COMPOUND INTEREST

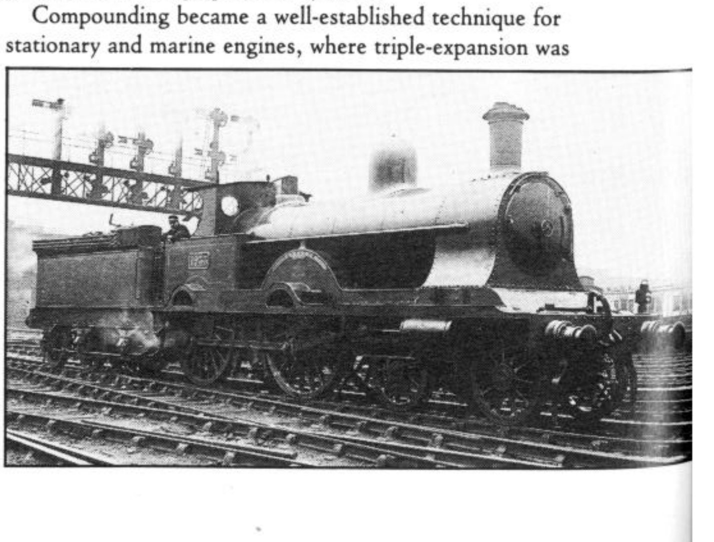
THROUGHOUT EUROPE AND NORTH AMERICA THE COMPOUND LOCOMOTIVE ENJOYED BOTH SUCCESS AND LONGEVITY; INDEED, ONE CLASS OF RUSSIAN COMPOUNDS NUMBERED NO LESS THAN NINE THOUSAND ENGINES. YET, DESPITE THE EFFORTS OF LOCOMOTIVE ENGINEERS SUCH AS FRANCIS WEBB, THOMAS WORSDELL, WALTER SMITH AND SAMUEL JOHNSON, COMPOUNDING NEVER BECAME WHOLLY ACCEPTED ON BRITAIN'S RAILWAYS. IN THIS EXAMINATION OF THE THEORY AND PRACTICE OF COMPOUNDING, STEPHEN HARRIS LOOKS AT THE REASONS FOR THIS CURIOUS RELUCTANCE

Above: The most populous class of British compound locomotives was that of the Midland Railway and it is on the Midland main line at Mill Hill that No1040 was caught at the head of a down express on June 5, 1937 (*H.C. Casserley*). Right: One of the compound 4-4-0s designed by F.W. Webb for the LNWR, No1933 *Barfleur* stands at Chester on April 3, 1920 (*H.C. Casserley collection*).

OTHER countries had compound locomotives in abundance. In France and in parts of Germany they were long considered the norm for express working; in many parts of the world, the compound Mallet-type articulated engine lasted for decades, and in the USA reached colossal sizes (though 'simple' versions got even bigger); in Russia, Lopushinskii introduced a two-cylinder compound 0-8-0 design of which more than *nine thousand* were eventually built. (Admittedly, it was his 'simple' class E 0-10-0 which became the world's most numerous class with an estimated total of 12,000 units!). The Great Northern Railway of Ireland's most famous express engine design was the 3-cylinder compound 4-4-0 class introduced in 1932, Nos83-87 (named after birds of prey). Yet in Britain, the total number of compounds in service at nationalization in 1948 was only about 240, and these were all of one type. So why did compounding never really happen here?

In a conventional or 'simple' engine, steam is admitted to the cylinders at boiler pressure, moves the piston and is then exhausted to the atmosphere. Engineers realised early on that the steam was still at considerable pressure when it left the blastpipe, and that a lot of power was being wasted, even when the steam was used expansively by cutting-off the admission to the cylinder before the piston had travelled its full length. The most obvious way of getting the steam to do some more work before allowing it to escape was to feed it to another cylinder. This is what happens in a compound engine: the steam goes from the boiler into a high-pressure cylinder or cylinders, and the exhaust from the still-expanding steam is fed into a secondary or low-pressure cylinder. The low-pressure cylinder needs to be very much larger in diameter to allow the steam, now at probably under half its original pressure, to provide a roughly similar 'push'. Restrictions on the flow of steam through the low-pressure cylinder simply cause increased back-pressure on the high-pressure cylinder.

Compounding became a well-established technique for stationary and marine engines, where triple-expansion was



common and even four-stage expansion had been used. Later, two-stage compounding was also successfully applied to road locomotives, ploughing engines and steam rollers. Many railway engineers tried compounding (although only Webb on the LNWR seems to have tried a triple-expansion engine), but the results almost never justified the expense. In a way, this is not surprising, because a number of factors combined to make things more difficult for the Victorian railway engineer: first, space and weight considerations, which prevented the use of really large cylinders; second, the same restrictions prevented the use of very high boiler pressures, which would have made compounding worthwhile; and third, any steam railway engine had to combine the ability to start a heavy train from rest with the ability to maintain this power output while running freely and economically at high speed.

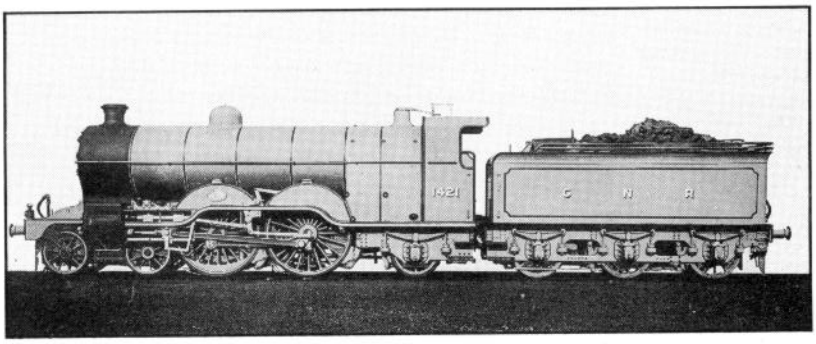
This last ideal was difficult enough to achieve with a simple-expansion engine, let alone a compound. It is hard to escape the conclusion that a majority of British steam locomotive designers achieved success more by good luck that by any serious grasp of the real behaviour of steam, port design or control of valve events. Time and again, locomotive superintendents followed free-steaming, free-running engines with supposedly 'improved' designs spoiled either by poor steaming or by poor front-end design. In such cases compounding, so to speak, compounded the problem: it could never effect a cure.

