RAILWAY REFLECTIONS

A PERSONAL ASSESSMENT OF SOME ASPECTS OF RAILWAY HISTORY

BY MICHAEL RUTHERFORD

No 138

‘EXPORT OR DIE!’ BRITISH DIES AND MODERNISATION PART

ABOVE: **Three 1,600hp diesel-electrics were ordered by the Southern Railway which had a post-war plan to dieselise non-electric routes. These locomotives were not rushed out and had improved engines. The first two (Nos.10201 and 10202) of 1,760hp were built at Ashford in 1950/51 whereas No.10203, built at Brighton in 1954, was held back, redesigned and fitted with the MKII engine of 2,000hp, becoming the prototype for the EE Type 4. It was captured here when new in April 1954 on a test train at Waterloo.** (S. C. Townroe/Colour-Rail DE629)

This year, 2008, marks the 50th anniversary of the first batch of Type 4 main line diesel-electrics delivered as part of the British Railways Pilot Scheme of the Modernisation Plan of 1955 and this was alluded to in the colour spread included in last month’s *Backtrack*.

Those ten locomotives (Nos.D200–209) were built by the English Electric Co. at the Vulcan Foundry, Newton-le-Willows, which had become part of the English Electric Group in 1955 although having had close ties with the Preston-based organisation since 1946. In its turn the Vulcan Foundry had taken over Robert Stephenson & Hawthorn’s two years previously although that company had only been formed in 1937 when one-time Newcastle upon Tyne neighbours Robert Stephenson & Co. and R. & W. Hawthorn, Leslie & Co. amalgamated. By that time Stephenson’s had transferred to their new factory in Darlington which began production in 1901–02 and Hawthorn, Leslie’s had Forth Banks works expanded into Stephenson’s former Forth Street premises.

The ten Type 4s were not the first of the Pilot Scheme orders to be delivered. Twenty Type 1s had also been ordered from English Electric (Nos.D8000–8019) and were built concurrently with the Type 4s at the Vulcan Foundry, sixteen being delivered from July 1957 to the end of that year and the rest in the first quarter of 1958.

Further deliveries of the latter began in September and October 1959 with batches from both Newton-le-Willows and Darlington, the Lancashire factory also producing more Type 4s

One of 32 Bo-Bo 660hp locomotives built for the 3ft 6in Tasmanian Government Railways between 1950 and 1952, twenty by the Vulcan Foundry and twelve by English Electric, Preston. (Author’s Collection)

The LMS 1,600hp pair in later, green livery with the up 'Royal Scot' at Lichfield in May 1959. (E. S. Russell/Colour-Rail DE480)

EL-ELECTRIC MANUFACTURERS

ONE: ROOTS

too, in far greater numbers than the Pilot Scheme had envisaged.

The Type 4, in essence, was very little more than a modified version of the Southern Region No.10203, redesigned for quantity production and with the inclusion of substantial 'noses' at both end on the insistence of Mr. R. C. Bond, BR's Chief Mechanical & Electrical Engineer, who thought such structures were useful as 'crumple zones' in an accident and would also reduce the effects of 'sleeper-dazzle' at speed whereby a driver's vision is distracted and eye fatigue increased.

It is now nearly eight years since I looked at some early British diesel-electrics[1] and especially the use of the Beardmore engines and also the valiant attempts of the rail traction department of W. G. Armstrong Whitworth & Co.'s Scotswood Works on Tyneside. The Beardmore engines were supplied both with complete traction units or railcars separately and manufacture was also licensed to the Westinghouse company in the USA. A large range of units was supplied for export by the Scotswood factory and it is just possible, had circumstances been a little different and investment capital more readily available, that British industry could have established a compehensive worldwide diesel traction market before the Electromotive Division of General Motors began production in 1937 at La Grange, Illinois (west of Chicago), a greenfield site in 1935 when the first sod was turned over.

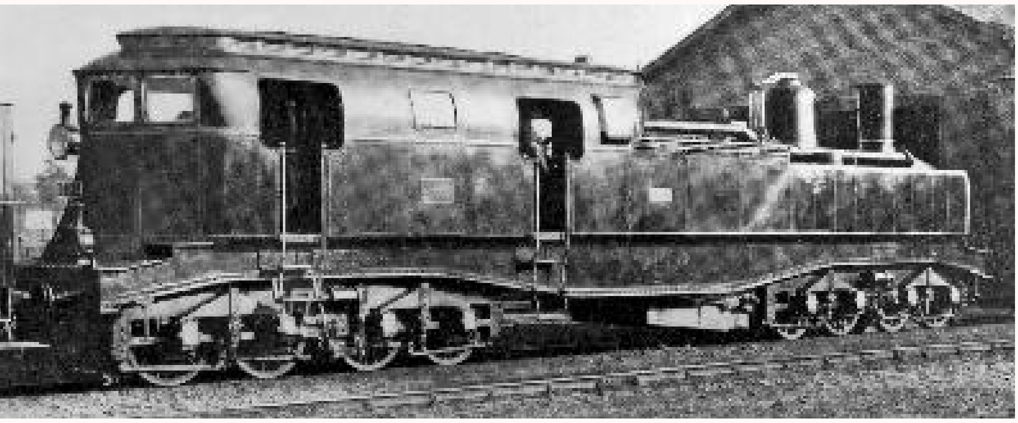
The English Electric Co. received but little mention in those articles because its main contribution in the period was concerned with diesel-electric railcars and some diesel-mechanical shunters and railcars carrying the Drewry Car Co. badge. Likewise a two-part article on modernisation in Ireland (both North and South) added little because once again English Electric were not greatly involved.[2]

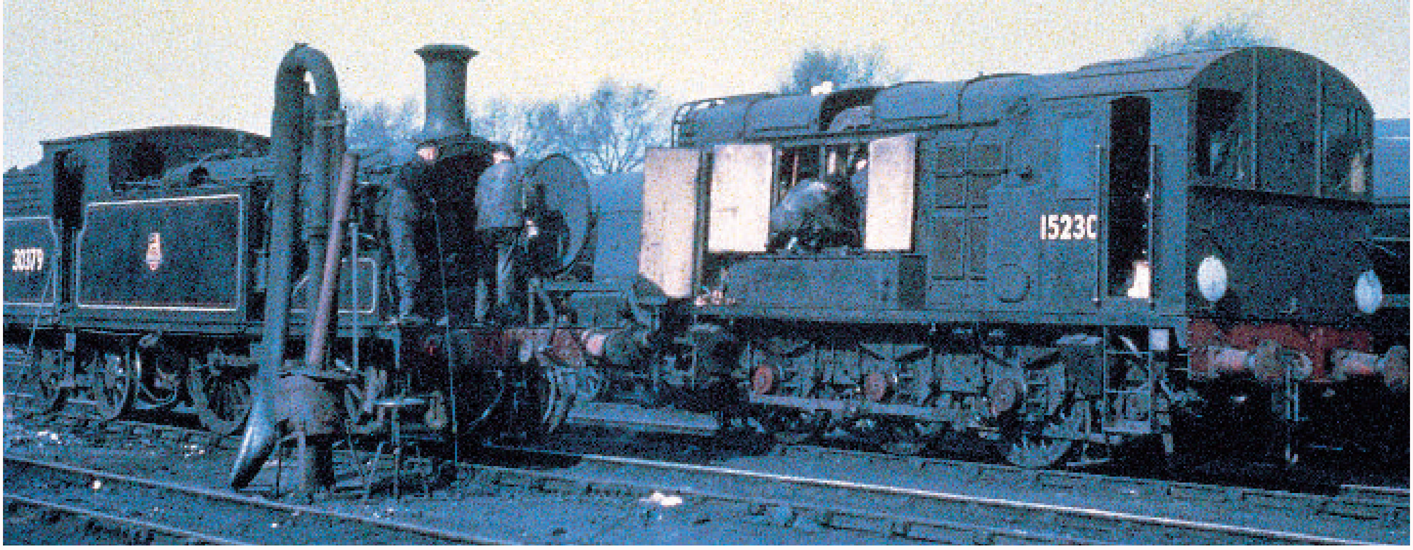
This series therefore will start by concentrating on the English Electric contribution following some relevant historical background. Although the company's first essay into main line diesel-electric traction was a trio of metre gauge machines built for Brazil in 1938 which, like contemporary diesel-electric shunters, were only fitted out at Preston — the mechanical parts and running gear having been built at Hawthorn, Leslie & Co.'s works in Newcastle — we must never forget that between the two world wars English Electric built a considerable number of powerful straight electric locomotives for many parts of the world and was thus not without considerable experience and awareness of the many likely problems which would occur.

