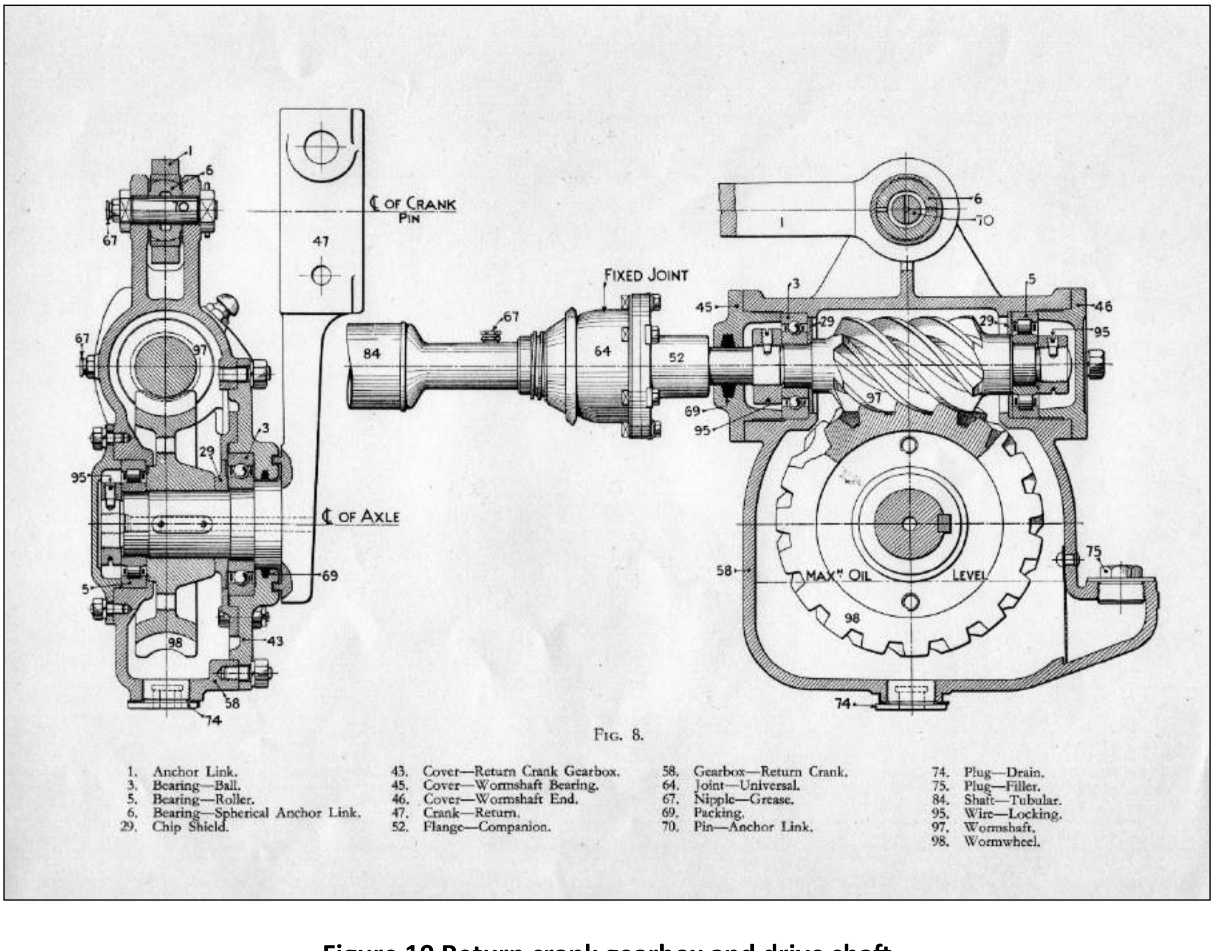


Figure 10 Return crank gearbox and drive shaft

There was no connection between the RC gear and the Sentinel system, it was a desire to get away from the limitations of the OC system deriving its motion from a normal link gear.

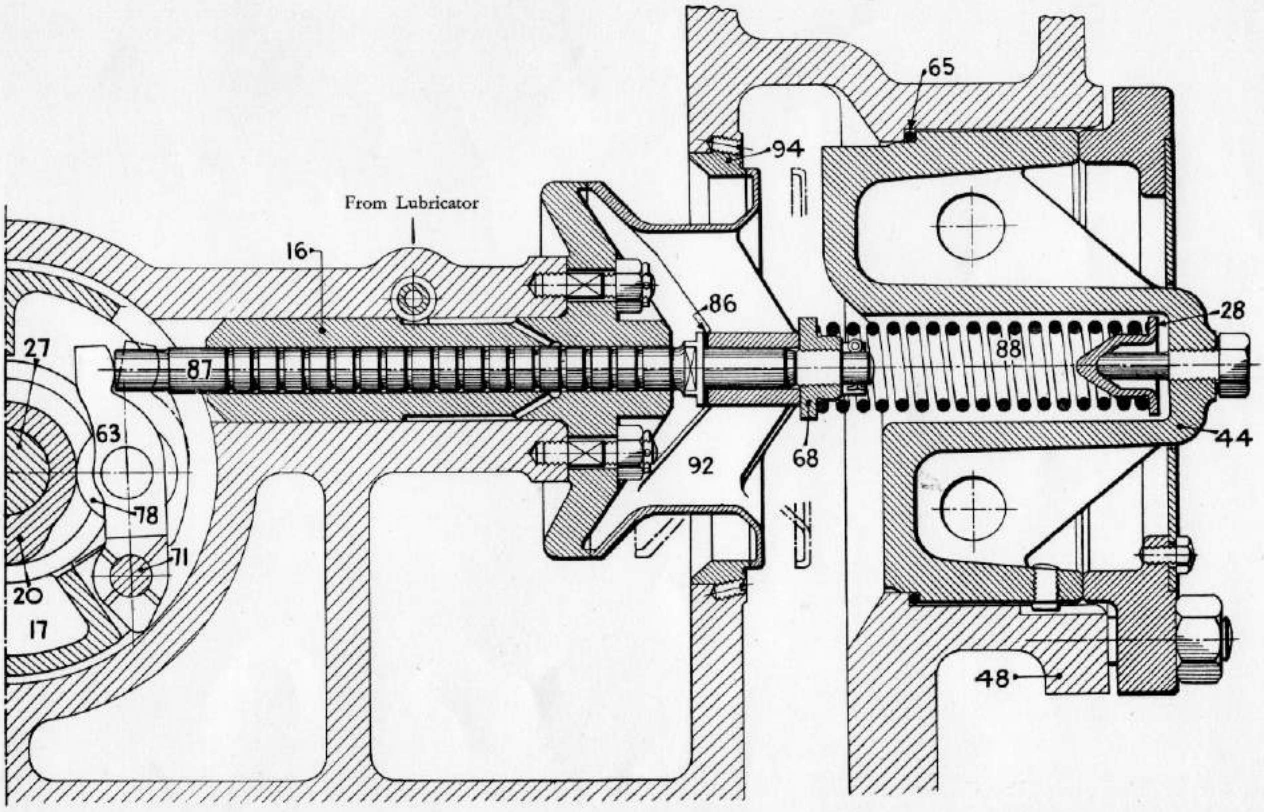


FIG. 17.

16. Bush—Valve Spindle.
17. Cage.
20. Cams—Exhaust Forward.
27. Camshaft.
28. Cap—Spring.
44. Cover—Valve.
48. Cylinder.
63. Intermediate Lever.
65. Joint Ring—Valve Cover.
68. Nut—Valve Spindle.
71. Pin—Intermediate Lever Fulcrum.
78. Roller.
86. Shims.
87. Spindle—Valve.
88. Spring—Valve.
92. Valve—Exhaust.
94. Valve Seat—Outer.

Figure 11 RC Exhaust Valve

Flat seated valves of Patent GB411536A certainly were imported from Lentz and the problems of valve leakage caused were legion. Albert Reidinger set about solving this problem, hence the analysis based on the Theory of the Resilient Valve in “The Una-flow Steam-engine” - Johannes Stumpf 1922 and the angled valve seat where thermal expansion originated from a single point coincident with both valve seats, like a point of distant infinity in a drawing. Lentz valves were also badly pressure balanced which caused fatigue breakages when boiler pressures increased in the 1930s. Valve technology of the 1930s is covered in the German book “Die Steurungen der Dampfmaschinen” H Dubbel 1923. Upon their introduction differences began to arise between Lentz Patents and Hugo Lentz. This was further intensified by Kupka’s introduction of the intermediate lever for which a patent was granted, and the difficulties became of such magnitude that Lentz broke off his association with Lentz patents. They in turn insisted that the gear was henceforth the “OC” gear, and the “RC” gear and that the company name be changed to Associated Locomotive Equipment Ltd (ALE) to purge away all apparent connections with Lentz. From this date all Lentz valves made by ALE had angled seats.

The 1930s saw a period of rapid acceptance of poppet valve technology on British railways.