But for some nineteenth-century designers, efficiency through compounding became a holy grail, pursued despite continued failures. One of the main attractions was the hope that compounding would solve the problem of condensation in the cylinders. It was thought that since the condensation was caused by the temperature drop due to expansion in the cylinder, if the expansion process was shared between two cylinders, the temperature drop and hence the condensation in each would be less. Of course, the real answer to this problem was superheated steam, so it is not surprising that interest in compounding died away somewhat rapidly once the performance and coal-economy benefits of superheating were proved. The heyday of compound experimentation was in the era of saturated steam.

The first British compound locomotive may have been an obscure one built in 1827, or it may have been an equally unsuccessful design by Nicholson on the Eastern Counties Railway in 1852. Apart from these efforts, the first and most individualistic British compounder was Francis William Webb, who was chief mechanical engineer on the London & North Western Railway from 1871 to 1903.

Webb's first compound engine was completed in 1882, and was largely based on proposals by David Joy, who had much experience of marine practice. No 66 *Experiment* was an express engine, with the same boiler that had been used on the successful 2-4-0 "Precedent" class, but running at a higher pressure of 150lb/psi. Two high-pressure cylinders, of 11½-inches bore x 24-inches stroke, were mounted outside, driving the rear pair of 6ft 6in wheels, with their Allan-type slide valves mounted underneath and driven by Joy valve gear. The single low-pressure cylinder, 26-inches x 24-inches, was inside, again with Joy valve gear and driving the front 6ft 6in wheels. The four drivers were not coupled by connecting rods, and so the wheel arrangement was properly described as 2-2-2-0.

A further twenty-nine "Experiments" were built, but the class was far from being a success. The 11½-inches high-pressure cylinders of the original engine were enlarged to 13-inches to give better starting, but from the point of view of compounding theory this could only have made the engine less efficient, since the ratio of volumes between the low- and high-pressure cylinders was now less than 2:1. The next series, Webb's more massive "Dreadnoughts", were better in this respect at least, with 14-inches high pressure cylinders and a 30-inches low-pressure. The larger boiler of the "Dreadnoughts" had a bigger grate area and a pressure of 175lb/psi. The driving wheels, again uncoupled, were 6ft 3in diameter. A total of 40 were built between 1884 and 1888. The "Dreadnoughts" had wonderful names even by the exotic standards of the LNWR: *The Marchioness of Stafford* was the odd lady out among a collection that included *Medusa,*



Above: H.A. Ivatt undertook some experiments with compounding during his time with the Great Southern and Western Railway in Ireland but saw no great advantages. His later work with compounding on the Great Northern was only at the insistence of general manager, Oliver Bury, and the final outcome was this 4-cylinder compound Atlantic, No1421 (*H.C. Casserley collection*).

Greyhound, Vandal, Harpy, Thunderer, Leviathan, Mammoth and so on. The series was filled out by a number of *City Of Liverpool, City of Manchester* and others, while railway history was evoked by the *Huskisson* : but, though it would have been appropriate, *Autocrat* presumably wasn't named for Webb himself!

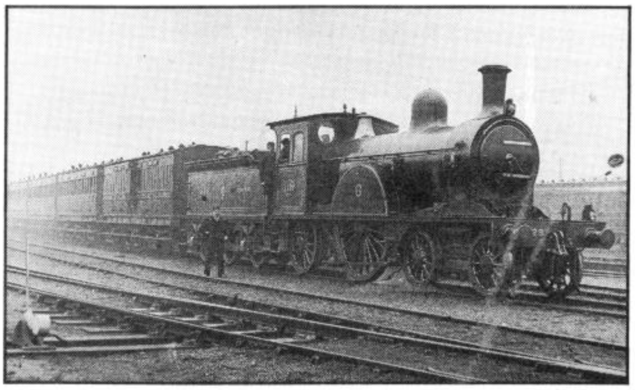
Although they were faster and better load-haulers than the "Experiments", the "Dreadnoughts" were still rather mediocre engines and were very far from having proved any benefit from the compound principle. But after this came Webb's most successful compound class, the "Teutonics". For this series, which had the same boiler and cylinder dimensions as the "Dreadnoughts", Webb enlarged the driving wheels to seven feet diameter. More crucially, the Joy valve gear for the low-pressure cylinder was dispensed with. Instead, the inside cylinder's valve motion was derived from a single loose eccentric, which was free to turn on the crank axle but was driven by a pin on the side of the crank web. The pin worked in a slot in the eccentric, so that the eccentric would automatically take up the correct position for forward or backward gear when the engine started to move. This meant that the inside cylinder could not be 'linked up': it was always in full gear, with inlet and exhaust ports open to their maximum. Also, the valve travel for all the cylinders was increased against that of the "Dreadnoughts".

Coupling rods could have saved drivers of the "Teutonics" from what must have been the greatest possible embarrassment on starting, when, as sometimes happened, the two pairs of driving-wheels started to slip and revolve in opposite directions! This could happen because when an engine had set back on to the front of a train, the loose eccentric would still be in 'reverse' gear. For starting, the driver operated a valve in the smokebox which directed the exhaust from the high-pressure cylinders straight up the chimney instead of feeding it into the low-pressure cylinders. But if this valve stuck or leaked, and steam did get into the low-pressure cylinder, the front driving wheels could start slipping backwards.

