Upgrading Narrow Gauge Standards

Shinichi Kato

When the railways were nationalized between 1906 and 1907, the skeleton of the nationwide trunk rail network was nearly completed, as mandated in the Railway Construction Act of 1892. At the end of 1907, nationalized railway lines in operation totalled 7,165 km. Construction continued and 2,677 km of line were added by the end of 1919. In addition to active line expansion, the first decade after the nationalization up to the 1910s was characterized by vigorous efforts to improve the quality of facilities.

The nationalization of railways was accomplished by merging government-owned railways and 17 private railways. The facilities and equipment varied widely in level of technology due to different histories of imports and management policy. Some large private railways had poor facilities and equipment. In some cases, different interconnected railways did not allow through operation of freight cars. Thus, technical unification was an important goal to complete the nationalization, and served as the basis of further improvement.

Unification of standards and gauges was accomplished by incorporating the latest technologies. The process was concurrent with the industrial revolution in Japan, which occurred between the 1890s and the 1900s, followed by the burgeoning of the heavy and chemical industries in the 1910s. Rapid development of railway technology formed an integral part of the industrialization process and boosted transport capacity significantly. Government railways, a gigantic industrial customer, also had an engineering arm covering basic research and manufacturing, which led development of Japanese railway technology and modernization of the rail industry.

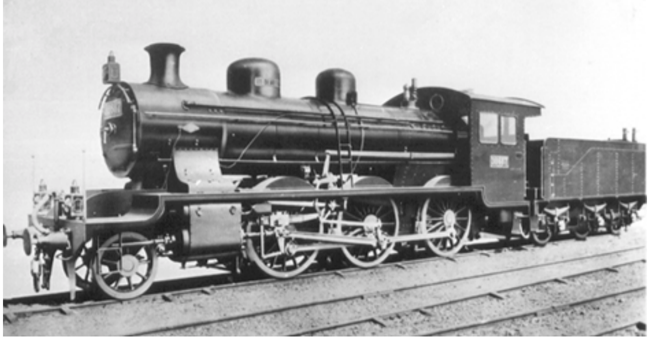
Improvement of Railroad Facilities and Equipment

A major event, which undoubtedly contributed to the development of railway technology in the 1910s, was the debate on the use of standard gauge (1435 mm). Although standard gauge was not formally adopted, it was persistently advocated by many in the railway industry, and the debate spurred extensive research reconfirming the disadvantages of narrow gauge. In other words, the railway authority tried to ensure the upgrading of railroad facilities by adopting technical standards equivalent to those for standard gauge as far as possible within the restraints of the narrow gauge.

Construction gauge, loading gauge, distance between track centres, bridge specifications, and other standards were established on the basis of standard gauge. For example, standards for axles were adopted to eliminate the need for replacement, at conversion to standard gauge, which incidentally brought side benefits of better riding stability and comfort.

Another notable improvement was eliminating steep grades commonly associated with Japanese railways. On the Tokaido Line, for example, there were many sections (1 in 40) consisting of continuous 25 per mill grades, and rerouting was carried out to reduce them to 10 per mill (1 in 100) levels, including excavation

■ 9600 Locomotive (Transportation Museum)



■ 8620 Locomotive (Transportation Museum)

■ Class 9900 (D50) at Yamakita Depot on Old Tokaido Route *(Transportation Museum)*

■ Yasujiro Shima (1870-1946) *(Transportation Museum)*

Yasujiro Shima graduated in Mechanical Engineering from the Imperial University in 1894. Initially, he worked at Kansai Railway, a major private railway company, before nationalization, and then joined the government railways as head of the Rolling Stock Division until the 1910s. Mr Shima was a leading figure in standardization of domestic locomotives, and the 8620 and 9600 locomotives incorporated his ideas. As a vigorous advocate of standard gauge, Mr Shima successfully conducted tests on technical converting to a standard gauge system in the suburbs of Tokyo. He devoted himself to upgrading national railways by implementing new standards under the restraints of narrow gauge. In 1918, he was appointed Chief Engineer, the highest-ranking railway engineer. In 1939, he spearheaded a shinkansen project led by the government and developed a plan for a standard-gauge high-speed rail system connecting Tokyo and Osaka in 4 hours and 30 minutes. The project, held in abeyance during WWII, was resumed on the basis of his master plan and became reality as the Tokaido Shinkansen in 1964. The technical manager of that project was his son, Hideo Shima.

of long tunnels. One of the most memorable works was construction of the Tanna Tunnel connecting Atami and Numazu, designed to avoid the mountain route via Hakone, which constituted the largest bottleneck to the reduction of travel time on the Tokaido Line. Excavation of the 7,804-m tunnel faced numerous obstacles as it advanced through volcanic zones characterized by soft formations and water seepage, as well as a major fault, until its completion in 1934. In the process, there were many sacrifices and tragedies, together with heroic episodes, which form the subject of various novels and dramas. Clearly, construction of the Tanna Tunnel stands as a milestone for major projects in pre-war Japan.