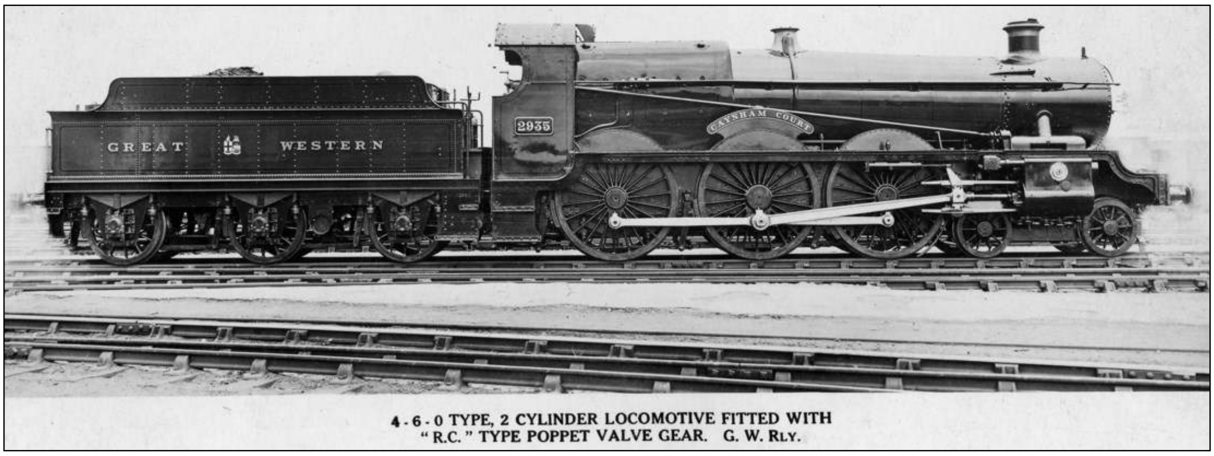


Figure 12 GWR RC Poppet valve gear

The GWR had a jaundiced view of poppet valves due to their unfortunate experiences with 2935 Caynham Court. It was acknowledged that there were deficiencies in the application due to the design of the Lentz Patents cylinder casting (Patent GB422297A) and 19 square inch poppet valves flow passages, most inadequate for the cylinders. This has resulted from the GWR directive to match piston valve clearance volume. This alienated Stanier before he went to the LMS. Fowler and Beames behind the scenes were reasonably well disposed to make a trial with poppet valves.

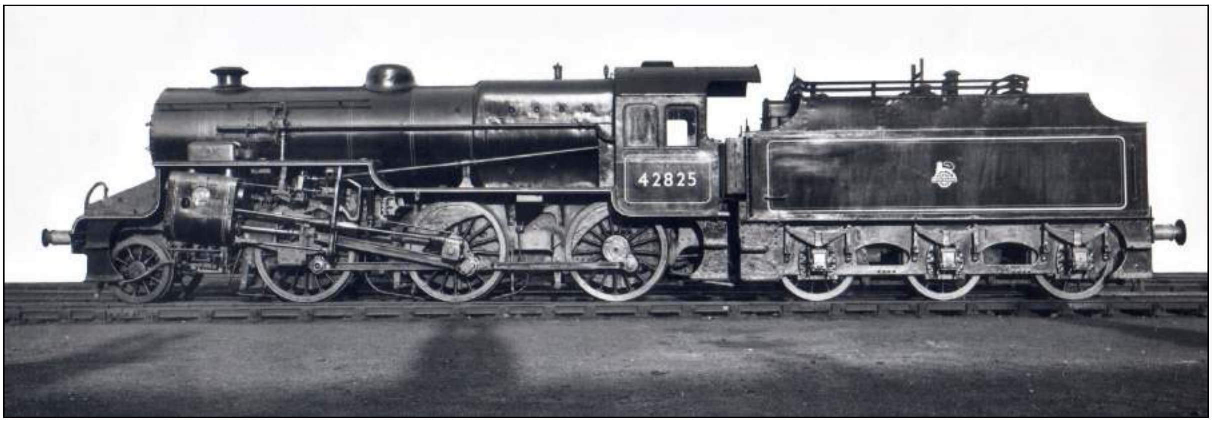


Figure 13 LMS 2-6-0 Crab 42825 one of 5 fitted with RC Gear in 1931.

Hence the Crabs and the Caprotti Claughtons but development stopped here because of the Lemon-Stanier regime having other priorities and caustic viewpoints. Gresley with Bulleid behind him was enthusiastic and felt there was a big future and instilled this in his staff. Spencer was reasonably well disposed, and Harrison later turned the tables and had 71000 and 73125-54 fitted up with poppet gear.

