tion routes. This went hand in hand with the expansion of the railroad network, with railroads being set up everywhere as trunk or sub-trunk railroad transportation routes and roads being part of transportation systems that consisted of feeder roads radiating out from the railroad stations. Most river transport was being phased out throughout the Meiji period, its place being taken by the newly opened railroads. The last of the river transport routes on the Tone and Yodo rivers began to rapidly decline around 1910.

The import of motor cars to Japan began at the beginning of the twentieth century, and there was a rapid increase in the import of American-made cars from World War I on.[5] The operation of internal-combustion-engine buses began to increase around 1910, and the greater use of these motor vehicles brought on needed reform in road policy, supervision, and the technical structure of roads and bridges.

The Road Law went into force in April 1920 and demanded a large amount of the central government budget for the repair of roads that had previously been the responsibility of the prefectures, counties, and municipalities. In that same year the Home Ministry devised a 30-year plan for the improvement of national and prefectural roads, and, accordingly, began paving roads and building large, permanent bridges. However, the new policy on roads would not begin to show any results until the next period under consideration.

Notes

1. *Nihon tetsudō shi* (History of Japanese railways), vol. 2 (Railway Ministry, 1921), pp. 73–74.
2. *Ōsaka-shi Kōtsūkyoku gojū-nen shi* (Fifty-year history of the Osaka Metropolitan Transit Agency), "Deliberation Papers," p. 15.
3. Ibid., and *Ōsaka-shi Kōtsūkyoku nanajūgo-nen shi* (Seventy-five-year history of the Osaka Metropolitan Transit Agency).
4. Sanada Hidekichi, *Naimushō chokkatsu doboku kōji ryaku shi – Okino hakase den* (Brief history of civil engineering construction projects directly controlled by the Home Ministry – Tribute to Dr. Okino) (Kyukokai, 1959), p. 9.
5. The first motor car in Japan is said to have been an electric car for which Japanese people living in the United States raised $3,000 to purchase and send as a wedding present for Crown Prince Yoshihito (later the Emperor Taisho), who was married in May 1900. Okamura Matsuro, ed., *Nihon jidōsha kōtsū jigyō shi* (History of motor-vehicle transport operations in Japan), vol. 1 (Jiyukai, 1953), p. 2.

Railroads

Eiichi Aoki

The Plan for a Change-over to Standard Gauge

The proposal to reconstruct tracks to "wide" (i.e. standard) gauge[1] was started in 1909 by Goto Shimpei, director-general of the Railway Agency

under the Katsura cabinet, in an order to the Railway Investigating Committee to make an economic comparison for a railroad between Tokyo and Shimonoseki that would have both international standard gauge and narrow gauge tracks and be built to meet the estimated increases in future transport demand. The report of July 1909 on the survey gave an estimated cost for building a railroad with international standard gauge rails in a separate location of ¥202.8 million, while upgrading transport capability by improving existing narrow-gauge tracks would cost only ¥137.0 million. This report insisted that keeping narrow gauge and making improvements in it was the better policy.

It can be imagined that Goto, who had conceived the standard-gauge policy, was dismayed by this report. Consequently, he instructed an engineer, Ishikawa Ishiyo, to make a study of the 1909 report. Ishikawa's report, submitted in July 1910, stated that reconstructing the existing narrow-gauge tracks to the international standard could be done for ¥152 million. That meant only a 15-million-yen difference between the cost of a change-over to standard gauge and the Railway Investigating Committee's estimate for keeping and improving the narrow-gauge tracks. This led to the conclusion that a switch-over to standard gauge would be beneficial in the light of future increases in transport demand.

Based on this report, the Railway Agency firmed its resolve to rebuild to standard gauge, and the government included reconstruction costs in its 1911 fiscal budget proposal to the Imperial Diet. But with the opposition from Seiyukai Diet members, costs for standard-gauge reconstruction were removed from the budget. However, the government, after consulting with government and private experts, set up in April 1911 a Preparatory Committee for the Rebuilding of Railways to Standard Gauge.

Then, in August 1911 the entire Katsura cabinet resigned, to be followed by two Seiyukai cabinets, first the Saionji and then the Yamamoto, which cancelled the plan to reconstruct to standard gauge based on their forecast that no source for funds could be found. The Preparatory Committee was disbanded and the preliminary arrangements made in preparation for a shift over to standard gauge and that had advanced with the construction and improvements in trunk railroads were abandoned.