The potential of electric traction was recognised as soon as the earliest working motors had been lashed up but they invariably obtained energy from early forms of battery, although electrical storage technology grew rapidly along with the spread of the earliest applications of electricity such as the telegraph. Fortunately, unlike the hit-and-miss development of the steam engine and steam locomotion which pre-dated and indeed instigated the development of thermodynamics as a scientific discipline, the fundamentals of electromagnetic theory were understood and electrical engineering already a specialism with many successful commercial applications by the time electric traction became viable.

Michael Faraday's ground-breaking work in electro-magnetism was presented in a paper read to the Royal Society on 24th November 1831, little more than a year after the opening of the Liverpool & Manchester Railway. The following decades saw a great deal of inventive work undertaken on dynamos and motors but it was the electric telegraph which became the first important commercial application of electricity, powered of course by batteries, a source too heavy and costly for general traction purposes, although successfully demonstrated by Robert Davidson in the 1840s.[3]

The two Heilmann steam-electrics used on the CF de l'Ouest of France in 1897 (Nos.8001/2) were a remarkably bold experiment attempting to obtain the benefits of electric traction without the infrastructure costs. There had been a prototype (*le Fusée*) in 1894 which had been used to test the concept. These two engines were the forerunners of all later diesel-electrics and steam- and gas-turbine electrics. The engines were of the Willans central valve type built at their Rugby works which turned to steam turbines and diesel engines a few years later. The early English Electric traction diesel engines were designed and built there. (Author's Collection)





Inventors and entrepreneurs in electrical engineering developments came from all walks of life, from academics to backyard tinkerers and snake-oil salesmen. They also came from most countries in the western world and, because of greatly improved communications, technological transfer from country to country and diffusion of new techniques from industry to industry was much more rapid than in the first industrial revolution.

There is no place in this article for a survey of electrical engineering landmarks nor full details of electric traction developments but it should be sufficient to mention a few names of pioneers; these should not be regarded as the most significant or important, however.[4]

Zenobe Gramme was a Belgian who combined several earlier separate inventions into a practical dynamo (direct-current generator) in 1870 and in 1873, at the Vienna Exhibition, demonstrated that the same machine could operate either as a motor or a generator, with energy converted from mechanical to electrical and vice versa and transmitted by wires.

A number of different patented designs of dynamos and motors was produced and sold by commercial firms but the most notable application was the demonstration of a small locomotive by Werner von Siemens at the Berlin Trades Exhibition in 1879; a similar machine was demonstrated at the Crystal Palace and other trade exhibitions in various countries.

It would be wrong to credit Siemens with being a sole inventor with a priority in the invention of electric (rail) traction; the whole subject is very complicated and defies a simple summary. Nevertheless his little locomotive(s) have been regarded as 'the catalyst' of the electric traction era. They led directly to small narrow gauge electrically-powered industrial railway systems at mining installations as well as inspiring operators of existing street tramways (powered by horses, cables, steam and occasionally — and briefly — more exotic sources of power) to look to electricity as a practical alternative.

The introduction of diesel traction into a steam fleet produced 'The Problem' clearly seen here as smokebox char is shovelled from an M7 0-4-4T alongside a standard EE diesel shunter (No.15230, built at Ashford in September 1951). The latter has its inspection doors open and fitters perhaps look for the cause of a failure when it's behind them! This little scenario was photographed at Eastleigh in April 1953. (S. C. Townroe/Colour-Rail DE616)

A Timken roller-bearing advert featuring a Queensland Government Railways Co-Co in 'Sunlander' livery. Ten of these single cab streamliners were built by the Vulcan Foundry in 1954 and were designed to work in pairs where necessary in true US manner. There is a hint of the livery of *Deltic* of December 1955. (Author's Collection)

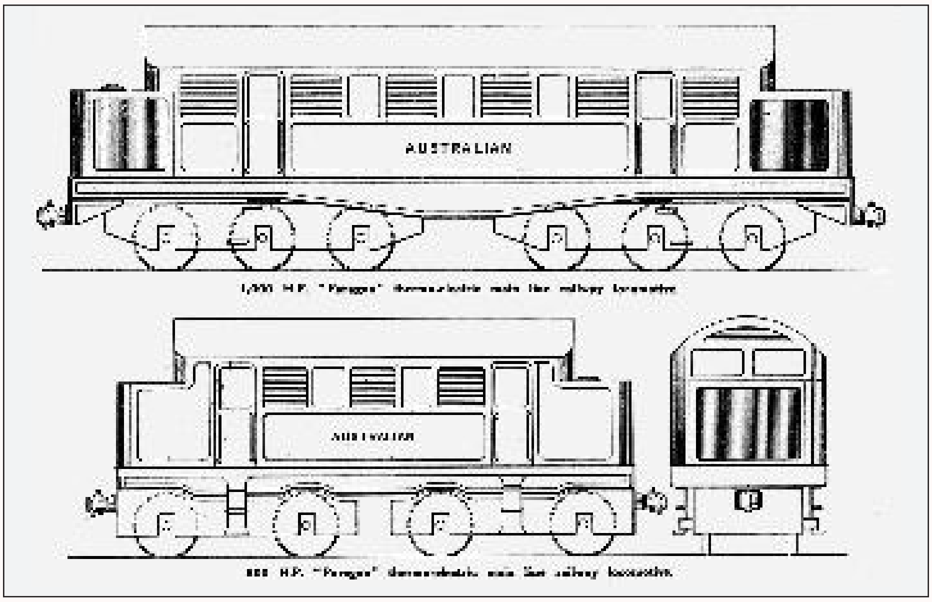
Siemens (1816–92) was by that time a very successful inventor, engineer and entrpreneur. Born into farming stock at Lentha, near Hannover, he was knighted in 1888; hence the 'von'. He invented the pointer telegraph in 1846 (nine years after Samuel F. B. Morse's invention of the writing telegraph) and in the same year discovered that gutta-percha (the dried sap of the Malayan palaquium tree) was the best material for electrical insulation and because of its water-repellant properties was ideal for insulating underground cables.

In 1847, with J. G. Halske, he set up the Siemens & Halske company in Berlin to manufacture telegraph equipment and sent his two younger brothers, William (1823–83) — later knighted by Queen Victoria — and Friedrich, to Britain to represent the firm and protect its interests and a factory (Siemens Brothers & Co.) was opened in Woolwich, Kent, in 1865.

Back in Germany Siemens & Halske developed the electric actuation of railway signals and one of Siemens' associates, Carl Frischen, developed automatic block signalling in 1870–72, two decades before the first such application in Britain (on the Liverpool Overhead Railway in 1891–93).

The problems of electrification centred on generation and distribution. These were costly and required good commercial reasons to install. Electric lighting in the form of arc lighting had been very effective in large spaces such as railway stations and goods depots but was too bright and unsuitable for the small rooms found in domestic homes or in office and shop buildings. The development of the incandescent light bulb by Joseph Swan in England and Thomas Edison in the USA was to change everything and occurred concurrently with Werner Siemens's little locomotive demonstrations, giving great impetus to investors, entrepreneurs and visionaries.[5]

Traditional stationary steam engines were far



William Peter Durtnall was one of the pioneers and early champions of electric transmission for ships, road vehicles (from buses to racing cars) and railway traction. His ideas were packaged under the 'Paragon' badge and were taken up by R. & W. Hawthorn, Leslie & Co. Ltd. of Newcastle upon Tyne around 1910. The firm quoted for the locomotives for the Trans-Australian Railway but the First World War ended these revolutionary proposals and steam traction was used in association with a very costly programme of drilling for water in the desert. (Author's Collection)

too slow to run the generators of the time and the speeds necessary to generate sufficient current and so the two machines were connected by ropes or belts, the large pulley fixed to the flywheel of the steam engine driving a much smaller one on the generator — in effect 'gearing up' the rotation of the engine. This was not really the answer, however; the engines were very big and needed to be housed in large buildings, the loss of power due to friction was very high (up to 10% of the power of the steam engine) and thus both capital and running costs were high.