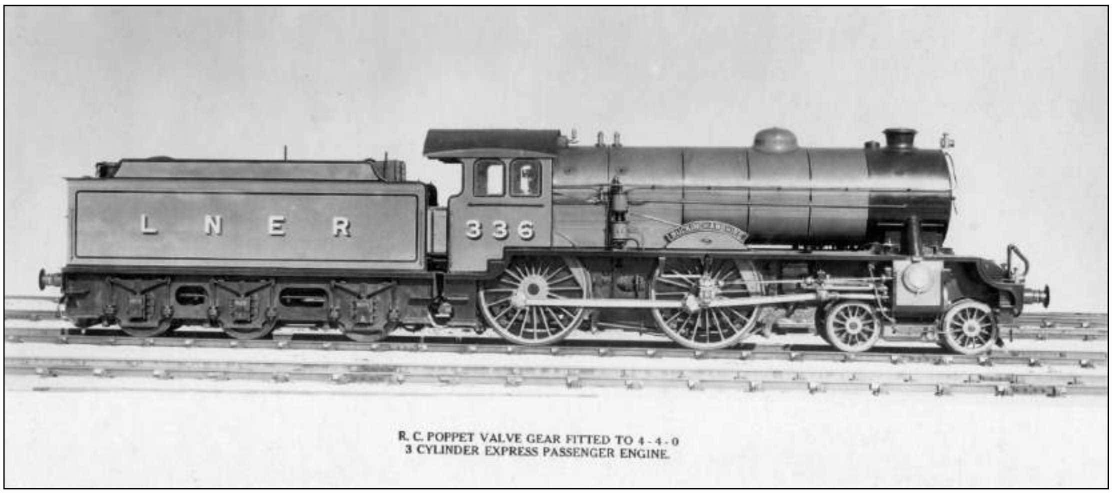


Figure 14 LNER Shire RC Poppet valve gear

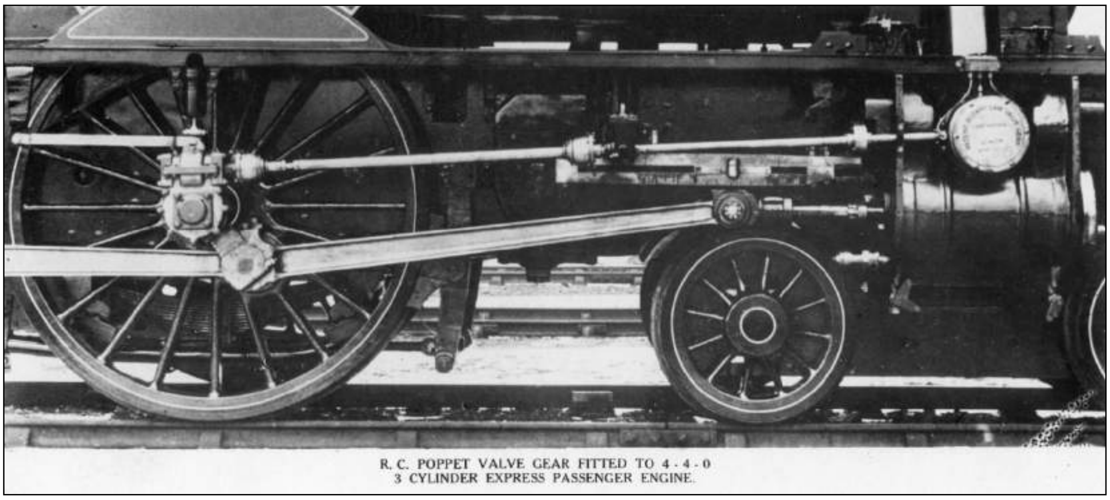


Figure 15 LNER Shire RC Poppet valve gear

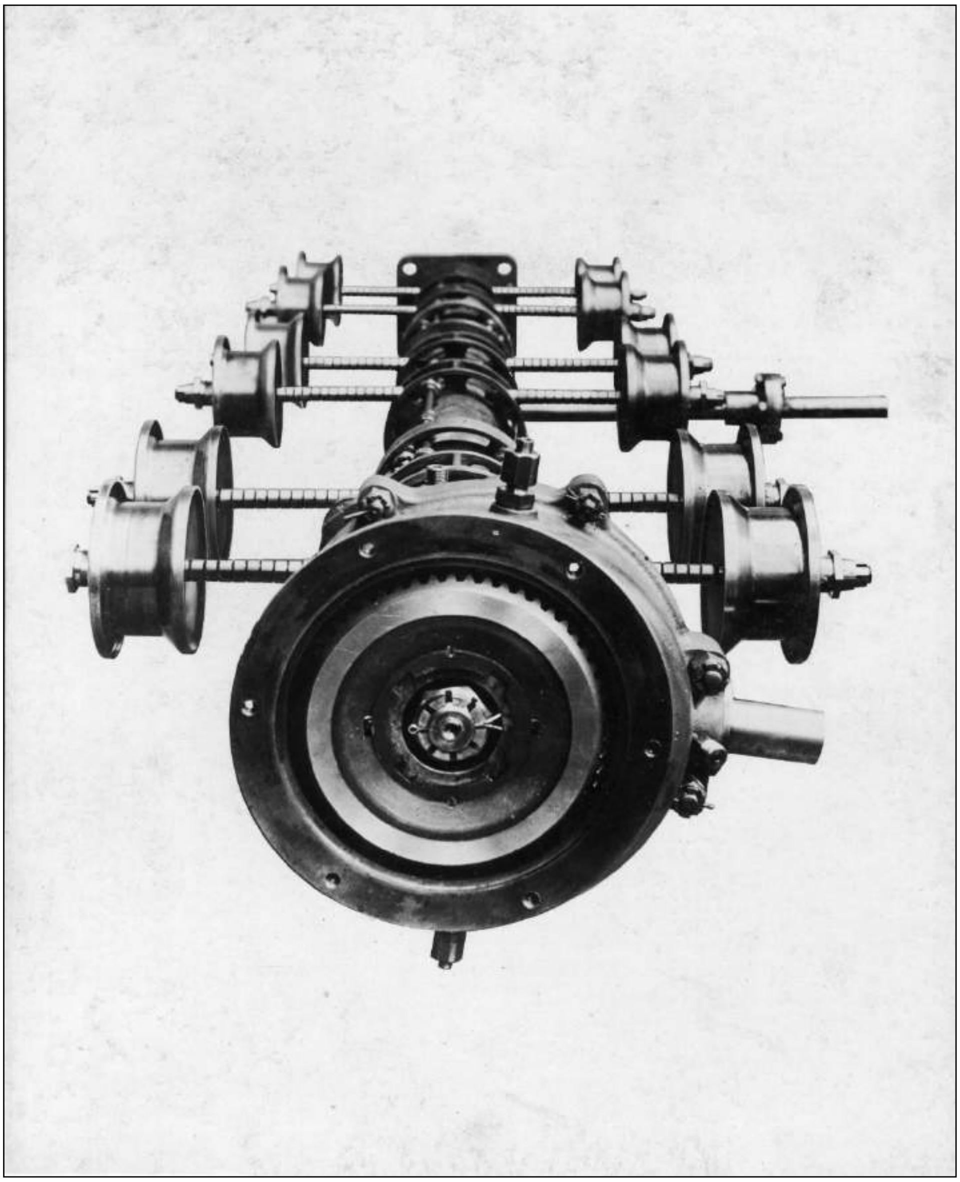
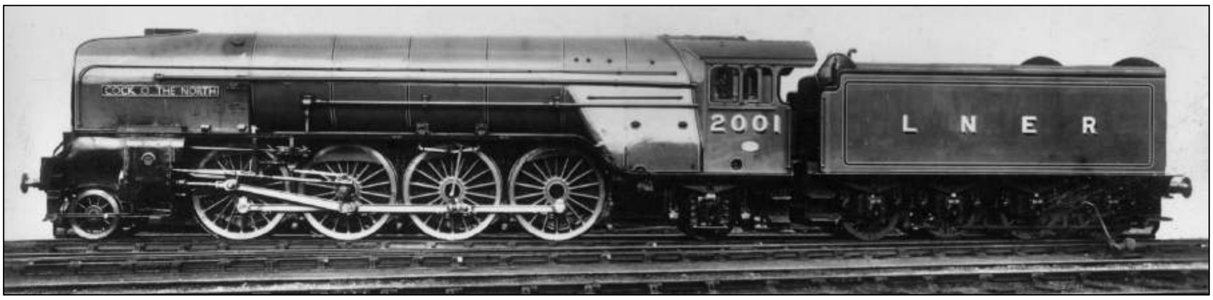


Figure 16 LNER D49 Shire RC Poppet valve gear

Gresley applications of the RC gears fell foul somewhat of the original 5 step cam arrangement, later altered to 7 cams on some, if not all the D49s, these improved matters but even then, drivers were known to run between the cams to get a few extra positions. This caused high loadings as the ramps and chamfers on the rollers were never man enough for this practice.

The earliest applications of the RC gear had a tangent form cam but the desire for greater valve accelerations to increase the dwell - open period saw a considerable amount of work done on experimental cam forms at the firm of C J Fitzpatricks & Co of Acton, West London and with the moderate weight valves in existence at that time a concave cam form became possible to increase the accelerations. These forms gave reasonably acceptable life of both cam and roller, but the Hertz contact stress loadings were on the high side with a single point of contact loading. i.e there was not much in hand should the use of bigger valves be specified. In terms of loading, after the experience with LNER 2001 "Cock o' the North" a set of stepped cams were fitted but these eventually failed. When working out the original schemes Albert Reidinger and Gordon Walker proposed 6-inch inlets and 7 inch exhaust valves but Mr Gresley insisted on the maintenance of his very big cross sectional area steam and exhaust passageways and much against the grain ALE accepted 8 inch inlets and 9 inch exhausts. Initially the continuous profile cam was specified by Gresley as he wanted fine graduation of the big tractive effort of this very powerful engine. The continuous cam profile was made from an accurate master and then the blanks were produced by a single point tool arranged to follow the master. Fitzpatrick of Acton solved the manufacturing problem, they were later taken over by David Browns.

To this end D49 Number 282 had been fitted with a continuous profile cam in 1932 but this had not been too successful due to excessive wear on the smaller cut off portions after only 9 months running where the roller had cut a vee groove in the surface. However, Gresley persisted, and the continuous profile cams were specified for number 2001 but were removed in under 10,000 miles due to wear. The replacement stepped cams were also badly damaged but the milage is not known. This was attributed to the extra mass of the valves and the stronger springs needed to keep the valves in control on the cams, without roller bounce. The optimum opening distance for a poppet valve is a function of the valve diameter, and this has a direct mapping to the acceleration of the opening cam profile and hence drive force. The valve mass increases with the square of the valve diameter, so cam inertia forces increase with the third power on the valve diameter. On other lesser duties however the concave flank cam was commonly used where the valve timing requirements of the railway could be met. The effects of thermal distortion are also more significant with increasing diameter.



L. N. E. R.

2–8–2 THREE CYLINDER ENGINE. TYPE P.2.

GAUGE OF TRACK	CYLINDERS		DRIVING WHEEL DIAMETER	BOILER		FIREBOX		TUBES		
	Diam.	Stroke		Inside Diam.	Pressure	Length Outside	Width Outside	Number	Diameter	Length Between Tube Plates
4ft. 8½ins.	21ins.	26ins.	6ft. 2ins.	6ft 3 7/16ins.	220 lbs.	10ft. 8⅜ins.	7ft. 9ins.	121 43	2¼ins. 5¼ins.	18ft. 11¾ins

WHEEL BASE			WEIGHT IN WORKING ORDER				
Driving	Engine	Engine & Tender	Pony Truck	Coupled	Trailing	Engine	Tender
19ft. 6ins.	37ft. 11ins.	64ft. 0⅞ins.	T 11 C 10	T 80 C 12	T 18 C 3	T 110 C 5	T 55 C 6

FUEL	EVAPORATING SURFACES—SQUARE FT.				SUPER-HEATING SURFACE Sq Ft.	GRATE	TRACTIVE POWER AT 85% Boiler Pressure	FACTOR OF ADHESION
Kind	Tubes	Flues	Firebox	Total		Length 86ins. Width 83¾ins.		
Coal	1354	1123	237	2714	776	Area 50 sq. ft.	43462 lbs.	4·15

EIGHT WHEELED TENDER CAPACITY: WATER—5000 GALLONS COAL—8 TONS

Figure 17 LNER 2001 RC Poppet Valve gear post card

Lentz Patents man Mr Phillips was seconded to Paris and went armed with a bundle of drawings and with this knowledge Dabeg were able to prepare their own designs for a particular application. They certainly followed the ALE principles and were not restricted in following the layout in the way that Hugo Lentz had stipulated to Lentz Patents. The various areas of the world in which the three companies could operate saw that they did not tread on each other's toes, so design communisation was pointless. There was very good cooperation, as Mr Phillips was loaned to Dabeg and was involved in the Kylchap bypass fitted to LNER 2004 Mons Meg whose development was terminated by the war and never restarted, Patent FR864741A. In 1929 Mr G W Alcock and Mr Roberts came over from Franklin USA for familiarisation with design detail.

1936 Saw consolidation in the British poppet valve suppliers, Caprotti Valve Gears Ltd were never felt to be a serious competitor. ALE had all the work that they could handle.

Poppet valve gear orders 1927 to 1937			
	ALE	CVG (UK supply)	CVG (Italy supply)
Original equipment orders	84	32	11
Sets of equipment supply	531	263	44

Perhaps the biggest difference was that every ALE set was profitable. It seems that much of the bitterness in the competition emanated from Caprotti Valve Gear, as at one stage it was rumoured that ALE would take over Caprotti Valve Gear as the latter was financially living on borrowed time for most of its life. In the end ALE staff were astounded when Caprotti Valve Gear took them over and were most interested to know where the money had come from to buy them in a stealth deal funded via Heenan and Froude and A P Good of the Brush group. The resentment smouldered after the take over as one by one the ALE people left. Mr Poultney was scapegoated over the loss of a South African Railway order and left and was soon followed by Albert Reidinger who could see no future as Caprotti Valve Gear were anxious to supress the RC and OC gears. From this point forwards Caprotti Valve gear was promoted and developed but the company retained the ALE name.

Albert Reidinger left to work with Rendel Palmer and Tritton, Engineers of Westminster. Albert Reidinger and Poultney developed their own ideas outside which would develop into Reidinger Rotary Valve gear and his own company.

In 1940 Albert published “Valves & Valve gears for Steam Locomotives” with co-author Chas S Lake. It is still in print today, and the contents encompass the breadth of valve gear options theory and practice in the 1930s. It includes the operation of Cossart Valve gear covered in Patent GB392794A with a photo of the Beyer built Algerian Cossart Garratt shown below but did not include the photographs of the components.