But standard gauge reconstruction proposals again surfaced in the subsequent Okuma and Terauchi cabinets. In deciding on a seven-year plan for the construction and improvement of the National Railways in 1914, Sengoku Mitsugu, director-general of the Railway Agency, considered arguments for standard gauge and in July of that year appointed an Investigative Committee for the Reconstruction of Railways to Standard Gauge. The committee devised four rankings according to the amount of reconstruction required: existing narrow gauge, strengthened narrow gauge, ordinary standard gauge, and strengthened standard gauge. A comparison survey was conducted and a report given on the use of strengthened standard gauge in the following year. The report estimated that if construction started in 1916, it would take 12 years to widen the gauge on the route between Tokyo and

Shimonoseki and 25 years to rebuild all tracks in Honshu. In response to this report, the government set up a Gauge Survey Committee in April 1916 that was directly under the control of the prime minister and charged with carrying out specific surveys.

In October 1916, the Terauchi cabinet provided Goto with his third appointment as director-general of the Railway Agency, and Goto moved rapidly to firm up proposals for standard-gauge reconstruction. He first proposed, in December of that year, that the cancelled Preparatory Plan for Reconstruction of Existing Trunk Railways to Standard Gauge be resurrected. It took one year to convince the cabinet, and not until December 1917 did the cabinet decide to submit the proposal to council. During this period, Shima Yasujiro (who was appointed chief engineer for the railroads in April 1919) of the Railway Agency's Mechanical Engineering Bureau led the rapid preparations for a concrete proposal and experiments conducted for the reconstruction. One of the experiments was a test construction of standard-gauge tracks between Haramachida and Hashimoto on the Yokohama Line and operation on these tracks of locomotives and passenger and freight cars rebuilt to run on standard gauge. At the Oi Factory, engineers test-built equipment for replacing axles on freight cars and devised methods by which axles could be easily changed to either standard or narrow gauge at points connecting the narrow and standard gauge tracks.

The proposal to change the gauge of the National Railways, made at this time, stated that it would be simple to widen the gauge and leave existing facilities and rolling-stock width as is, a concept referred to by "light railroad, standard gauge." Some of the steps that it called for were the simple trimming back of station platforms, widening the space between the centre line of double tracks, operating locomotives of the same weight as those operated on European railroads, and leaving major bridges as they are or moderately reinforcing them. The proposal basically stated that the reconstruction could be completed by just widening the ties and the wheel axles of rolling-stock. The construction was to start in fiscal 1918 and would consist of one or two additional rails laid on the outside of existing tracks. The first railroad to be reconstructed was the Bantan Line (between Himeji and Wadayama), with completion slated for April 1918. In the first stage, reconstruction was to proceed in western Japan, with construction scheduled to move eastward, and all railroads in Honshu were to be standard gauge by March 1923. To meet with the new requirements, all newly manufactured rolling-stock and locomotives were to have their axles widened and lengthened so that they could handle standard gauge. The proposal did not get to the stage where the cabinet would have to make a decision on it, but it brought the plans for standard gauge that much closer to actually starting.

However, the reins of government again reverted back to the Seiyukai in September 1918 and Tokonami Takejiro became director-general of the Railway Agency under the Hara cabinet. In February 1919, Tokonami made a statement before the Imperial Diet rescinding plans to go to the standard gauge. Then, with the onslaught of the post–World War I reces-

Table 3. Chronology of the standard-gauge reconstruction issue (during the time the Railway Agency was extant, 1908–1920)

Year	Prime minister	Director-general of the Railway Agency	Main events relating to standard-gauge reconstruction
1909			December 1908 – Railway Agency set up July – Railway Investigating Committee reports on standard and narrow gauge comparison
1910	Katsura Taro	Goto Shimpei	July – Ishikawa Ishiyo's "A Comparison of Standard and Narrow Gauge Railroads between Tokyo and Shimonoseki" October – Notification on standard-gauge construction regulations (temporary) for construction and improvement of the Tokaido and other lines December – Decision made in railroad committee to rebuild all tracks between Tokyo and Shimonoseki to standard gauge
1911	Saionji Kimmochi (August)	Hara Takashi	January – Diet postpones decision on the track reconstruction proposal April – Preparatory Committee for the Rebuilding of Railways to Standard Gauge
1912	Katsura Taro (December)	Goto Shimpei	January – Abolition of Preparatory Committee for the Rebuilding of Railways to Standard Gauge
1913	Yamamoto Gonnohyoei (February)	Tokonami Takejiro	
1914	Okuma Shigenobu (April)	Sengoku Mitsugu	June – Plan to prepare for standard gauge on main trunk lines abolished
1915			July – Appointment of Investigative Committee for the Reconstruction of Railways to Standard Gauge
		Soeda Juichi (September)	December – Plan for reconstruction to standard gauge submitted to cabinet for subsequent consideration
1916	Terauchi Masatake (October)	Goto Shimpei	April – Set up Gauge Survey Committee December – Gauge Survey Committee disbanded