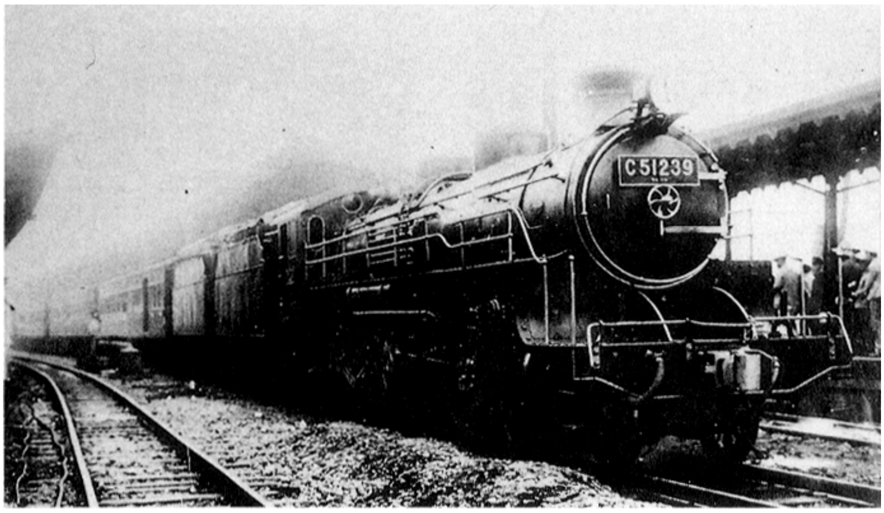
On the other hand, use of heavy rails progressed at a much slower rate. 60-pound (30 kg) rails were selected as standard rails in 1906, with 75 pounds (37 kg) being used in some sections. The use of 100-pound (50 kg) rails had to wait until 1922. Also, no systematic effort was made to ease tight curves.

Thus, standardization of the Japanese narrow gauge rail system progressed to achieve relatively high loading gauge, while remaining structurally vulnerable in many aspects compared to international standards. Double tracking work was delayed, while electrification of trunk lines did not progress to the full extent. Meanwhile, to develop a comprehensive transportation system supplementing the insufficient capacity of railways by coastal shipping, regional ports and harbours as well as water-land interfaces were constructed.

Evolution of Rolling Stock Technology

At nationalization, there were approximately 2,000 locomotives of 190 models in Japan. The majority were made in the USA and UK, each of which held roughly equal shares, followed by Germany (20%), and the remaining number were built domestically. Their performance varied widely making it difficult to deploy them according to actual needs or to develop a nationwide transportation system. Although local works were manufacturing locomotives by the end of the 1890s, there was still strong demand for foreign locomotives, partly because the industry could not reduce manufacturing costs by mass production because orders came from a wide range of customers with different specification.

After nationalization, Government railways purchased a few large tender 2C1 type locomotives from the UK, the USA, and Germany. They developed domestic standard locomotives based on these imports. After establishing standards and manufacturing methods a 1C type locomotive for express passenger trains (Class 8620) and a 1D type locomotive for freight trains (Class 9600) were completed. The 8620 was relatively small and lightweight and represented a realistic design for actual grades and curves. Its maximum speed was limited to 85 km/h based on track standards. The 9600 had a fire box above the driving wheels providing more tractive force from a bigger boiler. Up until 1926, 620 units of the 8620, and 770 units of the 9600 were pro-



■ Class 18900 (C51) hauling *Tsubame* Test Train (Transportation Museum)

duced and deployed nationwide.