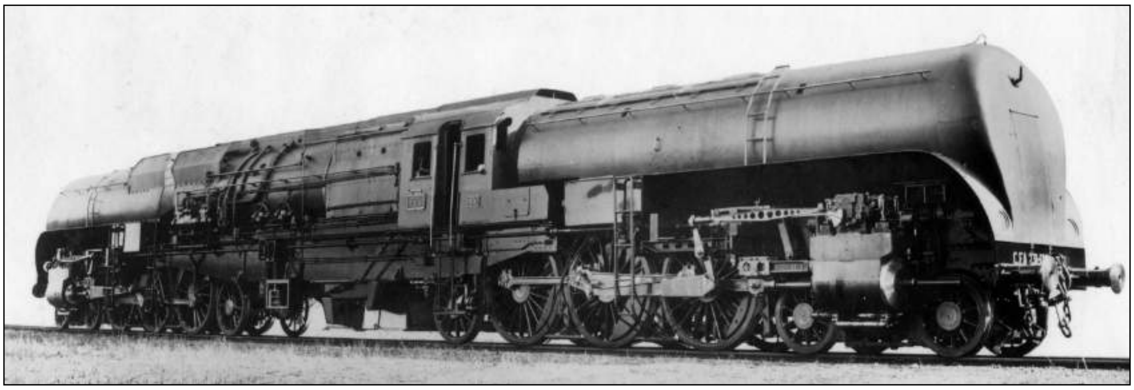


Figure 18 Beyer Cossart VG Algerian Railways 4.6.2+2.6.4

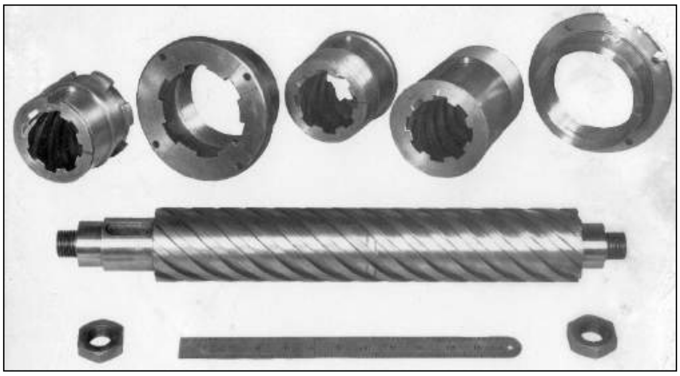


Figure 19 Cossart Cam shaft and nuts components

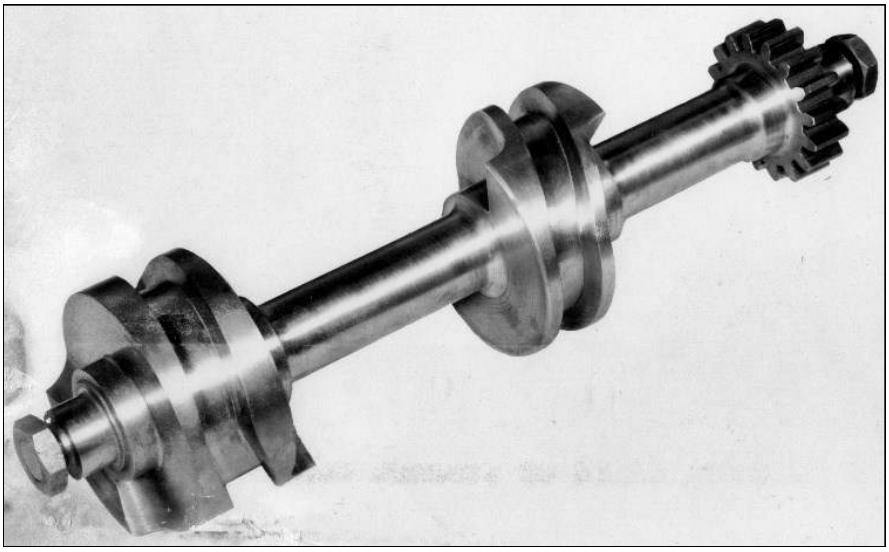


Figure 20 Cossart Control shaft Barrel cam for movement of nuts along the thread to adjust the cam cut off.

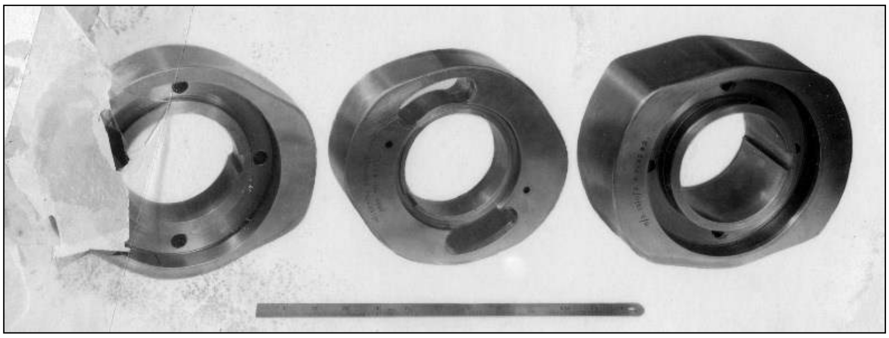


Figure 21 Cossart Cams Exhaust in the middle

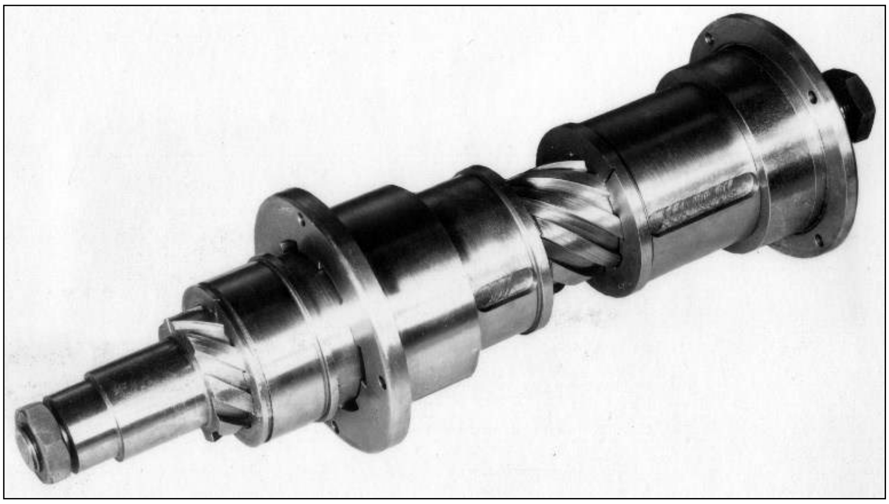


Figure 22 Beyer Garratt Cossart camshaft without cams

Cossart is a very clever copy of the functionality of Caprotti implemented by an alternative mechanical method to avoid patent infringement. The Cossart valves are unique to this valve system having piston rings like a piston valve but being short stroke and in the style of a poppet valve. This may have sparked a dream in Albert's mind.

The book's closing pages present the idea of an Infinitely variable valve gear with individual adjustment of valve events. The Reidinger Rotary gear would overcome many of the snags of the RC stepped cam gear, and cunningly was designed to be a direct replacement for ALE RC gear. The gear adopted the same functionality as Caprotti; the differential action of two mirrored cams is added together to generate an infinitely variable action. Described in Patent GB413708A and with more detail in refined patent GB491729A. Two cams with a line contact footprint share the force to drive the poppet valve, as with Caprotti valve gear. On both Caprotti and Reidinger the two cams share the same camshaft axis. The Reidinger cam shafts are shown in the figure below, showing two variants.