Very quickly two fields of development revealed themselves: one was to produce generators which did not need to be run so fast (multi-pole types were evolved) and the second was to produce high-speed steam engines.[6] The result was direct drive of generators by engines, the whole arrangement being much smaller than the earlier set-up. Such steam engines required light, high-precision components and exceptionally good lubrication. They were usually multi-cylinder machines, often single-acting with totally enclosed crankcases, but when A. C. Pain, a draughtsman working for G. E. Belliss (later Belliss & Morcom), patented in 1890 and 1892 a system of forced lubrication to all parts, it became possible to use double acting engines without knocking from the crankpins. Oil at between 10 and 30psi was delivered via an oscillating pump, driven from the valve eccentric, through passages drilled through the crankshaft to the big ends and then through external pipes to the little ends which also had passages drilled through them.

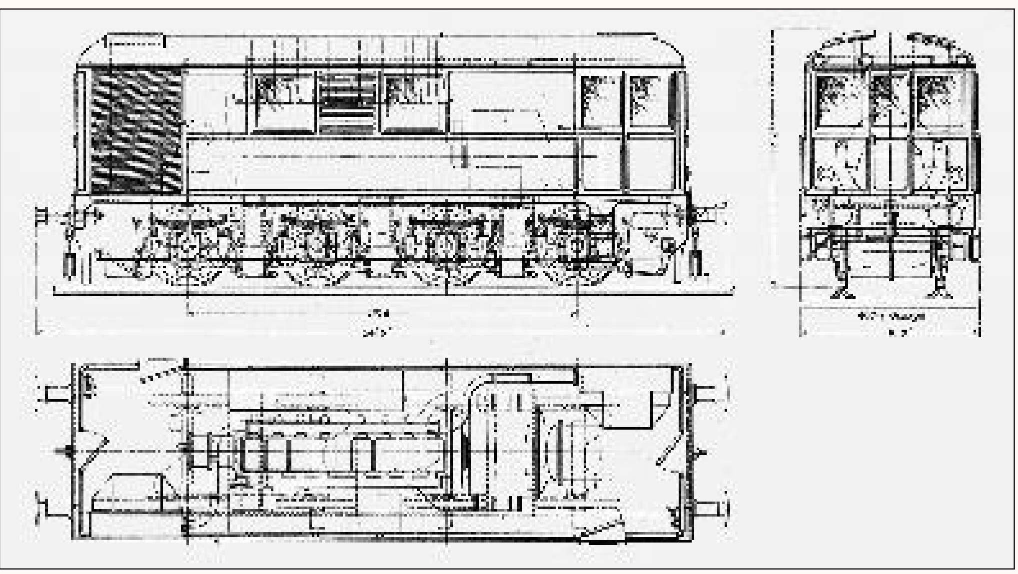
Generating sets were soon being supplied to a myriad of users in a range of industries as well as establishments such as hospitals, laundries and large hotels. From the very beginning, however, one make of engine was quickly adopted for power station work, especially those generating direct current (dc) where the sets could be run in parallel. Those engines were built to the designs and patents of Peter Willans who had a factory at Thames Ditton in Surrey — Willans & Robinson Ltd.

His earlier engines were three-cylinder single-acting types including some compounds but in 1884 he introduced the central valve engine. In that design the high pressure piston was mounted in tandem on top of the low pressure one (mounted vertically in this case: usually called 'steeple' form). Both were single acting and the common diameter piston rod was a large diameter tube in which inlet and outlet ports were cut. Within the tube was a multi-headed piston valve worked from an eccentric on the crankpin and this valve controlled the flow of steam.

These engines were supplied in several sizes and multiples of cylinders and proved so popular a new factory was planned on a greenfield site at Rugby in 1894. The Victoria Works was opened in 1897 and became part of the English Electric Co. in 1919. The green field site was chosen in December 1894.

Such an efficent, compact generating set as the central valve engine came to the attention of Jean Jacques Heilmann who, realising the flexibility and advantages of electric drive but wishing to avoid the high capital costs (and distribution problems) associated with possible main line electrification, sought to combine an on-board prime-mover with an electrically driven train.

This Beardmore proposal of 1927 illustrates how similar such schemes were to its steam engine counterparts. This was to be a heavy goods locomotive of 1,000 installed horsepower equivalent to 0-8-0s in service at the time. (Author's Collection)

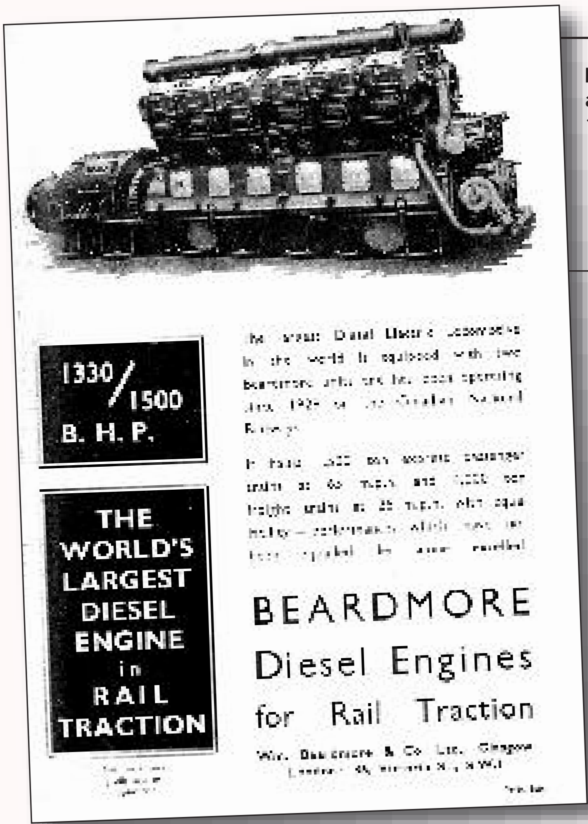


It is often said that certain designs or prototypes in many areas of activity were 'ahead of their time' and thus not fully appreciated and developed. There can be no past locomotive developments which deserve this appellation more than the steam-electric locomotives of Jean Jacques Heilmann and the Société Industriel de Moteur Electrique et à Vapeur.

Heilmann, like a number of great French engineering innovators, was from Alsace. He saw, as did the other members of his company, that electricity would revolutionise the world and that it was the ideal way to power the railway system. He also saw, in the days before public power supply networks, that electrification was to be a high-cost business requiring generation and transmission systems to be included in the calculations which would limit the application of electric traction to specialised railways — particularly in urban areas, for high-density traffic on short routes. His plan, therefore, was to build electric locomotives which generated their own power, allowing that power to be used more effectively and over a much wider range of speeds than was possible with the conventional direct-drive steam locomotive.

Members of Heilmann's team included Charles Brown, an Englishman and former manager of the Swiss Locomotive Works at Winterthur (he designed the engines installed in the prototype locomotive), and Charles E. Brown (son), formerly of the Oerlikon works in Zurich and co-founder of Brown, Boveri & Co. of Baden (he designed the electrical equipment).

The prototype was named *Fusée* (*Rocket*).[7] A Lentz-type boiler with a stayless corrugated firebox supplied steam to a two-cylinder compound engine driving a dc generator (or dynamo) and this in turn fed eight electric motors each of which was axle-mounted, the running gear forming two eight-wheeled bogies in a Do-Do configuration. At first Heilmann conceived a multiple unit train with powered axles throughout and a mobile power plant at one end but this was 1892, five years before Frank Sprague's American



Beardmore advertised its engines to no avail after 1930 (this one comes from 1933) — the depression killed off much interest — but the whole range had a power:weight ratio of two to three times that available in the few diesel engines then available for rail traction purposes in the USA. (Author's Collection)

patent for multiple unit control (using low voltage control signal wires) was first applied — on Chicago's South Side Elevated Railway — and so a locomotive it was to be.