1917		Nakamura Korekimi (April)	May – Experiment in standard-gauge reconstruction on Yokohama Line (until August) December – Preparations to reconstruct to standard gauge on main trunk lines revived
1918	Hara Takashi (September)	Tokonami Takejiro	
1919			February – Director-general negates proposal to reconstruct to standard gauge in Diet.
1920			May – Railway Agency upgraded to become the Railway Ministry

Source: Mainly from *Nihon tetsudō shi* (History of Japanese railroads).

sion in 1920, the fiscal situation was such that it would have been unable to handle standard-gauge reconstruction.

The debate over standard gauge continued after that, but realization of such a plan was very remote. The National Railways continued its efforts and was somewhat effective in improving the transport capabilities and speeds of trains on the existing narrow gauge.

Domestic Production of Rolling-stock and Standardization

In examining the situation of the supply of rolling-stock and engines after railway nationalization, we see that most of the locomotives were foreign made, and Japan was self-sufficient only in the production of passenger coaches and freight cars. Most of the electric car rolling-stock that was being built throughout the country had to rely on imported electric motors and trucks, although the car bodies were domestically manufactured.

Through nationalization, the new National Railways had taken over all types of locomotives from the private railroads, some 190 different models, and was working on a project to come up quickly with a design for a standard locomotive.

The Railway Agency was working toward both domestically producing and standardizing steam engines and had also begun, in 1909, designing three types of tender-locomotives, one for light passenger transport, another for freight, and yet another for high-speed passenger hauling. All of these locomotives were to be used on the trunk lines; the engines for trains on the branch lines would be pulled from the existing stock. In standardizing locomotives, it was decided to equip all steam locomotives with boilers of the Schmidt type superheater in order to improve the thermal efficiency of the boilers.

Light passenger and freight locomotives were, from the very first, to be domestically produced. Wheel arrangement for the former was to be of the 2B type and, for the latter, the 1D type. The wheel arrangement that had been traditionally used would be continued, and existing models would be made larger and their boiler systems strengthened so that they could be used for superheated steam. The model for the light passenger type was the 6760, and the freight model was the 9600. These two ultimately became the standard models and were put into mass production. However, Model 6760 was not suited to handle the large volumes of traffic as the demand for passenger transport increased, and only 88 of them were produced from 1914 to 1918. In contrast, the 9600 was considered very good and 770 of these locomotives were manufactured from 1913 to 1926 (see fig. 3 in chap. 5).

The locomotives for high-speed transportation were large engines that Japan had no experience with; indicating only the basic requirements, orders were placed with manufacturers in Great Britain, Germany, and the United States. Japan imported four models: the 8700, 8800, 8850 (having a 2C wheel arrangement) and 8900 (2C1 wheel arrangement) in 1911–1912, and used them mainly to haul long-distance trains on the Tokaido

Line. To save foreign currency, only the locomotives themselves were imported; the tenders were built domestically. With the exception of Model 8700, these locomotives were superheated steam models. Exact replicas of models 8700 and 8850 were placed with domestic manufacturers so that they could gain experience in the manufacture of these types of high-speed locomotive. Based on these models, a slightly smaller domestic standard locomotive, the 8620, was developed, of which 672 were produced between 1914 and 1929.

In addition to this, 60 locomotives in four different models of the compound Mallet type, especially designed for use on gradient lines, were imported from the United States and Germany in 1911–1912. However, these were later replaced through the development of locomotives of the simple expansion type and were never produced domestically. Four E-type Model 4100 tank locomotives, weighing more than 60 tons, were also imported from Germany and were used as prototypes for the domestically produced Model 4110, 39 of which were built from 1913 on.

In this way, the National Railways succeeded in domestically manufacturing standardized locomotives for use on the trunk routes. And, as far as the National Railways was concerned, the import of steam locomotives ended in 1912, although there were test imports of three-cylinder locomotives later. However, Japan's rolling-stock and locomotive manufacturers did not, at that time, have the ability to keep up with the demand for locomotives that resulted from the expansion of the rail network, in both its National Railway and private light railroad forms. Consequently, it was necessary to rely on German and US manufacturers for much of the import of light railroad locomotives, which continued until 1928.