Most famous of the "Teutonics" (and the last of the ten to be built, in 1890) was No1304, *Jeanie Deans*, which worked the 2.00pm Crewe express from Euston, returning with the 7.32pm from Crewe, from January 1891 until August 1899, apart from overhaul periods. Timekeeping was consistently exemplary, and it seems that *Jeanie Deans*, with a regular crew, used slightly less coal per mile than others in the class. In 1895, No1309 *Adriatic* made a special stop run from London to Crewe (158.1 miles) at 64mph.

But Webb's next express engine design showed a regression into eccentricity: this was No3292, *Greater Britain*, built in 1891, and a very large engine for the time. History has shown that merely elongating a successful boiler tends to make matters worse rather than better anyway, but with *Greater Britain*, Webb positively ensured poor steaming by putting his ill-conceived 'combustion chamber' in the middle, breaking the flow of hot gases through the tubes. The extra length was supported on a pair of trailing wheels, and as Webb still insisted on doing without coupling-rods, this made the engine as 2-2-2-2.

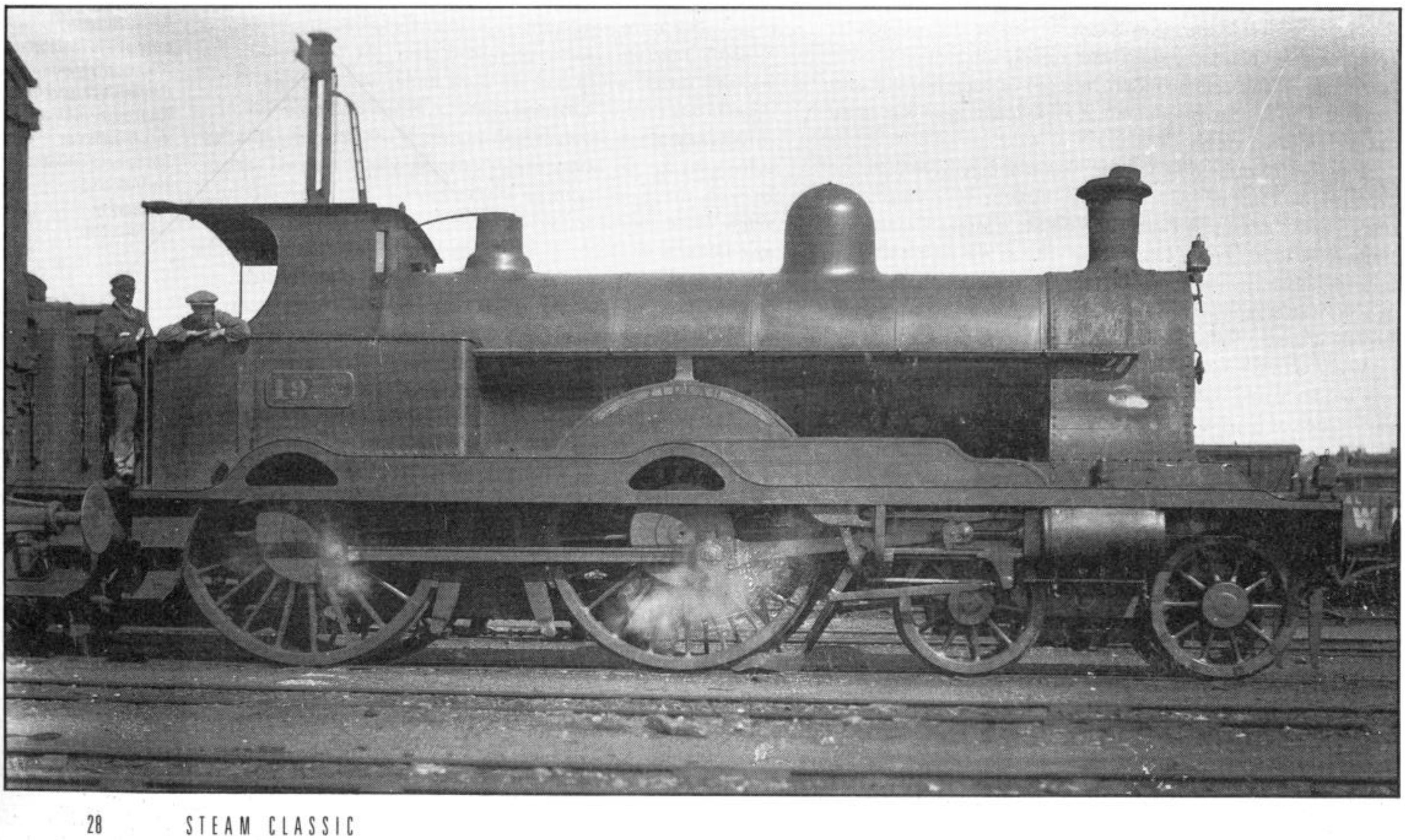
The ten engines in this class were completed by mid-1894, by which time a 6ft 3in version, No20 *John Hick* had also gone into service. A further nine of this class were constructed in 1898, but by that time Webb had started work on his four-cylinder compound 4-4-0, the "Jubilee" class. Webb's primary consideration seems to have been to provide a centre bearing for the driving axle, and this restricted the size of the two low-pressure cylinders between the frames to 20½-inches bore, giving an inadequate low- to high-pressure cylinder volume ratio of only 1.69:1. Added to this drawback was the fact that these engines used only two sets of Joy valve gear for all four cylinders, so that the low-pressure cylinders were 'linked-up' with the same cut-off as the high-pressure ones. This brought back the same old severe restriction to the free passage of steam which, whether by luck or judgement, the loose-eccentric gear of the "Teutonics" had avoided.



Right: North-Eastern Railway Class I 4-2-2 No1329, a 2-cylinder compound built using the Worsdell-von Borries system in December 1888. The class only numbered ten engines (another class of compound singles, with detail differences, Class J, also numbered just ten) and all were eventually rebuilt as simples – in the case of No1329 in May 1900. It was withdrawn from Hull shed, along with four others of the class, on January 28, 1921 (*H.C. Casserley collection*).