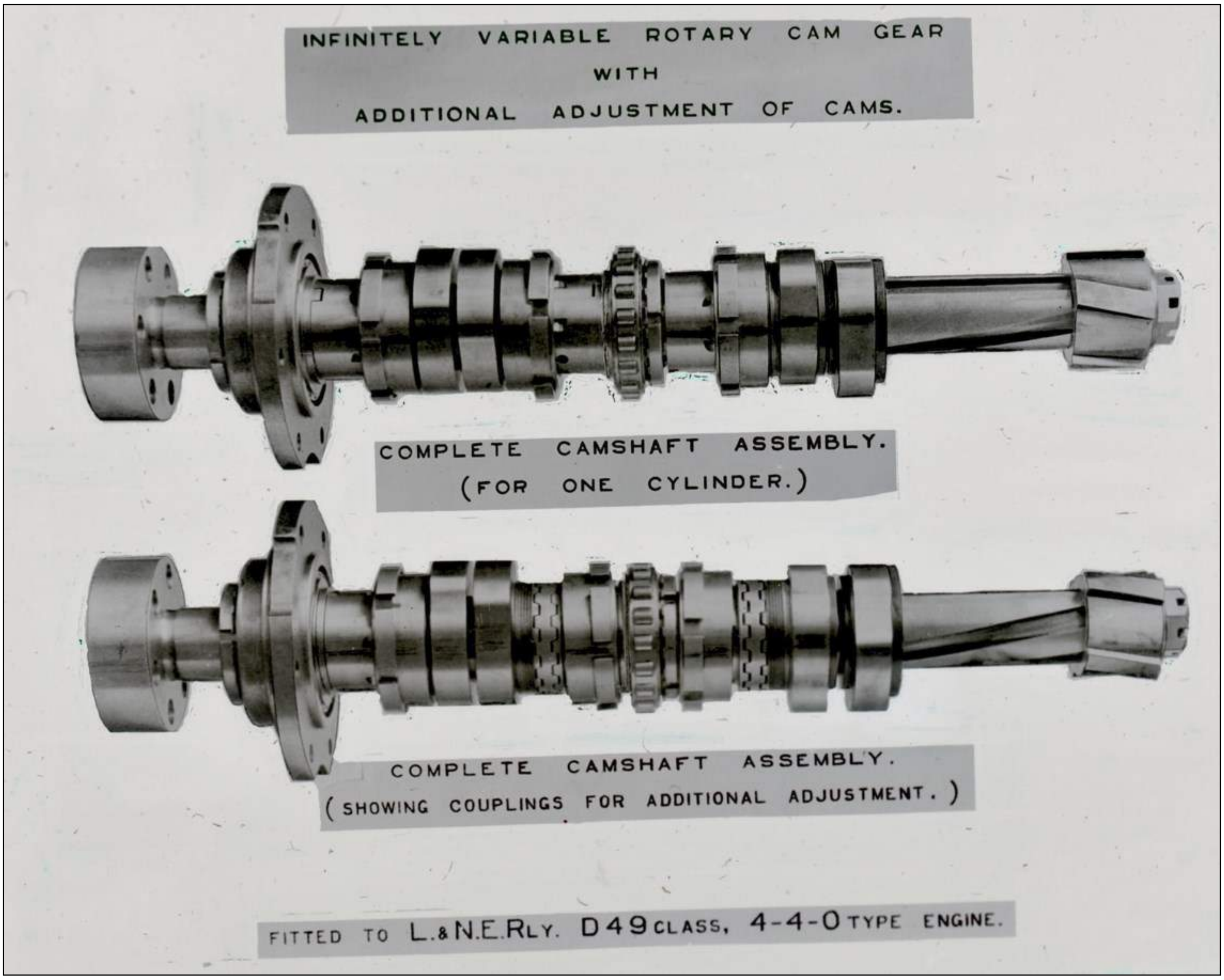


Figure 23 D49 Reidinger gear cam shafts

The camshaft has two slots machined in the surface, one for each cam. The cams have dogs in the bore which engage with the slot in the shaft. As the shaft is moved left and right the cams are spun rotationally adjusting the valve opening and closing points to the required cut off. The lower shaft shows castellated spacers in another version. These are unique to Reidinger gear and allow the fine adjustment of the cam's angular position. On Caprotti the same adjustment requires a new cam to be machined.

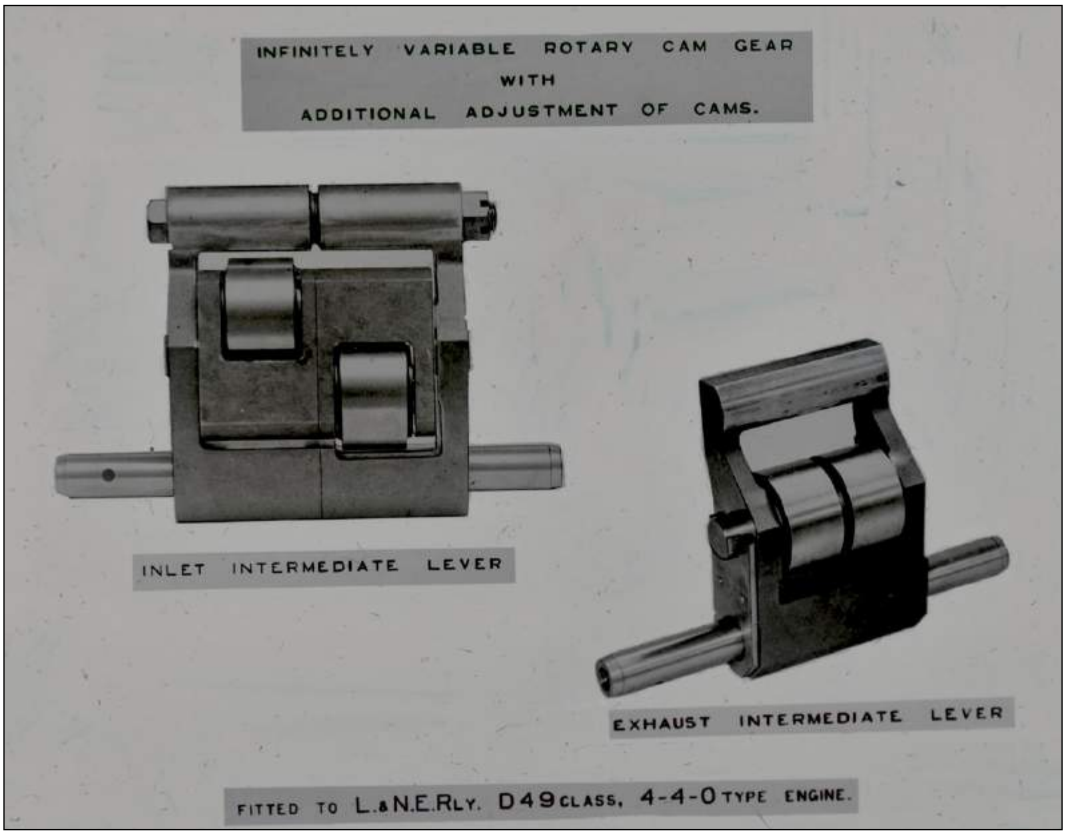


Figure 24 D49 Intermediate lever

The steam valve intermediate lever incorporates a swinging arm, the two rollers shown run on the cams, and pivot within the intermediate lever midway. The profile of the two cams is added together forming the variable open and close profile to drive the steam valve. The intermediate lever pivots about the lower shaft, and the striker at the top is a tappet for the valve stem. The Exhaust valve does not have variable compression, so no swinging link is required. Therefore, Reidinger is equivalent to the 1930s Caprotti which also had fixed compression. The British Caprotti of the 1950s added variable compression by adding two exhaust cams together to form a variable exhaust valve opening profile.

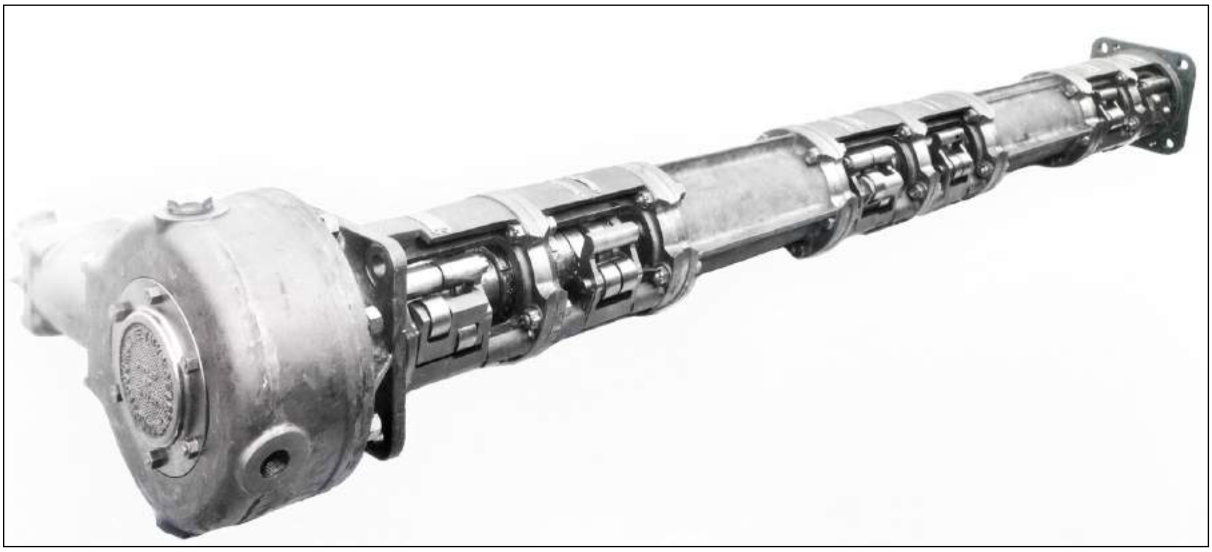


Figure 25 D49 Reidinger Rotary Valve Gear

The first application of the RR gear was in 1939 to D49 No 201 “The Braham Moor”. The gear had been designed over several years by Albert Reidinger and upon the takeover by Caprotti Valve Gear in 1936 he had applied officially to develop the gear under them. Permission was refused and in a climate of increasing difficulties Albert

Reidinger left to form his own company, Locomotive Valve Gears Ltd in 1937. The upshot was his own gear designed so that it could be fitted into the cylinders of RC geared engines, there being a great advantage from an economical point of view to use existing cylinders for experimental valve gear. Gresley was very enthusiastic about this as he saw a means of overcoming the stepped cam which had handicapped his D49s and 2001 Cock o' the North. However, Gresley died in 1941 and in his stead came Thompson, committed to sweep away as much Gresley as he could get away with and under wartime conditions there was no inclination to continue with an experimental gear. Orders were given for the removal of the gear, and it was carted away by Albert Reidinger for storage in his father-in-law's engineering works for the duration of the war. This set of gear, which had been made by Varley Pumps Ltd incidentally was subsequently resurrected at the request of R Riddles and fitted to 62764 "The Garth" in 1949 and a series of tests undertaken at the recently opened Rugby Locomotive Test Plant. Locomotive Testing Station Rugby report R1 compared the experimental poppet valve gear with the standard piston valve, finding it developed the same power at much shorter cut off, which results in considerable economy. However, difficulties with coal being of inconsistent quality, and supply of footplate staff with experience of an LNER D49 in an LMS area hampered the results as did the test plant being in a state of development itself. The RR experimental gear suffered three failures. One valve steam failed with a fatigue flaw, one valve spring fractured and there was a failure of two small spring clips retaining locknuts. The most serious problem is discussed in the appendix No 4 which is a suspected valve steam leak indicated by excessive exhaust steam temperature after a period of running. The test station manager Mr D R Carling felt it was trouble often met with poppet valves due to the thermal distortion of the valves, and cages if used, or the entire cylinder casting with the complex passages around the valves which moved with temperature misaligning the sets of valve seats in the Lentz system. In his opinion this could be addressed in time, but overall felt Caprotti valves had less trouble than Lentz.