There was much publicity surrounding *Fusée*'s trials in 1893 and also much criticism; it was too costly, it was too heavy, it was too complicated, it required too many specialists to cherish it etc., etc. These were all the arguments brought up against the diesel-electric half-a-century later (and probably by some of the same Jeremiahs!). It was an experiment, it did inevitably have teething troubles, but it produced its power using less coal than a conventional locomotive. It also had great speed potential (it reached 67mph, nearly the French limit), had all its weight available for acceleration and braking and rode like a Pullman carriage. A Westinghouse air brake system operated an early type of disc brake.

Electrical developments overcame problems in that area; ironically it was the steam side of things that was retrogressive, even though the overall fuel saving in service was 15%. Heilmann envisaged operating his locomotives as a hire package, supplying locomotives, maintenance and crews; opposition to this radical stance by entrenched power within the railway establishment was inevitable. Even so, the Cf de L'Ouest thought the system held enough promise to try and a pair of 'production prototypes' was designed and built, becoming Nos.8001 and 8002 on that system.[8]

The new locomotives had larger, conventional boilers with Belpaire fireboxes, wide grates and generous ashpans. The Willans & Robinson Rugby-built central valve engines were of the six-crank type with a maximum rating of 1,600bhp; the maximum continuous rail horsepower was stated to be 1,350hp.

According to *The Engineer,* "The stability and steadiness are especially noticeable, and it appears that one can write with comfort on the locomotive while it is running at 100kph."

The newspapers, too, seemed impressed. The Paris correspondent of the *Morning Post* wrote, "It seems that the praiseworthy efforts of the French Western Railway Company to construct a really practical electric locomotive have at last been crowned with success. A perfect Heilmann machine has been produced, which is far superior to the steam locomotive from every point of view. Next spring travellers from Paris to Granville, Laval and Angers will make the journey in three hours without a stop. One of the chief problems to be solved was how to get rid of the trepidation (*sic*) which, in the case of a locomotive weighing 120 tons, would have rendered the metals unsafe. The Heilmann machine can start a train weighing 450 tons without the slightest jerk, and on St. Cloud Hill, after a stop, it restarted quickly and easily, though only using a sixth part of its power — 950 ampères instead of 6,000 (*sic*). Regular speeds of 110 or 120 kilometres (*sic*) are assured with such machines as this new one. Its power in ordinary working circumstances is 1,600 horsepower."

The Heilmann locomotives had an advantage over future diesel-electrics in that one of the fundamental characteristics of the steam engine is that it gives maximum torque at starting and so the control arrangements between engine and dynamo (in this case a modification of the Ward-Leonard system) could be much more straightforward than those required for an internal combustion engine/generator combination which had to avoid the possibility of stalling.

The company behind these locomotives soon ran out of money, even though there was a great deal of interest in its schemes as far apart as Russia and the USA. The locomotives were dismantled and each bogie used as the running gear for some straight electric 0-8-0 locomotives to work the 4km between St. Germain Ouest and St. Germain Grande Ceinture in Paris, which mostly lay underground.

Thus the mother and father of all main line diesel-electrics were a pair of steam locomotives built way ahead of their time, looking like something from a Jules Verne or H. G. Wells science fiction adventure story of the era. Ten years or more later, with the application of high superheat and mechanical stokers or light fuel oil firing, they might have made a commercial breakthrough but that was not to be.[9]

The high speed steam engine for electricity generation gradually gave way to the steam turbine of Sir Charles Parsons (and an early steam-turbine electric obviously inspired by the Heilmanns) and the Rugby factory of Willans & Robinson built its first diesel engine in 1906, a single cylinder machine of 130bhp containing the seeds of the later 'K' series.

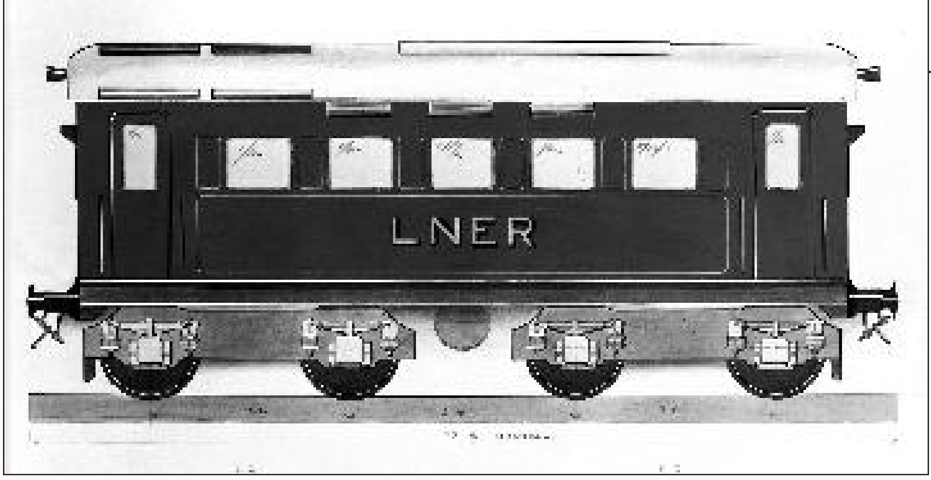
Internal combustion engines had been produced in Britain for several decades by the turn of the century mainly using coal gas either as a by-product from within an industry or from the town gas systems as they were introduced and extended. Gas engines obviated the need for boilers with all the associated firing, overseeing, maintenance and insurance although their application was limited. They were built under licence[10] to the patents of Jean Lenoir and were soon complemented by Nicolaus Otto's 'silent engine' and then his four-stroke cycle in 1877 which by 1885 had been adapted to burn petroleum (gasoline) using a carburettor as a vaporiser.

Petrol was a volatile and dangerous by-product of the rapidly expanding oil industry whose main yield was oil for lighting and heating; gradually, lubricating and other specialised oils were developed, often to replace those obtained from vegetables and animal fats. There were many attempts elsewhere to burn less volatile fuel oils but numerous difficulties were encountered: in starting, in vaporisation and in preventing the build-up of carbon deposits.

One of the first men to address the difficulties was William Priestman of Hull.[11] Priestman was educated at Bootham School in York and served an apprenticeship with Sir W. G. Armstrong & Co. in Newcastle and later worked at the North Eastern Railway's Gateshead Works before returning to his father's Holderness Factory in Hull. He applied for his heavy oil engine patent in 1885 and production engines were soon driving machinery and barges the world over. In 1894 a shunting locomotive was built which was given a trial on the Alexandra Docks lines of the Hull & Barnsley Railway and three years later an oil-engined lorry was built. Transmission problems delayed acceptance of both concepts.

A contemporary of Priestman was another Yorkshireman, Herbert Akroyd Stuart, who was

The 2,660hp (2'Do1') + (1'Do2') twin-unit locomotive running on the Canadian National Railway when new in 1927. Each unit was fitted with one of the Glasgow-built Beardmore 1,330hp V12 engines. This was the first of the type to run in North America, the next being a pair of General Motors Bo-Bos (built by the St. Louis Car Co.) used for the new 'Super Chief' service of the Atchison, Topeka & Santa Fé at the end of 1935, eight years later and eight years wasted as far as British exports were concerned. (CNR/Author's Collection)



The Harland & Wolff Company of Belfast set up a diesel traction department in the 1930s using the Danish Burmeister & Wain engine technology which it built under licence. The company sent out details of various proposals to many companies complete with drawings coloured to the companies' livery. This Bo-Bo was sent to the LNER with no response. (Author's Collection)

working on oil engines and took out a patent in 1890.[12] In it he described a four-stroke cycle, the induction stroke drawing in air only and compressing it on the second stroke into the combustion chamber into which the fuel oil was then sprayed by solid injection. The engine was not cold starting; the combustion chamber was first heated with a lamp — the 'hot-bulb principle' — but once running enough heat was retained for no other ignition to be required. One of the first engines (built at his father's Bletchley Works) was sent to F. W. Webb at Crewe but what was done with it is not known.