After World War I, two new models were developed to meet rapidly-growing traffic volumes on trunk lines, the 18900 (later renamed C51) for passenger trains and the 9900 (D50) for freight traffic. The former was designed to achieve performance equivalent to that available on standard gauge. It adopted the 2C1 axle layout, then standard for express passenger locomotives in Europe and the USA, and its driving wheels had a diameter of 1750 mm, the largest of the narrow-gauge locomotives in the world. A total of 289 units were manufactured after 1919 and mainly introduced to trunk lines including the Tokaido and Sanyo. In 1930 C51 started hauling "*Tsubame*" limited express train on the Tokaido Line connecting Tokyo and Osaka in 8 hours and 20 minutes. The train long served as the star of Japanese railways and relied on the C51's outstanding performance. In 1934, completion of the Tanna Tunnel reduced the travel time to 8 hours. On the other hand, the 9900 with the 1D1 axle layout was built from 1923, totaling 380 units. The locomotive brought a breakthrough in freight transport by increasing hauling capacity on 10 per mill (1 in 100) grades to 950 tons, compared to 600 tons offered by the 9600.

The first standard passenger carriage was designed in 1910. The American-style, walk-through, center-aisle, wooden (steel body used after 1928), bogie car dominated the industry for many years.

Freight cars before nationalization mostly had a loading capacity of 7 to 8 tons. After 1913, 10-ton cars were adopted as the standard and existing cars were modified to help boost transport capacity. The shift to 15-ton cars was initiated in 1914.

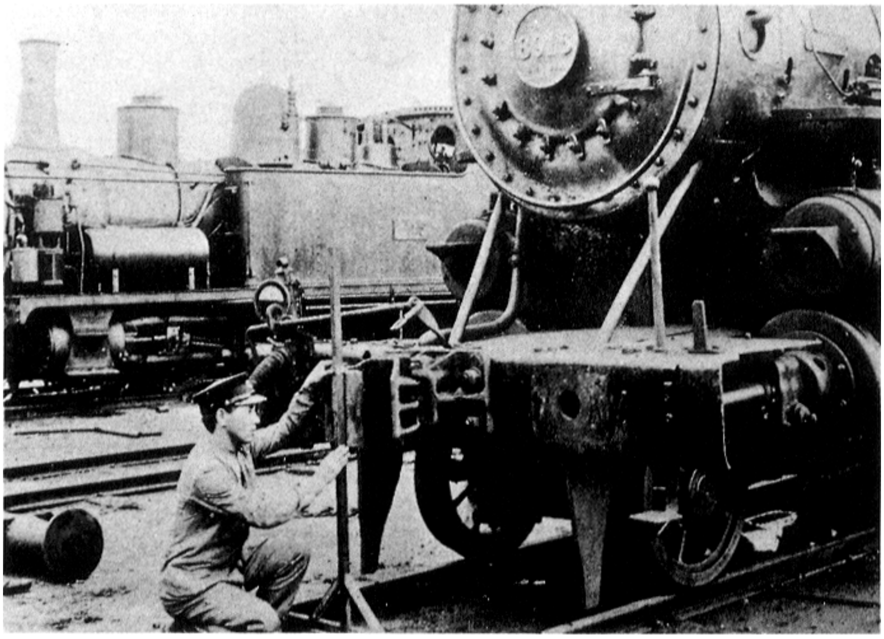
The government railways set a policy to establish technical standards for rolling stock by joint development with manufacturers who were responsible for production, while the railway operated repair shops. As a result, large manufacturers accumulated technical and production ability.

The most notable innovations improving transportation efficiency were air brakes and automatic couplers. In 1919, the government railways decided to use air brakes in place of traditional vacuum brakes and started to develop a local model on the basis of technology from Westing-house. All freight cars were equipped with pneumatic brakes by 1930, followed by passenger cars in 1931. Similarly, the use of American-type automatic couplers was decided in 1919. Freight cars presented a problem for replacement because they travelled all over the country and were coupled freely. It was decided to replace couplers in the field and at other sites nationwide on the same day, 17 July 1926 (20 July for Kyushu). To facilitate replacement, automatic couplers were temporarily fixed to 41,661 freight cars in advance and successfully took over on the preset dates. From the huge amount of work involved, it was a notable event in world rail history.