Webb also built 3-cylinder and 4-cylinder 0-8-0 compound goods engines, which lasted at least until the First World War. But when it came to express engines, Webb's successor George Whale lost no time in scrapping as many compounds as was practicable and replacing them with sturdy, simple 4-4-0s. Whale's successor, C.J. Bowen-Cooke did the same, and it is only curious that of all the compounds, the ineffectual "John Hick" class were last to be scrapped. Perhaps this was simply because they had been built last; or perhaps it was because, as they already had been relegated from the most important main-line duties, it wasn't essential to replace them. It is sad that Webb, whose "Teutonics" were almost a class of very fine engines (O.S. Nock describes them as a "near miss'), seemed unable to grasp what was good or what was bad about his designs, and clung to various irrelevant half-baked ideas which only made life harder and more frustrating for the enginemen.

Webb's efforts on the LNWR were idiosyncratic and



Below: Webb compound 4-4-0 No1947 Zillah (*H.C. Casserley*).

unscientific to the point of whimsy, and although they aroused interest in compounding, the North Eastern Railway's later Smith compound was to prove more influential. Compounding was introduced to the NER by Thomas Worsdell, who took over as locomotive superintendent in 1885. A year earlier, on the Great Eastern, Worsdell had introduced a 2-cylinder compound 4-4-0 which he had designed in collaboration with the locomotive superintendent of the Prussian State Railways, August von Borries. With the NER, he started by building 0-6-0 (Class C) and 2-4-0 (Class D) compounds using the same principles, and within a couple more years the NER had six classes of compound engines, including 4-2-2 (Classes I and J) and 4-4-0 (Class F) express engines and 0-6-2 tanks (Class B) as well. The 'one-off' compound 2-2-4 tank engine, No66 *Aerolite* is preserved at the National Railway Museum.

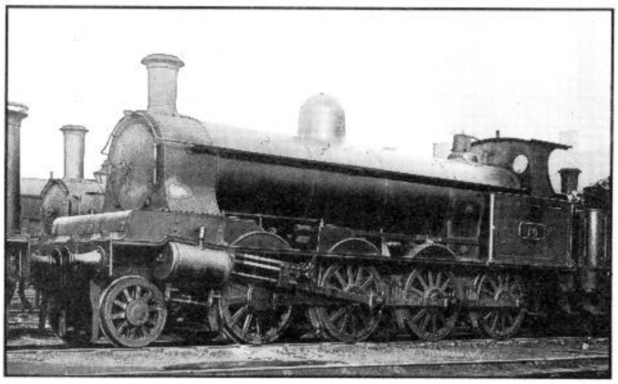
Most of these engines had an 18-inches x 24-inches high-pressure cylinder and a 26-inches x 24-inches low-pressure. Since the cylinders were side-by-side between the frames and with their centres equally-spaced on either side of the engine centre line, it was necessary to cut away the frame on the right-hand side to clear the diameter of the large low pressure cylinder. The Worsdell-von Borries system provided the driver with a valve to admit steam direct to the low-pressure cylinder as desired for starting. Royalities of £30 (or in some cases £50) per engine were paid in respect of the Worsdell-von-Borries patents.

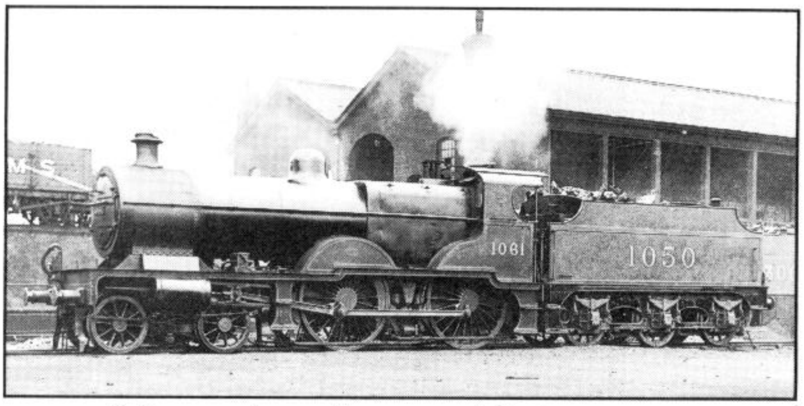
Wilson Worsdell, who took over from his brother in 1890, was against compounding and converted nearly all of T.W. Worsdell's engines back to simples. However, for purposes of comparison he did build one more Worsdell-von Borries 2-cylinder compound, the 4-4-0 No 1619. This engine was rebuilt later to become the first 3-cylinder compound on Walter Smith's system.

A Scotsman, Walter Smith was born in 1842, and served his apprenticeship at the Glasgow locomotive building firm of Neilson. He became chief draughtsman on the Edinburgh & Glasgow Railway under Samuel Johnson, then followed Johnson to the Great Eastern, but in 1874 took up an appointment as locomotive superintendent of the Japanese government railways. He returned to the UK in 1883 to become chief draughtsman on the NER.

Smith's system provided elegant solutions to some to the difficulties of compound design. His 3-cylinder design used a single high-pressure cylinder between the frames, with two low-pressure cylinders outside. This meant that all the cylinders could be of similar size and yet provide a high ratio of piston area between high- and low-pressure sections, and still gave the engine a symmetrical drive with good balancing. In Smith's rebuild of the Class M 4-4-0 No 1619, the inside high-pressure cylinder was 19-inches x 26-inches while the two outer low-pressure ones were of 20-inches bore and 24-inches stroke. Steam was admitted to the high-pressure cylinder by one of Smith's own piston valves, mounted below the cylinder, while the low-pressure cylinders had slide valves with their faces in the vertical plane just inside the frames.