Richard Hornsby & Sons of Spittlegate Ironworks, Lincoln, took over manufacture of Stuart's engines under the label Hornsby-Ackroyd and it was that firm which developed the engine further — Ackroyd Stuart emigrated to Perth, Australia, in 1899 due to ill health which had kept him divorced from developments at Lincoln. Those were carried forward by Robert Edwards, chief engineer.

A total of 32,417 engines was built, including the first oil-engined agricultural tractor and several oil-engined locomotives for the 18in gauge Royal Arsenal Railway at Woolwich and the 30in gauge Chattenden & Upnor Railway at Chatham Dockyard. Six locomotives in all were supplied between 1896 and 1903.[13]

One interesting test performed in 1892 was the raising of the compression ratio and blanking off the vaporising chamber with a plate; the engine was then started on compression only (as in a diesel) and run for six hours. This treatment inflicted heavy wear and knocking and the experiment was neither repeated nor used as a basis for the full implications to be followed up. Nevertheless, in practical terms Rudolf Diesel's engine had been anticipated. It is always worth remembering that the Hornsby-Ackroyd engines used solid fuel injection, essential in the diesel's lightweight and medium and high speed form as employed for traction purposes, whereas Diesel used the complex and energy consuming air-blast method for many years, usually one associated with the slow-running, heavy 'A' frame engines typified by those used in slow speed marine service.

On a personal note, I was given a 'courtesy car' a few years ago after the easily accessible firm which normally serviced my car (and which was easily reached on foot from home/work/the city centre) closed down, its successor being three miles out of town 'conveniently' near the outer ring road. The car was a 'diesel'. Not having been anywhere near one before I was told to 'wait until the light went out' before fully switching the engine on. Going through this procedure, I suddenly shouted "Ackroyd Stuart!". Fortunately the windows were closed so no-one heard me and removed the keys, but I have since pondered on how many so-called diesel engines in cars, lorries, buses and locomotives actually use a heating element or 'glowplug' for initial start-up and should therefore be called Akroyd Stuart engines. From then on I realised that the persistent use of the term 'oil' or 'heavy oil' engine in Britain was not just because of jingoism or anti-German feeling but was based on a reality often clouded by the myths and legends surrounding Dr. Diesel and his engine.

One of the earliest schemes based on an internal combustion engine with electric transmission for large, main line traction was for the Trans-Australia Railway, planned in the years preceding the First World War.[14] The locomotives were to be built by R. & W. Hawthorn, Leslie & Co. to the ideas of Captain William P. Durtnall who was a champion of electric transmission for road vehicles, ships and railway traction. His ideas and patents were marketed by a company under the 'Paragon' banner.[15] Unfortunately the war delayed the building of the railway and although the line crossed the arid Nullarbor Plain, steam was preferred for traction, water being supplied from a number of deep wells bored down into the desert. Hawthorn, Leslie only ever built one modest 'Paragon' locomotive — a 320hp Bo-Bo — but it was purely experimental and never left the works.[16]

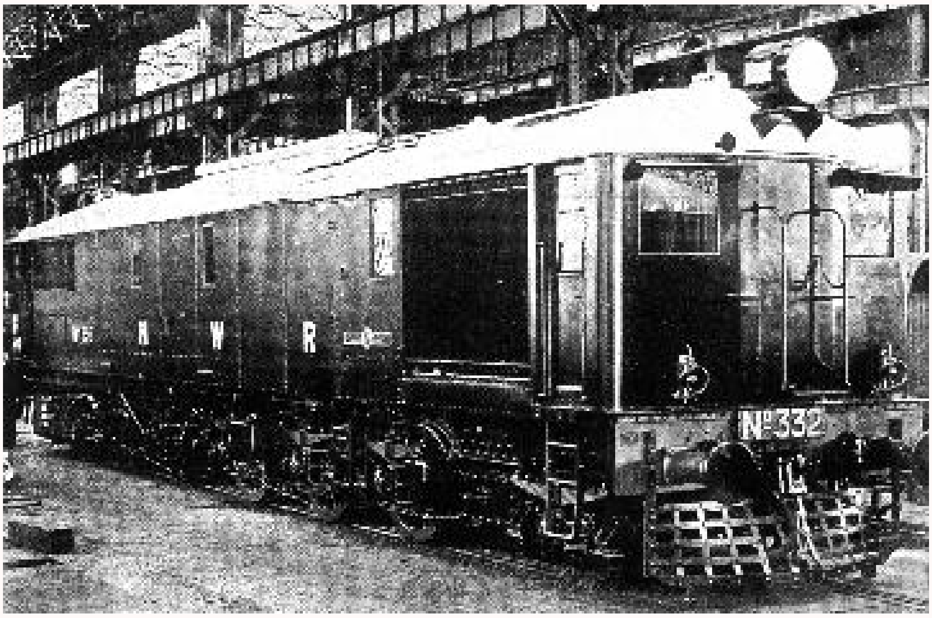
The major upheavals during the war and post-war period, as far as we are concerned was within the electrical and the locomotive building industries. In the early years of the twentieth century all the main players in the British electrical industry, except one, were wholly or partially subsidiaries of foreign ones; thus British Westinghouse was an outpost of the US Westinghouse firm, the British Thompson-Houston Co. was a subsidiary of the US General Electric Co. and Siemens Brothers' parent company was in Berlin.[17]

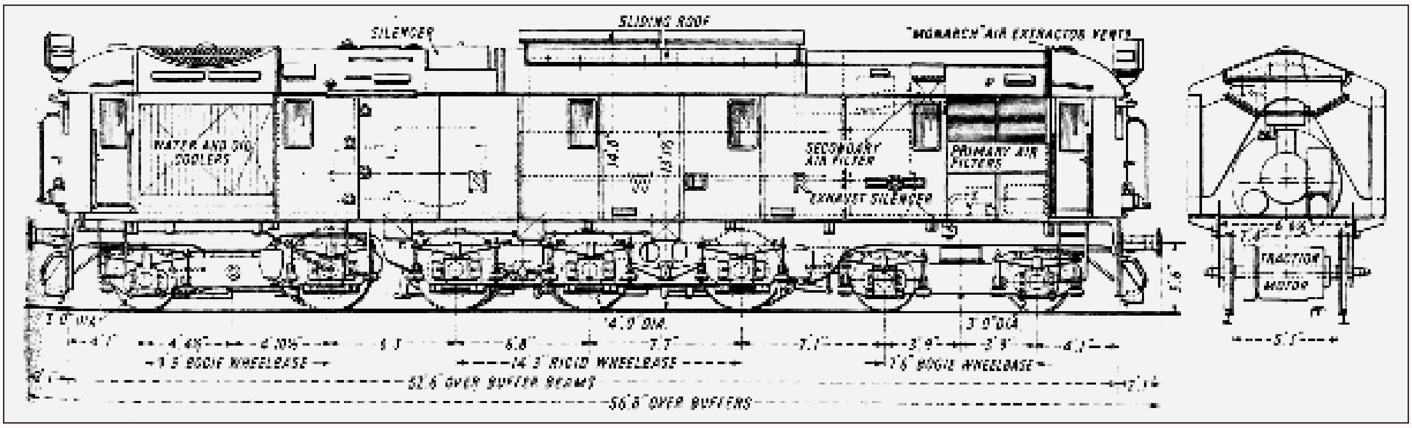
The exception was Dick, Kerr & Co. of Preston, a name known in our day more for its rightly famous and groundbreaking Ladies Football Team than for its work and products.

W. B. Dick & Co., based at the Britannia Engineering Works, Kilmarnock, a general engineering firm, typical of the period (and of Kilmarnock), became Dick, Kerr & Co. Ltd. in 1883 and began to specialise in tramway equipment, including the patent Morrison & Kerr steam tram (as supplied to the Alford & Sutton Tramway), as well as becoming contractors for complete tramway projects. The company was the contractor for the extensive Edinburgh cable tram system and the Liverpool Overhead Railway.