Further experience was called for by the Railway Executive and the RC fitted Crabs were converted to RR gear cambox in 1954 which in this case was supplied by J L Jameson of Ewell, Surrey. (Patent GB 491729A) The engine No 42824 received a new Reidinger cambox but retained the 1932 RC poppet valves. In 1957 the Rugby Locomotive Testing station released report R10 on comparisons between a piston valve and poppet Reidinger Rotary Crab. After 6 months of testing little was added to the Walschaerts gear versus Poppet valve gear knowledge base. The potential of poppet valve gear was unlikely to be exploited when fitted to a locomotive with low boiler pressure and superheat temperature.

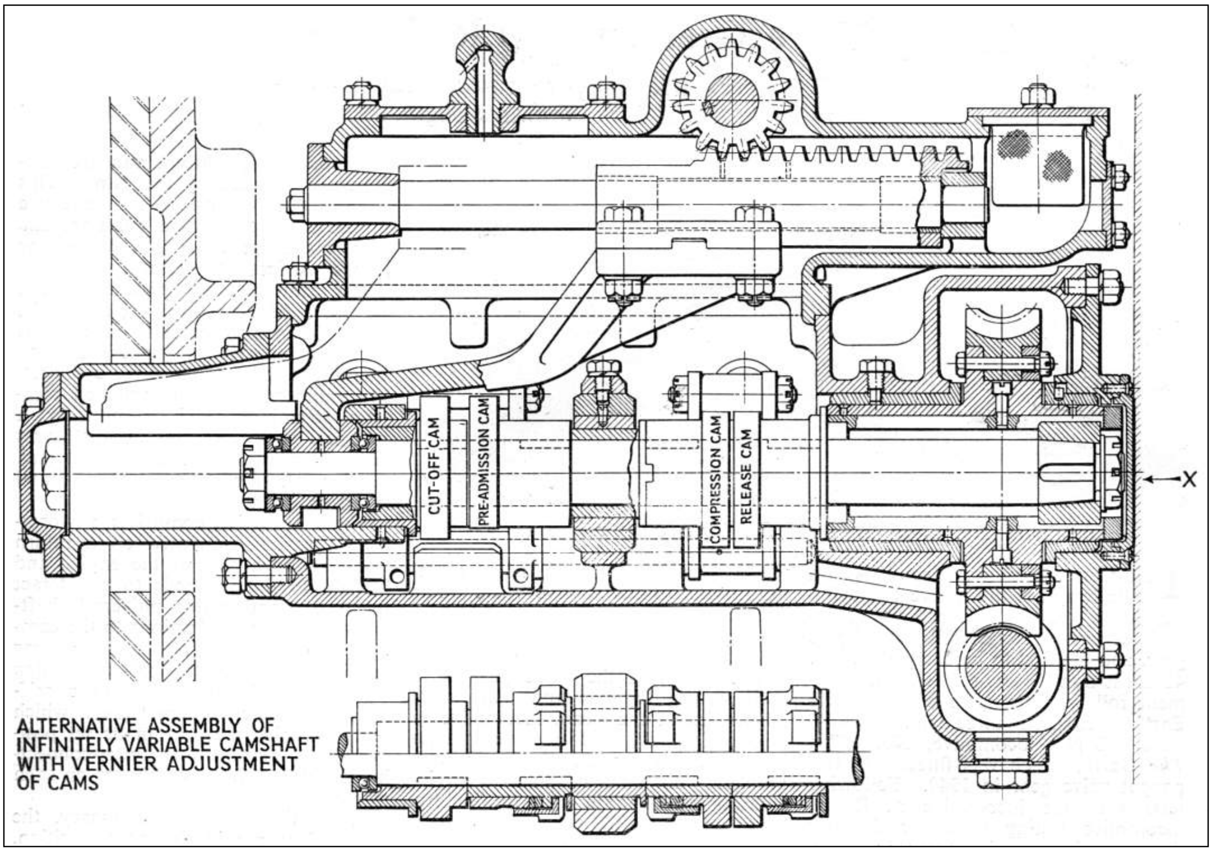


Figure 26 Reidinger Cam shaft cross section – replacement for RC gear

The cross section shows the D49 gear repackaged to fit in the envelope of the RC gear.

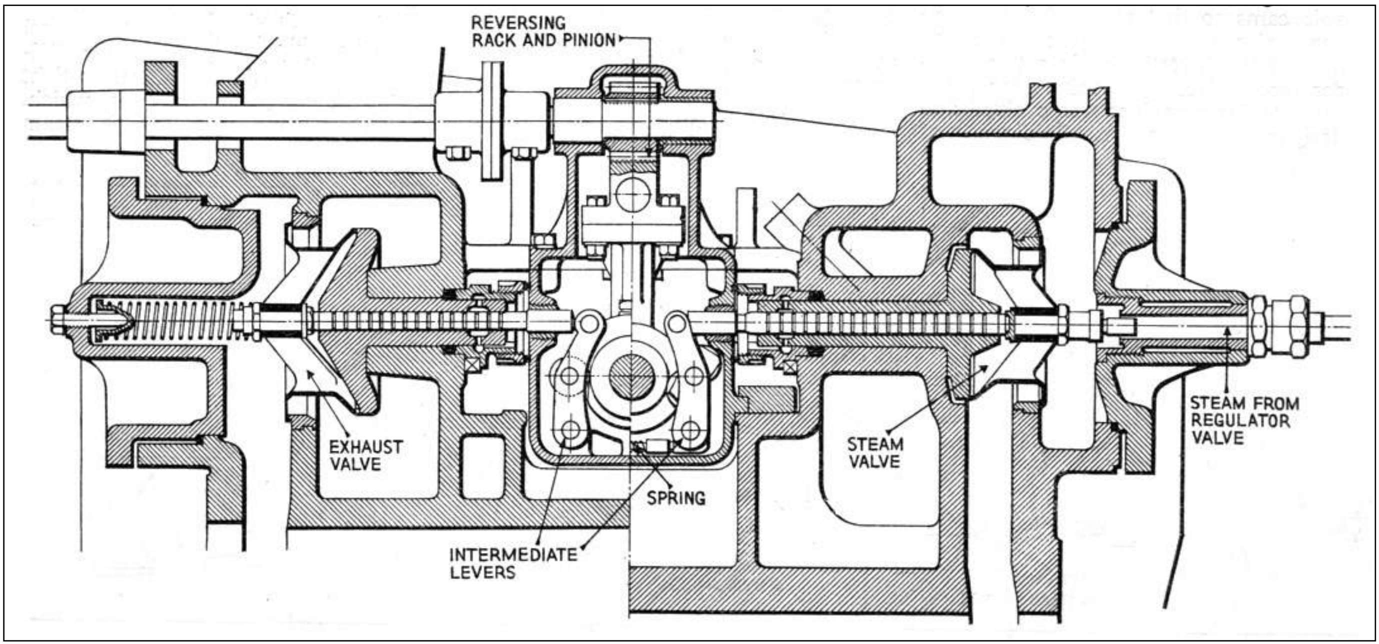


Figure 27 Actuation system cross section for Reidinger's RC replacement

Reidinger considered Caprotti had trouble with the sealing of the actuation steam to lift their exhaust valves to the closed position so retained the Lentz spring on the exhaust but on the steam valve copied Caprotti with steam actuation replacing the Lentz spring. In the figure above the exhaust valve is on the left, and the steam valve on the right. The swing link can be seen on the intermediate lever adding the two cam profiles together. For comparison the British Caprotti gear is shown below with the swing link on the rocker levers.