Enhancement of Railway Facilities in Tokyo Area

Master plans for rail networks in urbanized areas of Tokyo were established under city plans in the 1880s. However, the networks were incomplete at nationalization, and the completion and establishment of operation systems were left to the government railways. In fact, management policy was focussed on establishment and operation of nationwide rail networks, and did not feel responsibility for developing the public transportation network in the Tokyo metropolitan area. Nevertheless, the government railways with large capital and technical capability inevitably played a decisive role in devel-

■ Newly-completed elevated section of inner city line near Shinbashi (Transportation Museum)



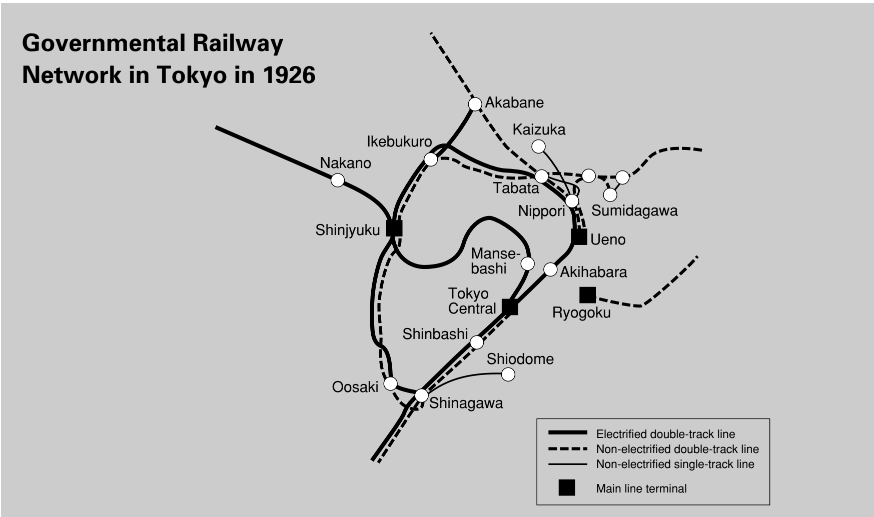
■ Changing to Automatic Couplers on 17 July 1926 *(Transportation Museum)*

oping urban transportation in Tokyo.

In 1906, immediately after promulgation of the Railway Nationalization Act, a new master plan was established. The plan, which essentially followed the previous policy, intended to make urban railways fully functional by increasing the number of tracks to 4 or 6 to allow separation of trunk lines from urban lines, and passenger traffic from freight traffic, during construction.

New lines were primarily designed to interconnect previously-isolated terminals of trunk lines by constructing a circular Yamanote Line, and inner-city lines connected to it. The plan focused on interconnection of terminals via feeder lines in the inner city, rather than integration of terminal functions. Since most new lines had elevated structure to pass through business or commercial centres, considerable cost and time were required. The circular Yamanote Line was completed in 1925, except for connection to a terminal station extending to Chiba Prefecture which was delayed until 1932. This marked the completion of the skeleton of the rail system in Tokyo. Tokyo Central Station, inaugurated in 1914, assumed the transportation hub in place of Shinbashi Station, serving as the terminal both for the Tokaido and Sanyo districts and city lines. Furthermore, Tokyo Central became a major symbol for railways in Japan.

Government railways started operating of electric multiple-unit trains when it acquired a private railway in Tokyo (Kobu Tetsudo-now Chuo Line). It immediately noticed their advantages in urban transport and decided to expand operation. In 1909, electrification of the Yamanote Line was completed and commercial operation started. In 1915, electric multiple-unit trains were introduced between Tokyo and Yokohama. With urban sprawl after WWI, rail lines served by electric multiple units were extended to the suburbs of Tokyo and started to serve as the mass transit system growing out of 'inner city lines'. The multiple units evolved with expansion of the network from two-axle cars used by Kobu Tetsudo, which were equipped with centralized controllers, to bogie cars used for the Yamanote Line, and train sets including Second and First class cars for the Tokyo-to-Yokohama section. This development of electric multiple units formed the basis of high-speed EMU trains in later years. Geographical expansion of sections served by EMU trains and improvement of service through higher frequency allowed government railways to become the major provider of public transportation in the Tokyo area. For example, EMU trains between Tokyo and Kurihama started operation in 1928 and covered the long distance (62 km) at high speeds. ■



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Mr Kato graduated in economics from Tokyo University in 1973 and joined the Ministry of Finance where his responsibilities include research into fiscal policy and railway history. He is the author of *Fiscal and Monetary Policies during the Reconstruction and High-Growth Period* and *Bibliography of Japanese Private Railways and Bus History.* He is currently a board member of the Railway History Society.