The North of England Railway Carriage & Iron Co. was in business in Preston from 1863 until it went into liquidation in November 1878 and the premises remained unoccupied for twenty years before being taken over by The Electric Railway & Tramway Carriage Works Ltd. in 1897 which also extended the works into some undeveloped areas of land. At the time there were few specialist tramcar builders in Britain, excess demand usually being supplied by some of the

The largest diesel-electrics built in Britain were two (1A)' Co2' for the North Western Railway of India in 1935, intended to work the mail trains from Karachi to Lahore over the Sind desert. The number of axles and electric motors was the same as for the CNR locomotives. There were teething troubles with these locomotives which were never overcome and Armstrong, Whitworth ceased rail traction work whilst the traction equipment was at Scotswood under repair and modification. The project ceased but the railway continued with its experiments with other railcars and locomotives. After partition Pakistan obtained Alco locomotives from the USA.
(Author's Collection)





The diagram for the Armstrong, Whitworth 1,200hp (Sulzer 8LD34 Type engine). The post-war English Electric 1,600hp main line locomotives for Egypt of the (1A) 'Do (A1)' type were almost certainly influenced by this design. Note the positioning of metal 'N.W.R.' letters on the side sheeting, something adopted on No.10000 — 'L.M.S.' in 1947. (Author's Collection)

traditional carriage and wagon builders. The ER&TCW, promoted by Dick, Kerr, was prescient in that it was ideally set up for the electric tramway boom which followed in the years up to the First World War.

The manager of the firm was E. A. Stanley who had had training in the USA where the streetcar boom pre-dated the British one and initially it was intended to import the motor-driven trucks from the USA from such makers as Brill and Peckham. In 1900 a new works was built alongside — the English Electric Manufacturing Co. Ltd. — to make miscellaneous electrical equipment relevant for tramways and related contracts and in 1905 the ER&TCW changed its name to the United Electric Car Co. Ltd.

In 1902 Dick, Kerr & Co. obtained the contract to electrify the Liverpool to Southport line of the Lancashire & Yorkshire Railway and in the following year absorbed the EEM Co. completely and that works took on the name of its parent company — Dick, Kerr & Co. Ltd. The United Electric Car Co. was finally taken over in 1917.[18]

The (new) English Electric Co. was formed in 1919 from Dick, Kerr & Co., the Phoenix Dynamo Co. of Bradford and Willans & Robinson of Rugby. The Siemens Dynamo Works in Stafford was purchased (it had be compulsorily acquired by the Government as enemy property during the war). The Phoenix Dynamo Co. of Bradford had been set up in 1900 in order to manufacture small motors and dynamos specifically for the textile industry but found wider markets and later became the centre of electric motor and generator design for English Electric.

In 1916 British Westinghouse was refused admission to the newly-formed Federation of British Industries because the company was American controlled and so the board decided to break away and asked for help from Frank Dudley Docker, a Birmingham financier and the boss of BSA and the Metropolitan Carriage and Wagon Co. He managed to pay off the Americans but his plans for a giant British electrical combine fell through and British Westinghouse and Metropolitan C&W were sold on to Vickers, the large electrical works at Trafford Park in Manchester, becoming Metropolitan Vickers (Metrovick).

One of the features of main line diesel-electric traction which was to become clear in 1920s and was to be a major arbiter for any firm trying to get in the market was the tri-partite nature of the job: diesel engine, electrical equipment and the mechanical contruction of the locomotive. Whoever signed the main contract had to guarantee the whole package to the customer and even a single locomotive was very expensive. It would certainly not have been a wise move for any of the traditional locomotive builders to take on such contracts and any of them that *were* interested tended to look to other forms of transmission, of the sort they could eventually construct themselves (hence many mechanical, pneumatic and hydraulic schemes in the 1920s and 1930s, eg the Kitson-Still 2-6-2, LMS 0-6-0 No.1831 etc.). If any contracts were to be undertaken it was best that the company named on the contract could supply at least two of the functions and perhaps, through associated companies, all three.

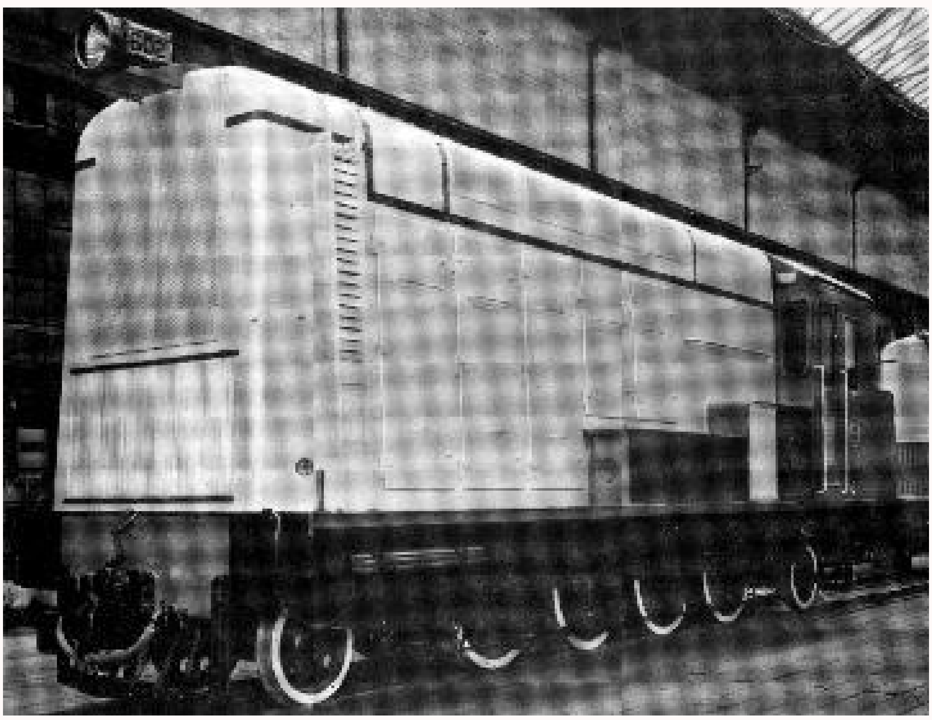
This explains to some extent how and why traditional locomotive builders such as the Vulcan Foundry were fairly effortlessly later absorbed into the dominating electrical companies.