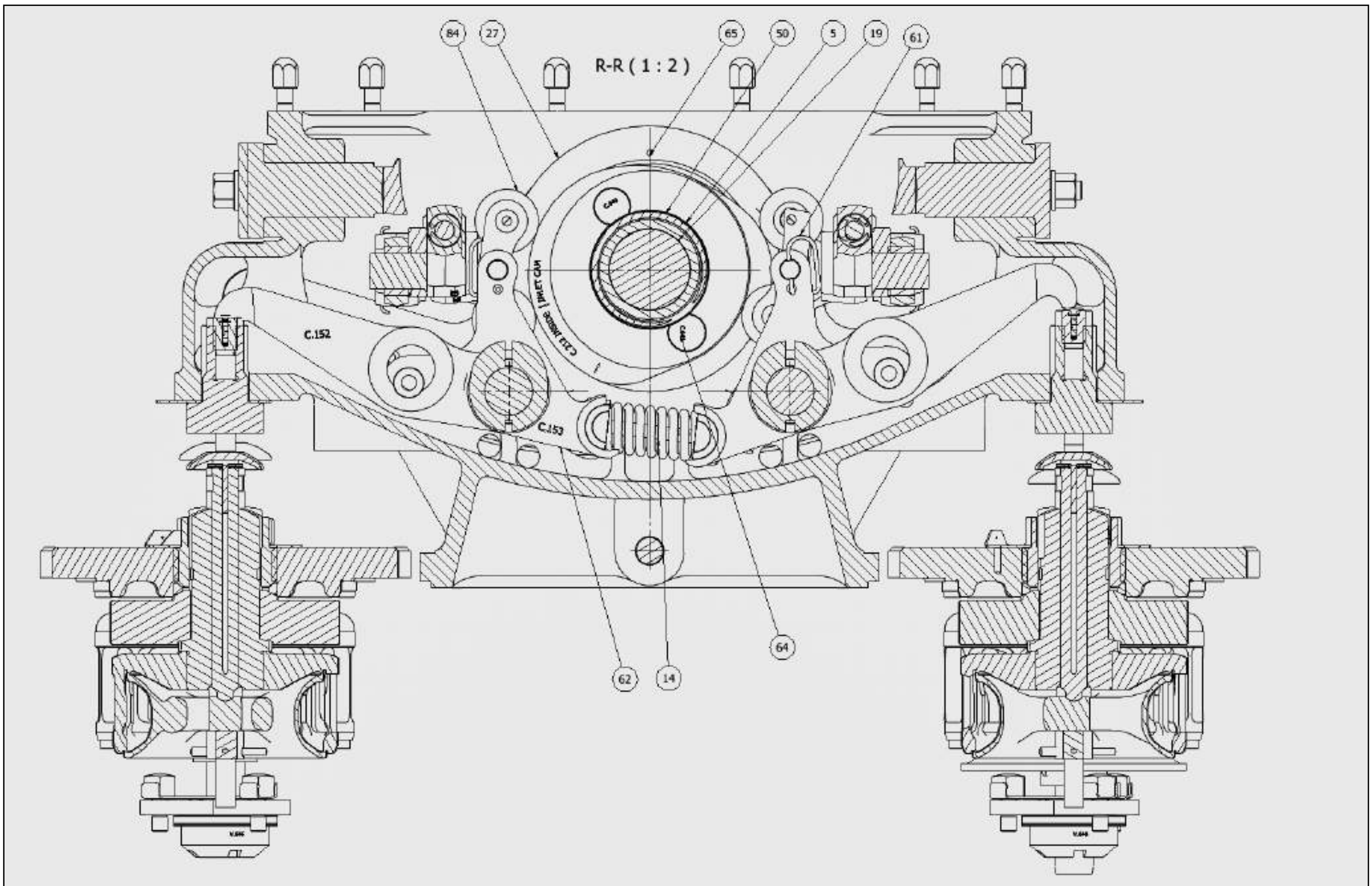


Figure 28 British Caprotti Steam valve actuation mechanism

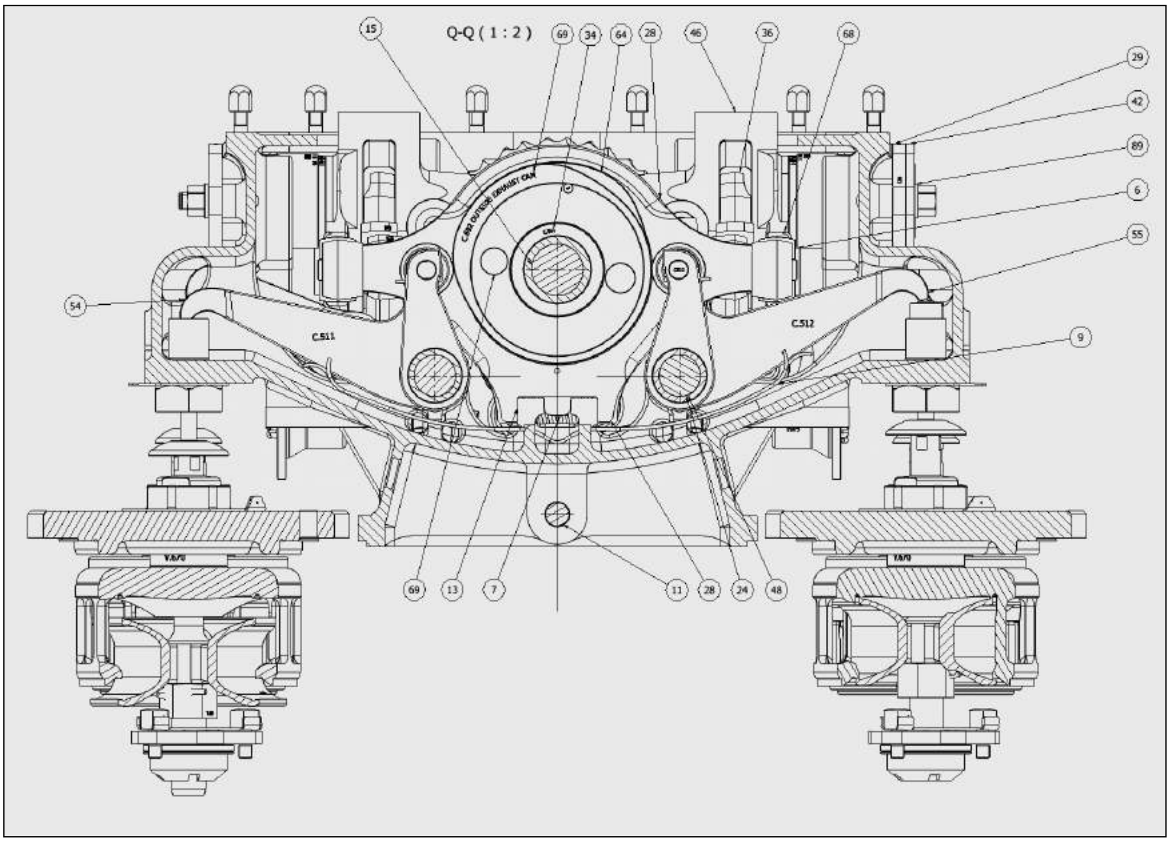


Figure 29 British Caprotti Exhaust Valve mechanism

The Railway Executive selected Caprotti, with Reidinger Rotary as a close second option for the BR poppet valve developments on standard locomotives.

During the late 1940s Albert Reidinger's team worked out designs of valve gear for the Indian WG class 4-6-2s and the Victorian Railways "K" class. At the peak about 6 designers and others were employed.