Smith provided a changeover valve so that the driver could start by feeding steam direct to the low-pressure cylinders, then switch from simple to compound working once underway. A one-way valve between the low- and high-pressure cylinders prevented steam going the wrong way back into the high-pressure cylinder when starting, but a small quantity of steam was fed direct from the boiler to the low-pressure cylinders even when working compound. However, the cut-offs for high- and low-pressure cylinders were controlled separately, a further complication for the driver.



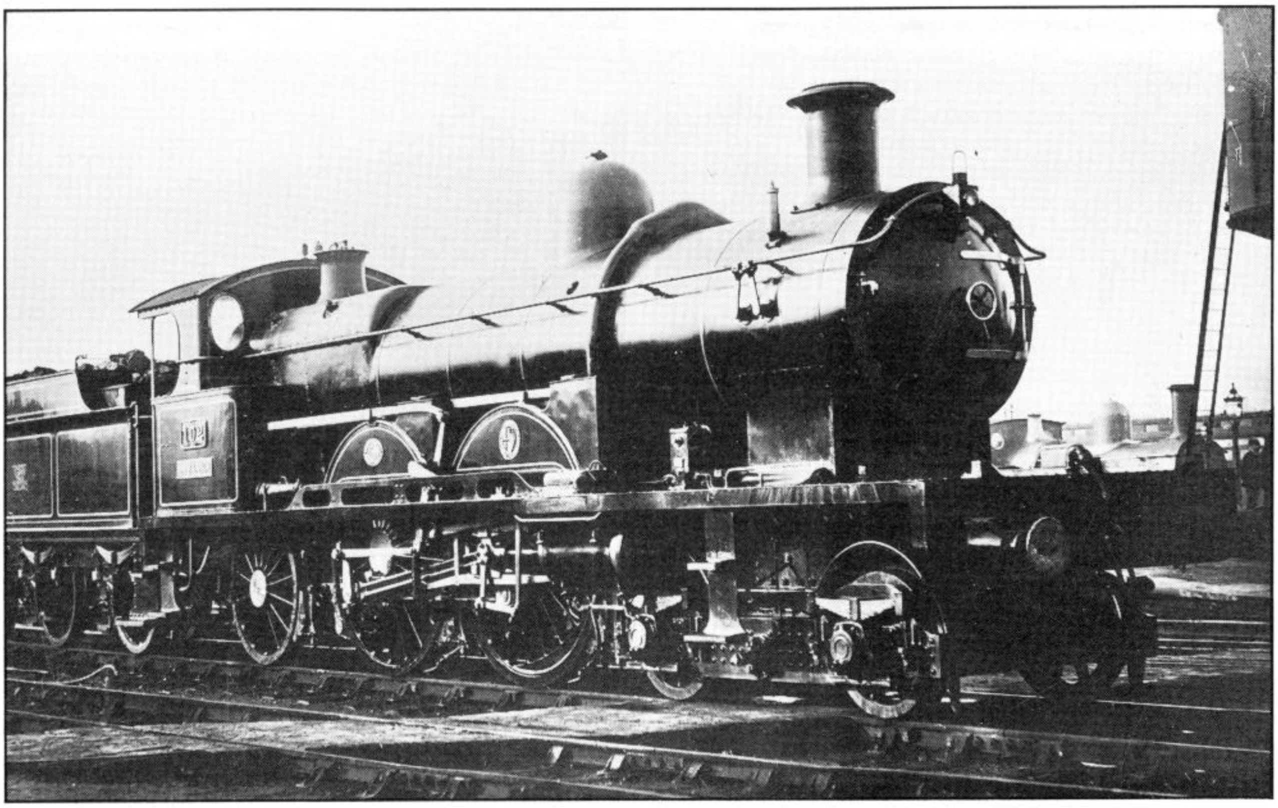


Left: Eight-coupled Webb compound No18, on shed at Willesden on May 3, 1924.
Below: Profile of Midland compound 4-4-0 No1050 at Derby on July 22, 1928 (both *H.C. Casserley*).

No 1619 was successful enough (it ran until 1930) but remained the only example of the type. In 1906, though, Smith was allowed to build two 4-cylinder compound Atlantics, No 730 and 731 (Class 4CC). Along the lines of earlier NER Worsdell Atlantics but with Belpaire fireboxes and a high boiler pressure of 225lb, these engines had 14½-inches x 26-inches high-pressure cylinders outside, and a pair of 22inches x 26inches low-pressure cylinders inside the frames. All four cylinders had piston valves, but by using inside admission for the high-pressure cylinders' valves and outside admission for the low-pressure ones, Smith arranged matters so that the two valves on one side of the engine always moved together and hence only two sets of valve gear were needed altogether. No730 had Stephenson's link motion, No731 Walschaerts valve gear.

Unfortunately, Walter Smith died only a few months after the completion of these engines. They were not particularly successful in service (even when, in 1915, superheating was added), and had cost around fifteen per cent more to build than the Class V 2-cylinder Atlantics. When Worsdell's successor, Vincent Raven, introduced the biggest and best of the North Eastern Railway Atlantics, the superb Class Z and Z1 designs, they were 3-cylinder simples. But by then, the influence of Smith's earlier work had already been felt on the Midland Railway, through the enthusiasm of his old friend and colleague, Samuel Johnson.

The Midland Railway's No1000, preserved and restored to MR livery in 1959 and currently part of the National Railway Museum display, is easily the best-known of all British compound engines. It was actually the Midland's first compound, built (as No2631) by Johnson in 1902 as a straightforward enlargement of Smith's NER No1619. No2631 and its sister engine, No2632, proved to be fast and



Right: Anxious to compare the merits of compound and simple working, George Jackson Churchward arranged for the import of a de Glehn compound Atlantic from France in 1903. Two more French Atlantics were purchased from Belfors Works for further trials, but the de Glehn system failed to persuade Churchward of the advantages of compounding. No104 *Alliance* was one of the imported 4-4-2s. (*H.C. Casserley collection*).

economical engines, encouraging Johnson to build three more of the same type, Nos 2633-2635. These were similar but did not have separate control of high- and low-pressure cut-off.