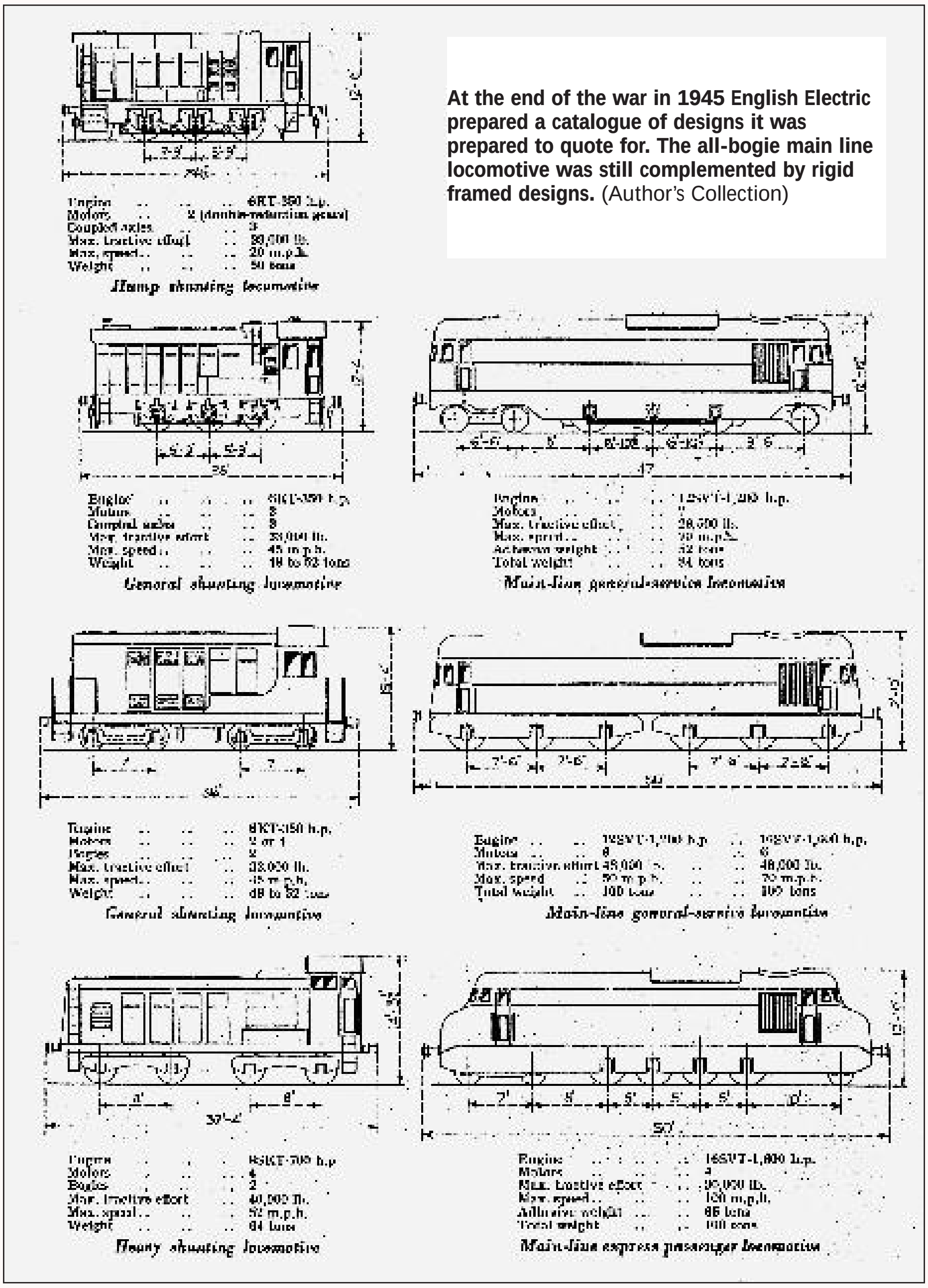
Despite all wishful thinking that it should be otherwise, the British electrical industry in the inter-war period came to be dominated by American managers and American money and it seems that English Electric was saved from going under after a poor showing in the 1920s by US help.[19]

The most expensive unit part of a diesel-electric locomotive was the diesel engine itself and the development of a suitable engine for railway traction, especially in the higher power ranges was a slow business; both land and marine applications were too large and heavy at first.

Two Swiss firms, Sulzer and Saurer, took the lead, the former in large railcars and early locomotives and the latter producing the first engines suitable for buses and lorries and which were easily adaptable for lighter railcars and railbuses. The First World War saw considerable developments in the internal combustion engine, particularly those used in aircraft, and those technical developments found their way into the engines used in sports and racing cars after the war. The airship, already regarded as a fire risk because of its hydrogen-filled gasbags, required engines which were more fuel-efficent and burned a less volatile fuel than petrol and so a great deal of effort went into developing powerful diesel engines with high power-to-weight ratios.

The first English Electric main line diesel-electric was this 1' BB1' design for the metre gauge Eastern Railway of Brazil. Many features are those of the 0-6-0 shunter then becoming something of a standard, the design and manufacture of which was undertaken by Hawthorn, Leslie & Co., English Electric only supplying the engine and electrical equipment. The Brazilian locomotives were the last to be erected at Forth Banks before being sent to Preston (the venue in the photograph) for fitting out. Note the cab is still like the shunter whereas the long hood is taking on the form best known in the British Railways EE Type 1. (EE/Author's Collection)





At the end of the war in 1945 English Electric prepared a catalogue of designs it was prepared to quote for. The all-bogie main line locomotive was still complemented by rigid framed designs. (Author's Collection)

The end of the hostilities left a number of large munitions companies looking for new product lines and alternative markets to exploit. In Britain several of such firms turned to the locomotive building field much to the alarm of the existing builders, most of which were members of the Locomotive Manufacturers Association.

Four of the big armament works stated their intention to move into locomotives. They were William Beardmore & Co. of Dalmuir, Sir W. G. Armstrong Whitworth & Co. Ltd. of Scotswood, Vickers Ltd. of Barrow-in-Furness and the Royal Arsenal, Woolwich.[20]

Vickers Ltd., after undertaking some miscellaneous steam repair work and building some Bo-Bo electrics for the Metropolitan Railway, dropped its plans. The Government-owned Royal Arsenal's scheme was ill-thought out and little more than a political gesture. The resulting fiasco cost the taxpayer over £1,000,000 for the 100 locomotives produced, some complete, many only in parts, before the Government withdrew from locomotive building.[21]

The two remaining firms — Beardmore and Armstrong Whitworth — offered severe competition to the traditional steam locomotive builders and were to become important pioneers in main line diesel-electric traction. Beardmore consisted of a number of different works and departments and built a wide variety of things from ships to aircraft and taxi-cabs to steam locomotives, production of the latter commencing in 1920. It was at Beardmore that Alan Chorlton developed his diesel engines for airships and it was from this range that came the earliest railcar applications — on the Canadian National Railway — in 1925.

There were others in various parts of the world, notably the conversion of a four-car set from the ex-Bury to Holcombe Brook 3,500V dc trial installation of 1913 (a Dick, Kerr contract). This was done in 1927–28 at the time when Crewe-trained Alan Chorlton[22] (later Sir Alan) was President of the Institution of Mechanical Engineers where he would have regularly met Sir Henry Fowler of the LMSR. The set was intended for main line trail running but ended up on stopping trains, sufferring from a great number of teething troubles and lack of interest by local operators (who probably knew nothing about it until it appeared on their patch).

The railcars, built for or by railways in various parts of the world, which carried Beardmore engines were overshadowed by a twin-unit main line diesel-electric (2'Do1') - (1' Do 2') of 1927 for the Canadian National Railway.[23] Each unit carried a Glasgow-built 1,330hp V-12 engine running at 800rpm. One of the engines was supercharged at the makers and gave 1,500hp but the equipment was removed as it was found to be too noisy.

The main contractor was the US company Westinghouse and large cast steel underframes were used on each unit supplied by the Commonwealth Steel Company of Granite City, Illinois (later the General Steel Castings Corporation famous for cast steel 'engine beds' for steam locomotives and patentee of the Commonwealth bogie). Unfortunately this resulted in an all-up weight of 290 (English) tons for 2,660 installed horsepower, hardly competitive when compared with the 'Superpower' steam of the era.

It has been suggested that this was a deliberate ploy by Westinghouse, a firm which was aggressively marketing full main line electrification schemes and did not want any competition from high-power diesel locomotives; railcars and switchers it could live with and indeed it took out a manufacturing licence to make a number of the Beardmore designs, although the first sixteen Westinghouse-plated engines were actually built in Glasgow. Railcars and switchers were built in the WEM Co. shops in East Pittsburg.

In the nine years from January 1928 to January 1937, Westinghouse produced 26 locomotives domestically and three in Canada as well as Beardmore engines for use in railcars and switchers built elsewhere.[24] The company had developed the engines with many design improvements. The four-, six- and eight-cylinder in-line engines with 8 in x 12in cylinders, giving 200, 300 and 400 horsepower respectively, were enlarged to 9in x 12in and increased in speed. The six-cylinder engine gave 400hp at 900rpm and a turbo-charged version produced 530hp at the same speed. Westinghouse produced a V12 version (800hp not turbo-charged) and two of these engines were installed in the largest locomotive built, a centre-cab Bo-Bo of 1,600 hp weighing 118 (English) tons and completed in January 1934.[25]

Westinghouse did not build any of the 1,330hp V12 engines (they had 12in x 12in cylinders) which is a pity; it may have enlarged the design into a turbo-charged V16 of 2,000 hp and pre-empted General Motors.