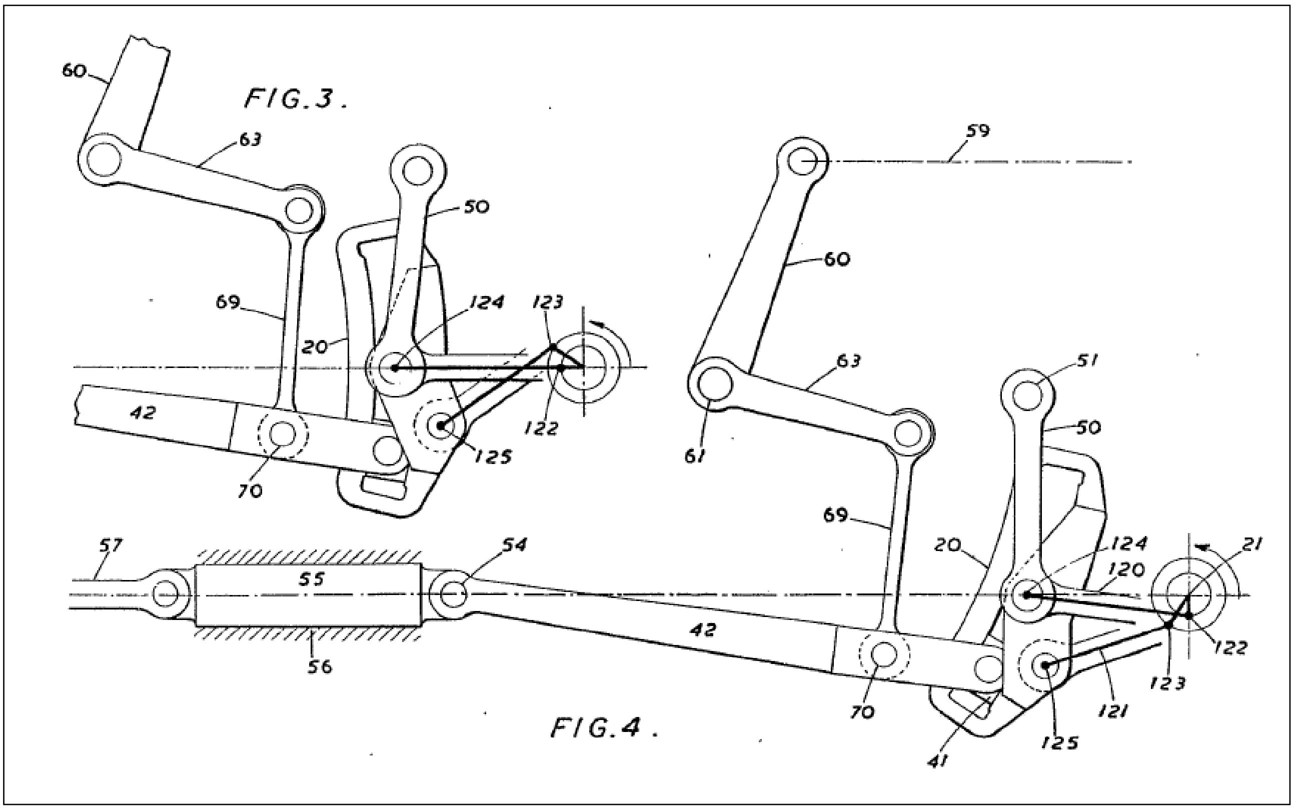


Figure 30 Reidinger Linkage gear Patent GB628172A

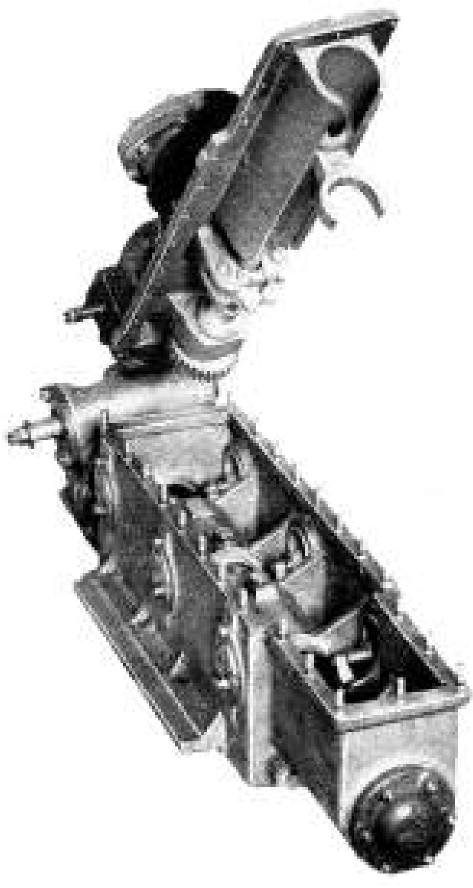
Although having no bearings on poppet gears Albert Reidinger worked out designs of enclosed link gear for Bulleid for fitting to the Lord Nelsons. Realising all the trials and tribulations connected with the chain drives on the Pacifics Albert schemed a valve gear drive from a return crank gearbox with a link mechanism enclosed in a small case. The valve spindle rod emerged through a sealed circular bush arrangement which would probably have been easy enough to seal against oil pumping out. This valve gear is covered by patents GB628107A and GB628172A.

A further scheme developed was an autolocking gear system which killed normal piston valve reactions adjacent to the link and prevented their passage to the driver's handwheel. The system also allowed a much freer handwheel and made reversal easy. Two sets were fitted to locomotives, thought to be class 9Fs.

Development of RC gear continued in the USA with an agreement with Franklin and Dabeg in 1937. The Franklin Type 'A' Oscillatory cam and later the Type 'B' Rotary cam Steam Distribution system. Modern Internal combustion automotive techniques use multiple valves per cylinder. Multiple small valves provide the same effective flow as a large valve, but with much reduced cam loadings. This is something Franklin exploited in the sunset of steam development.

FRANKLIN SYSTEM OF STEAM DISTRIBUTION 9

Cam Shaft.
Cams on either end of shaft are for exhaust valves; center cams are for intake valves.



Cam Box with cover raised.

gear box contains a worm gear, the wheel of which is driven by a drive link. The drive link provides compensation for rise and fall of the driving box and lateral movement between driving axle and engine frame. The worm gear converts the rotation taken from the driving wheel into rotary motion at right angles to it.

With the "drive-arm-supported" type of driving gear box, the worm wheel is keyed to the pin of the drive arm and flexibility is provided in the drive shafts. A torque rod is used to prevent rotation of the driving gear box.

A supported drive shaft, incorporating the necessary universal joints, transmits the motion from the driving gear box to a similar gear arrangement on the cam box. Here an identical worm gear drives the cam shaft, which is parallel to the axle, exactly in synchronism with the axle.

The cam boxes, as mentioned above, are located on the cylinders, between the steam chests. In the Type B system, all cams for one cylinder — for forward and backward motion, intake and exhaust — are mounted on the one cam shaft which rotates in synchronism with the main driving axle. Intermediate levers with cam rollers, one for each valve, follow the cams, actuating the valve tappets.

Figure 31 Franklin Type 'B' Bulletin 25A

First Lentz Patent had been set up and had most of the world at their feet, they were developing their own ideas, but a restraint was placed upon them by Hugo Lentz desire for conformity. Eventually they broke free, but it was the 1930s before they had buried the Lentz hatchet. Similarly Valve Gears Ltd (Wm Beardmore, Glasgow) had fallen foul of Athuro Capriotti's ideas which virtually wrote the business off at a loss. By 1930s ALE were emancipated sufficiently to aggressively follow up business all over the world but suddenly from a position of supremacy business-wise they found themselves sold to Caprotti Valve Gears, in comparison a slightly lame duck. Caprotti Valve Gears suppressed previous ALE activity including the RR gear which overcame many of the snags of the RC stepped cam gear.

Then came the war and everyone suffered and before a recovery could be made in this country nationalisation imposed a further set back. There was a bright hope in Riddles appointment to Chief Mechanical Engineer, but this was relatively short lived and the regime which followed was cool towards steam development.

Riddles had been keen on poppet valve systems since his involvement in 1928 with Caprotti Claughtons and saw to it that after 1948 a fresh start should be made. He only had a short time to do it in as the Government upheaval in 1954 of the Railway Executive saw Riddles retiring rather that working under JCL Train so this sealed the fate of future development.

By 1955 all parties were aware that they were now backing a looser and by 1965 it had become hopeless to continue. Both the Caprotti and Reidinger concerns ceased trading other than for intermittent supplies of spares and that was the end of a most promising story.

Poppet Valve gear summary chart				
	Lentz, ALE RC gear, Franklin	Caprotti	Cossart	Reidinger Rotary
Method of poppet valve movement generation.	Change of cam profile in operation.	Addition of two mirrored cam profiles with the relative angles between the cams adjustable	Addition of two mirrored cam profiles with the relative angles between the cams adjustable	Addition of two mirrored cam profiles with the relative angles between the cams adjustable
Drivers control of cut off	Gear and rack slides cam shaft to select a new cam.	Crank and connecting levers drive a nut along a screw thread causing rotation to drive the cams	Barrel cam moves nuts on a screw thread causing rotation to drive the cams.	Gear and rack slider the cam shaft. The cam rotational position is determined by a slot cut in the camshaft surface and a dog on the cam engaged in the slot. Each cam has a separate slot track. Rather like a variable pitch thread.
Method of valve closure	Spring return + steam pressure balance on valve.	Steam closure with steam action on valve stem end. + steam pressure balance on valve.	Spring return.	Exhaust valve closure with spring. Steam valve closure with steam action on valve stem end.
Cam force contact footprint	Pinpoint loading for continuous profile cams, line contact for stepped cams.	Line contact with two cams sharing the load.	Line contact with two cams sharing the load.	Line contact with two cams sharing the load.
Valve seats	Lentz and Franklin flat faced seats. RC gear has bevel edge seats with expansion from a single point.	Bevel edge seats with expansion from a single point of origin.	Piston valve ring seals running in a liner in a poppet valve style.	Same as Lentz.
Drifting or coasting engine condition	Bypass cam selected by moving reverser. Franklin has a bypass actuating piston and lever to open the exhaust valves.	Closing regulator causes the valves to drop open.	Westinghouse air pressure applied to piston forcing the exhaust valve open.	Inlet valves drop open on closing regulator, Exhaust valves controlled by springs.
Camshaft speed	Crank Speed	Crank Speed	Half crank speed	Crank Speed
Orientation of poppet valves	Horizontal	Vertical	Vertical	Horizontal
Country	Europe, Uk, British empire, Usa	Europe, UK, British empire. Caprotti failed in the USA as the European cambox was too weak for the bigger engines and suffered fatigue failures.	France and colonies	Uk, India, Malay

BURNING WOOD PELLETS IN A STEAM TRACTOR

By James Evans

(photos by James Locke)

I live in the bottom of a deep valley in Cornwall, and have been carer for a 1925 traction engine for over fifty five years. Best Welsh steam coal has always been essential for our road journeys over the years, especially when faced with our undulating terrain. I am now down to my last tonne of Ffos y Fran, which I normally rely on for the first couple of miles while climbing two hundred metres at the start of all outings.

Having done quite a bit of research into alternative fuels for the large Fairlie type loco I would like to see built for the Welsh Highland Railway one day, I have decided that dry wood pellets is the best bet. Wood chips were tempting due to their ease of manufacture, but with the loco would require a minimum bunker of eight cubic metres, quite impossible! Also due to their variable physical structure feeding the grate would have required quite complicated engineering.

Dry wood pellets on the other hand are very uniform in size and shape, and with higher density plus lower moisture content would be more suitable. I have therefore made the modifications so that I can try them out in my steam tractor, whilst maintaining the ability to fire some coal if required on our longer hills. Feeding the grate appears to be the greatest challenge, especially being able to do so without opening the fire hole door, and directed to anywhere the fire is burning fastest. The principle is 'deep bed combustion' with four to six inches of fire depth for half inch diameter pellets, and air through the grate will be very restricted. The grate itself was going to be covered with broken fire brick to form a fire-bed, but broken night storage radiator bricks should have better heat retention

I feel.

Fuel is fed from a hopper by a 1/4 kW twelve volt blower via a tube through the fire hole door, which is fitted with top air vents/sight holes with deflector plate inside; unfortunately there is not room for a brick arch. Within the fire hole there is a steerable deflector to direct the stream of fuel onto the required area of the grate.

This is just a trial and if will be interesting to see how it works. At the moment I'm fitting a new set of boiler tubes and completing another ten yearly overhaul, so next season we should be trundling around more or less renewably fuelled.