No1000's present outline reflects the modernising influence of Richard Deeley, who succeeded Johnson in 1904. He rebuilt the compounds with a superheated boiler having a slightly bigger grate and a working pressure of 220lb as against 195lb. Trials suggested that the Deeley-superheated 2-cylinder simple 4-4-0 was superior to an unsuperheated compound, but that a superheated compound was better than either. A further ten compounds were built in 1905-1906. By this time Deeley had further simplified matters for the driver of a compound by making the 'changeover' happen automatically on opening the regulator. When the driver first opened the regulator for starting, steam went mainly to the low-pressure cylinders, with a little going to the small high-pressure cylinder. This meant that the steam pressure was equal on either side of the high-pressure piston, so that it could move without hindrance and without the complication of Smith's one-way valve. Opening the regulator further, which was likely to happen at about 10mph, switched the engine automatically to compound working. The regulator could be closed down again without reverting to simple working.

The numbers of the Johnson/Deeley compounds are confusing, mainly because of the Midland's great renumbering of 1907. At this point the five Johnson compounds, Nos2631-2635, were renumbered Nos1000-1004. Deeley's 1905-1906 engines, originally Nos1000-1009, became Nos1005-1014 and subsequent members of the class, built up to 1909, followed in sequence up to No1044. By this time Deeley had fallen out with the Midland management and resigned, and so his projected 4-6-0 compound came to nothing. But after the grouping in 1923, when Sir Henry Fowler looked to existing designs to provide motive power for the huge LMS network, nearly 200 more compound 4-4-0s were built. These engines, as British Railways Nos40900-40939 and Nos41045-41199, just outlived the original MR engines Nos41001-41044, which were withdrawn between 1948 and 1952, but all were scrapped by 1961.

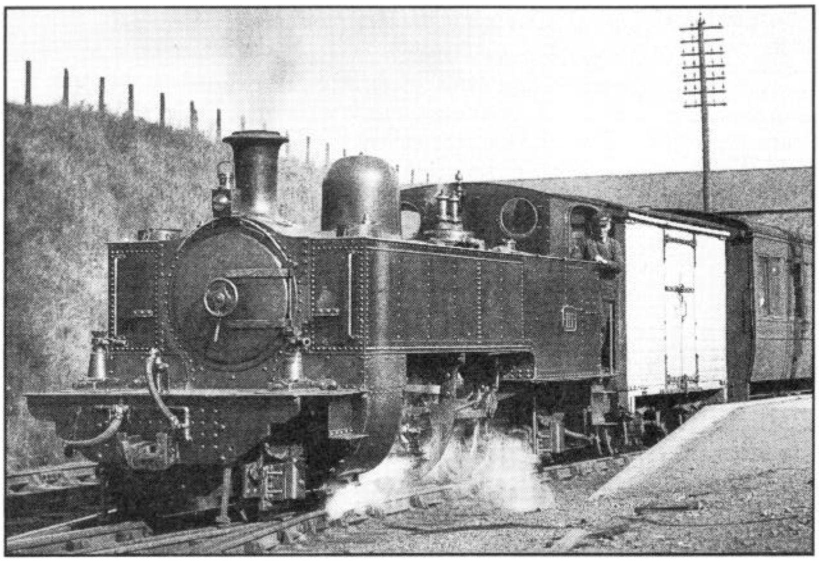
Trained at Crewe, and indirectly working under Webb, H.A. Ivatt remained unimpressed by compounding after his experiments of 1895, when he was locomotive superintendent of the Great Southern & Western Railway in Ireland. He tried compounding both an 0-6-0 and a 4-4-0, in each case replacing the pair of 18-inches x 24-inches cylinders with a high-pressure cylinder of 18-inches x 24-inches and a low-pressure one of 26-inches x 24 inches. This was easier than it would have been in England, because the broader gauge (5ft 3in) of the Irish track allowed more space between the frames. Boiler pressure was 150lb/psi. On the 4-4-0, the changeover from simple to compound was via a Worsdell-type flap valve; on the 0-6-0 the changeover was automatic after starting.

Below: Great Northern Railway of Ireland 3-cylinder compound 4-4-0 No84 Falcon at Amiens Street Station on June 4, 1932 (*H.C. Casserley*).