In June 1936 the locomotive builder Baldwin entered into an agreement with Westinghouse whereby it would actively enter the manufacture and sale of main line diesel-electrics solely using Westinghouse electrical equipment. Rather than obtaining rights to the Westinghouse-Beardmore engines, however, Baldwin developed the DeLaVerne series of engines which was built in Baldwin's Eddystone Plant, that company having been acquired amongst a number taken over in 1931. This is no part of our story other than to say that its predecessor, the DeLaVerne Refrigerating Machine Company, in 1891 acquired the sole American rights to manufacture engines to the British Hornsby-Ackroyd designs. Its first engine, built in 1895, was the first compression ignition engine to be built in the USA and is preserved in the Smithsonian Institution in Washington.[26]

Beardmore's rail department had not proved profitable despite being the fourth largest builder of steam locomotives in Britain between January 1924 and June 1929, as the table below reveals:

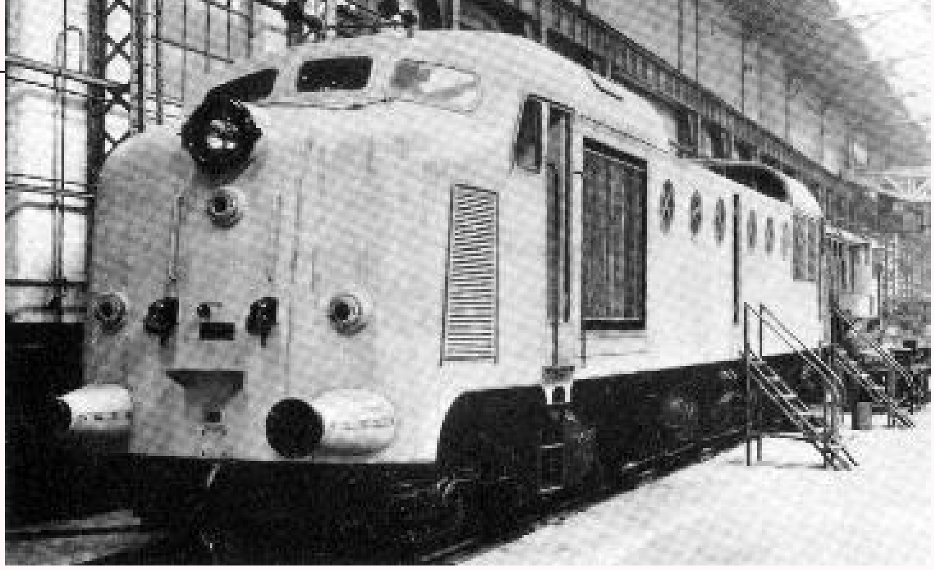
Firm	Quantity
North British Loco. Co.	595
Vulcan Foundry	410
Sir W. G. Armstong Whitworth	340
Beardmore & Co.	186
Beyer, Peacock & Co.	113
Robert Stephenson & Co.	109
Total	1,753

The steam side of things was thus closed down in 1930 after outstanding contracts had been completed although the British interest in Caprotti valve gear was retained and the diesel rail traction section continued its work.

The crash of the airship R-101 on her twelfth flight on 4th September 1930 had a *Titanic*- type effect on the British public and what had been regarded as a potentially lucrative market for high power-to-weight diesels was lost overnight. The last flight of the R-101 was the last flight made by a British rigid airship.[27]

In 1933 the Beardmore board decided to rationalise all its diesel work (air, marine, rail traction and road vehicles) and asked Sir Henry Ricardo to produce an independent report; this appeared in the following year. He found that the company was offering fourteen different high-speed engines with four cylinder sizes and that nine of them were for rail but there had been no new orders since 1930. He suggested that there had been a misplaced emphasis on rail and that the company should focus on engines for road vehicles. The company therefore rationalised diesel manufacture and closed the rail traction section although a spares service still operated. A number of engineers and designers from this department found their way to English Electric.

Armstrong Whitworth[28] entered the locomotive industry in a thoroughly well-planned manner in 1919 with two big orders: 50 0-8-0s for the North Eastern Railway and 200 2-8-0s for Belgium. The company had a full design and drawing office facility and could if necessary prepare completely new designs from an outline specification.



One of the Egyptian (1A)' Do(A1)' 1,600hp locomotives under construction at Preston. Engines for this order were transferred to the LMSR Derby Works in order to expedite the construction of Nos.10000 and 10001 and in particular No.10000 so that it could be completed before nationalisation. (EE/Author's Collection)

Twelve 1,600hp locomotives were built for Egypt, six at the Vulcan Foundry which was quick to advertise its experience and capacity in this new, modern field. (Author's Collection)

The earliest diesel orders were as sub-contractors to Sulzer Brothers of Switzerland and an order to the Buenos Aires Great Southern Railway of Argentina. In 1931 the company set up a diesel traction department in earnest and began building Sulzer and Saurer engines under licence.

Three diesel-electric railcars were purchased by the LNER: *Tyneside Venturer*, *Lady Hamilton* and *Northumbrian*, the latter working as *Armstrong-Shell Express* from London Euston to Castle Bromwich on the LMSR for the British Industries Fair in early 1933 before going to the LNER.[29] An 800hp 1-Co-1 'Universal' type mixed traffic design saw trials on the LNER in the summer of 1933[30] and further examples along with railcars and shunters were exported.

The biggest locomotives built were a pair of 1,200hp machines for the North Western Railway of India, intended to haul the heavy mail trains north from Karachi across the arid Sind desert. These locomotives had the unusual (1A)'Co 2' wheel configuration and although the 8LD34 engines gave no trouble, there were many problems with the generators and motors.[31]

Armstrong Whitworth withdrew from locomotive building on completion of a massive order for LMSR 'Black Fives' — 227 built in 1936–37.[32] This followed a large batch of 100 in 1935 and this steam work may have offset a little of the cost of running the diesel traction department. George McArd spent the last 25 years of his career with A-W and related that well over 100 draughtsmen and designers were employed on diesel work from 1934–36.[33]

The Defence White Paper of 16th March 1935 recommended re-armament and in particular a large Naval programme. Beardmore and A-W turned to this work (Scotswood as part of Vickers Ltd.) and there was also some reorganisation in the British locomotive building industry in 1937.[34]

Some staff from Armstrong Whitworth moved to English Electric and in 1937 the latter firm obtained its first main line diesel electric order, three 1' BB 1' rigid frame machines for the metre gauge Eastern Railway of Brazil. The firm also received a large order for railcars from Ceylon.[35]

The English Electric Co. had developed two distinctly different engines in 1933–4 from mainly, it appears, the work of Beardmore. The 'K' type with 10in x 12in cylinders first appeared in six-cylinder form in the first 0-6-0 diesel-electric shunter placed in service in April 1934. The engine was built at the old Willans works at Rugby and the locomotive erected at Hawthorn, Leslie & Co., Newcastle.[36]

This contrasted with the similar Armstrong Whitworth shunter which was first tried from 11th July 1932 in various LNER good yards in the Newcastle area. The most obvious difference between it and the English Electric version was jackshaft drive and inside frames. The LMS ordered a similar locomotive and then ten of each, A-W and EE, to slightly improved designs.[37]

The other EE diesel was the 'H' type which first appeared in 1934 in the single diesel-electric railcar *Bluebird* which was tried on the LMS.[38] This engine, specifically designed for railcars, was of 200hp and had six cylinders running at 1,500rpm as opposed to the 650rpm of the first 6KT installation which gave 300hp (that soon became 350hp at 700rpm in the first production batches and 350hp became the standard rating in British service).

The 'H' type was used in the 1937 order for railcars for the 5ft 6in gauge in Ceylon but after the war the 'K' type came to be used in many railcars in the classic layout typified by the Southern Region's Hastings units.

The first eight-cylinder 'K' was the 8KT used for the three Brazilian 1' -BB - 1' and was rated at 450hp. There were two traction motors, the driving wheels being connected through coupling rods and fly cranks in two groups. The frames were, of course, outside.

to be continued

References will be listed at the end of this series.