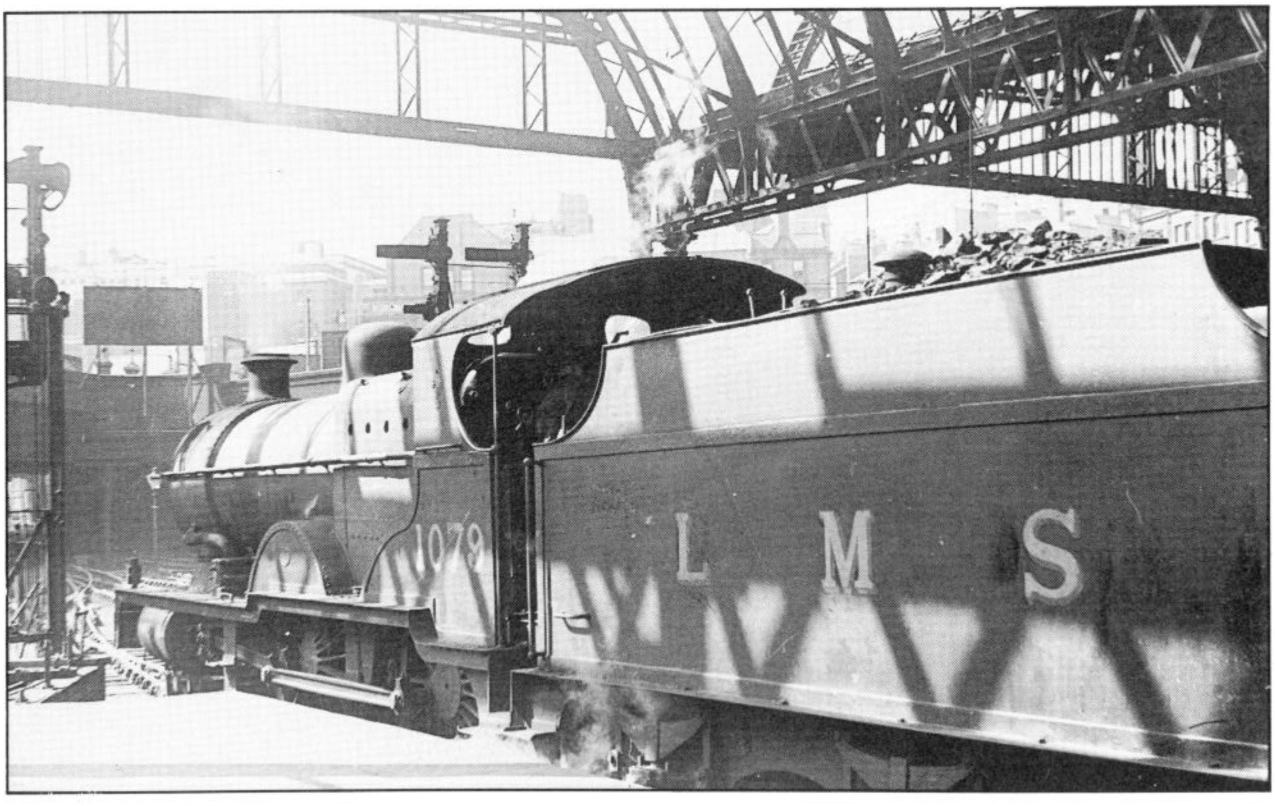
Comparison trials against otherwise-identical simple engines showed that nothing had been lost or gained by compounding.

On the Great Northern Railway in England, Ivatt experimented further with compounding, but only at the insistence of the general manager, Oliver Bury. Ivatt's Large Atlantic, No291, had been an unqualified success, but in 1904 Bury still believed that there were gains in economy to be had from compounding and, over Ivatt's head, arranged the purchase of a 4-cylinder compound Atlantic from the Vulcan Foundry. This more or less obliged Ivatt to design his own 4-cylinder compound version of the Atlantic, and the result was the three-engine comparative trials of 1906. The trials consisted of several weeks running on expresses between London and Doncaster, with crews rotated between the engines and incentives offered to the crew producing the best aggregate performance over the whole trial, to ensure that the men would do their best on all three engines. In the end, the simple engine came out with a coal consumption of just over 43lb per mile, a pound or so better than either of the compounds. This result confirmed Ivatt in his belief that compounding made engines neither better nor worse and this exercise proved the end of compounding on the GNR.

Though Ivatt was one of the pioneers of the 'big engine' in the early years of the century, his designs were conservative beside those of George Jackson Churchward on the Great Western. Churchward's willingness to study American and Continental practice made other designers look insular and unaware. His investigation of compounding began in 1903 with the purchase for trial of a successful example of the breed, the de Glehn 4-cylinder 4-4-2 from France. Churchward later bought another two French Atlantics, and



Top right: Irish Railways 2-cylinder compound tank locomotive No111 at Ballymena on August 11, 1930. Right: Another Irish compound, Northern Counties Committee 2-cylinder 4-4-0 No63 (essenially a version of the Midland design) at Portrush on August 10, 1930 (both *H.C. Casserley*).



Left: Midland Class 4P compound 4-4-0 No1079 awaits departure from Birmingham New Street on May 21, 1948 (*H.C. Casserley*).

Right: Like Johnson at Derby, the Great Central's John Robinson was attracted to Walter Smith's compound technique employed on the NER. Robinson designed two classes of 3-cylinder compounds. No365 *Sir William Pollitt*, pilot engine here, was outshopped from Gorton in December 1906. In 1911, it became the first of the GC compounds to be superheated and lasted until August 1947. (*H.C. Casserley collection*).

Below: No41102 arrives at Tebay with a railtour for Carlisle, via the LNER route to Penrith, on August 21, 1954 (*J. E. Wilkinson*).

eventually used a number of their features (notably the bogie design and some boiler ideas) for his own evolving standard types. The one feature which he did not adopt was compound working. In April 1904, he wrote that he had got the same power out of a simple engine working at 20-25 per cent cut-off as out of a compound at 55-65 per cent.

To some, this claim may have seemed inexplicable, but there was nothing illogical about it. Churchward had discovered how to obtain efficient expansive working in a cylinder by correct design of valve openings and steam passages. He pioneered the use of long-travel valves and large ports, which simply allowed steam to get in and out of the cylinders quickly; he also looked at the clearance ratio (the ratio of the volume in front of the piston when steam was admitted to the volume which was 'swept' when the piston was driven to the other end, analogous to a car engine's compression ratio). Some other designs, and particularly compounds, had hopelessly large clearance volumes which reduced the actual expansion ratio far below what might be expected from the cylinder dimensions. Quite simply, through poor design, many of the experimental compounds actually provided less scope for expansive working in their two stages than did Churchward's single stage.

Ironically, the highly-superheated steam and higher boiler pressures that became possible after, say, 1910, could have made compounding a somewhat more sensible option than before. Subsequently, attempts at compounding were very few and far between, and came to nothing, because even a well-designed compound could not show sufficient fuel economy to offset the higher first cost and maintenance costs. It is hardly to be wondered at that Churchward's successor, Collett, said 'no' to Stanier's proposal for a compound 'Castle' in 1930! From the moment that Gresley was forced to give up his high-pressure 4-6-4 design, No 10000*, the remaining history of the British express engine was straightforward. And simple. ■

*(*See 'They Made History, May issue – Ed.)*

STEAM CLASSIC

STEAM PORTFOLIO

Overleaf: Just three standard gauge locomotives working on the compound principle survive in Britain, none sadly currently operational, and one – presently to be found in the environs of Peterborough – that might be more at home somewhere in Paris!

Main picture: In 1886, the French engineer Alfred de Glehn built his first 4-cylinder compound for the Nord Railway. After teething troubles had been overcome, the design acquited itself well in service and, by the turn of the century, the first of the famous Nord Atlantics had appeared, making an impression upon, among others, George Jackson Churchward of the Great Western Railway. The de Glehn concept was then refined by another Frenchman, Gaston du Bosquet who, seeking the greater adhesion available from a six-coupled wheelbase, built a 4-6-0 version. This entailed a reduction in driving wheel diameter to 5ft 8in but du Bosquet compensated for any loss of speed by proportionately increasing the areas of the steam ports and passages, so making a considerable contribution to steam locomotive design *per se*.

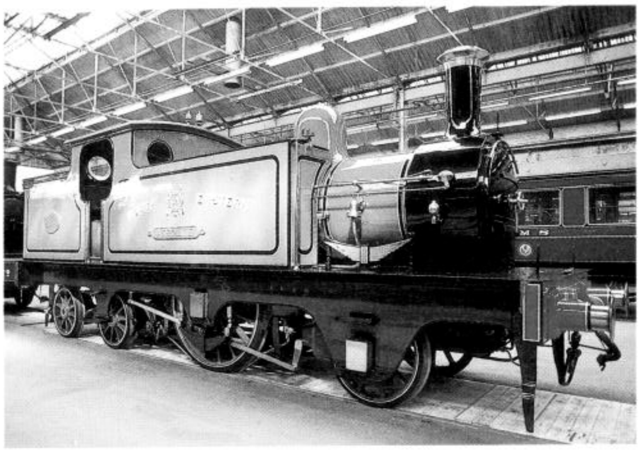
The first de Glehn/du Bosquet compound 4-6-0s appeared in 1908 and their performances soon earned them the wholly appropriate nickname of 'Runners' from engine crews. Altogether, 149 of the Nord 3500 class were built up to 1913 and, in terms of power-to-weight ratio, they have strong claims to be the most efficient 4-6-0s constructed anywhere.

The locomotives later became SNCF Class 230D and, in 1971, a group of British de Glehn enthusiasts banded together to buy one of the remaining engines from the French state railway, No230D.116 (ex-Nord 3.628). In 1980, this most historic of French locomotives, became part of the British national collection, but still based on the Nene Valley Railway at Peterborough where until recently it was the very last serviceable de Glehn/du Bosquet compound.

No3.628 is fitted with two regulators, the low pressure valve to assist starting and the main regulator to put the locomotive into full compound working. It has the Lemaître multiple-jet blastpipe (as experimented with by some British engineers such as Maunsell) and a Duplex reverser to give independent cut-off to high and low-pressure valve gears. Maximum boiler pressure is 16 bars (around 228lb/psi) and the locomotive employs divided drive (in the manner of the Gresley Pacifics) to its four cylinders and Westinghouse air-braking.

Inset, top: One of the oddities in the British national collection is the North Eastern Railway 2-2-4T No66 *Aerolite*, a locomotive specifically built for the purpose of hauling official inspection saloons. It was built as a 2-2-2T at Gateshead in 1869, replacing an earlier *Aerolite* which had been irreparably damaged in an accident the previous year. In 1886, it was rebuilt by Thomas Worsdell, remaining a 2-2-2T but carrying its water supply in side tanks instead of a well tank. Six years later, Wilson Worsdell converted the engine into a 4-2-2T and fitted compound cylinders. In 1902, it was rebuilt yet again, remaining a 2-cylinder compound but becoming a 2-2-4T. The name *Aerolite* – omitted on previous rebuildings – was refitted, along with new, if incorrect, numberplates which credited the locomotive as having been built in 1851. These were replaced with plates merely crediting Gateshead Works, without a date, when the locomotive was placed on display in the Queen Street railway museum in York in 1934.

Inset, lower: The most famous of British compound locomotives, Midland Railway No1000, is now part of the display in the north hall of the National Railway Museum. It was officially preserved in 1959 and did enjoy some main-line action in both the 'sixties and early 'eighties. As No2631 this engine was the first compound to be built by the Midland, to a design by Samuel Johnson, in 1902. The design was unashamedly based on Walter Smith's No1619 for the North-Eastern Railway. Rebuilt by Richard Deeley in 1914 with a superheated boiler and increased boiler pressure, the five prototype compounds became the precursors of a class of well over 200 locomotives, construction of which continued into the reign of Henry Fowler. The Midland engines easily outlasted any other British compound locomotives, the last being withdrawn in 1961.

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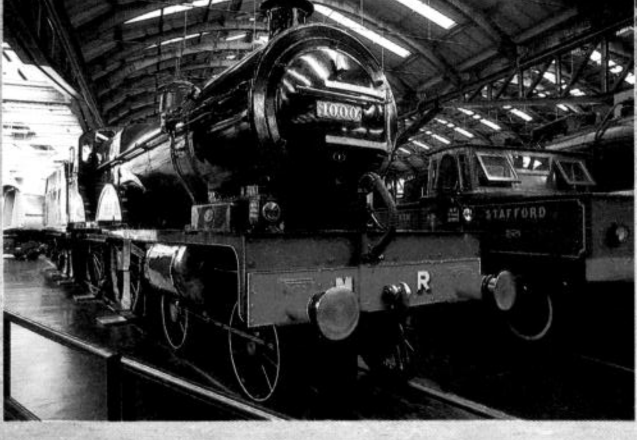
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