As for passenger coaches, in 1910, the Railway Agency decided to adopt the Specifications for the Construction of Passenger, Mail, and Baggage Coaches to provide a single set of standards for passenger-coach manufacture. The bogie passenger coach that was built according to these standards was called "basic passenger coach" (later a larger passenger coach became the basic type and this initial one was called the medium basic passenger coach). The basic passenger coach had two types of bogie, a two-axle or a three-axle bogie, each of which was compatible in terms of underframe and truck; in addition, coach bodies (made of wood) were standardized in their main dimensions and structure.

Manufacture of the basic passenger coach (medium) continued until fiscal 1917; as rolling-stock for the 1,067 mm gauge, it was considered large even by international standards. Kerosene lamps had been the traditional means of interior lighting, but, with the basic coach model came electric lights and a remarkable improvement in seating. In addition, after 1912 the National Railways completely stopped the production of two-axle passenger coaches.

Next we will examine the use and domestic production of a steam car that consisted of a passenger coach with a small boiler mounted at one end to self-propel the coach for use on frequent, small-unit transit service.

Table 4. Foreign and domestic production of standard steam locomotives

Type	Wheel arrangement	Model number	Manufacturer	Number produced	Production period
Light passenger	2B	6700	Kisha Kaisha	19	1911–12
			Kawasaki	27	1911–12
	2B	6750[a]	Kawasaki	6	1913
	2B	6760[a,b]	Kawasaki	88	1914, '16–18
Freight	1D	9550	Kawasaki	12	1912
	1D	9580[a]	Kawasaki	12	1912
			Kawasaki	686	1913–26
	1D	9600[a,b]	Kisha Kaisha	69	1918–19, '24–26
			Kokura Works (JNR)	15	1919
High-speed passenger	2C	8700	North British (Great Britain)	12	1911
			Kisha Kaisha	18	1912
	2C	8800[a]	Berliner (Germany)	12	1911
	2C	8850[a]	Borsig (Germany)	12	1911
			Kawasaki	12	1913
	2C1	8900[a]	American Locom. (US)	36	1911–12
	1C	8620[a,b]	Kisha Kaisha	384	1914–22, '25–26
			Hitachi, Ltd.	137	1920–26, '29
			Kawasaki	83	1921–25
			Nihon Sharyo	57	1922–26
			Mitsubishi	11	1924–26

Mallet-type for steep grades	BB	9020	American Locom. (US)	6	1911
	CC	9750[a]	American Locom. (US)	24	1912
	CC	9800[a]	Baldwin (US)	18	1912
	CC	9850[a]	Henschel (Germany)	12	1912
E-type for steep grades	E	4100[a]	Maffei (Germany)	4	1912
	E	4110[a,b]	Kawasaki	39	1913–14, '17

Source: Usui Shigenobu, *Kokutetsu jōkikikansha shōshi* (A concise history of steam locomotives on the National Railways), Denkisha Kenkyu Kai, 1956.
Note: Numbers are for the locomotives produced only for the National Railways
[a]Superheated steam locomotives [b]Standard model locomotive in final production

The operation of steam cars in Japan began in 1905 when the Seto Automatic Railway imported three Serpollet steam cars from France. In 1909, the National Railways' Kansai Main Line (between Minato-machi and Kashiwara) and the Hakata-wan Railway in Kyushu each began operating two Ganz steam cars. The Serpollet car was the 1887 creation of the French inventor Léon Serpollet and was equipped with a water-tube boiler that was semicircular in cross-section and burned coke for fuel. The engine was quite small: the boiler was just 1.05 m high and 0.57 m wide and weighed 600 kg.[2] The Ganz steam car was equipped with a water-tube boiler and was built by the Ganz Waggon und Maschinen Fabrik in Budapest, in, at that time, the Austro-Hungarian Empire. The Seto Automatic Railway used its two Serpollet cars for only three years, replacing them in 1907 with electric cars. The Serpollet had a complex structure, was difficult to operate, had frequent breakdowns, and poor operating performance. The Ganz cars used a high-pressure (16kg/cm^2) water-tube boiler, and motive force was transmitted from the cylinder to the driving wheels by gears. Osaka Ironworks (later the Sakurajima Works of Hitachi Shipbuilding) was later awarded a licence to produce these cars, manufacturing three of them for Omi Railway and Kanan Railway. However, the steam car that was most widely used in Japan was the Kudo system car, the first four of which were manufactured for Hase Tramway in 1909. By 1923, Kisha Kaisha alone had produced 43 Kudo cars (Ichikawa Katsuzo Shoten and Edamitsu Ironworks also manufactured several under licence from Kisha Kaisha). The Kudo system was designed by a Kisha Kaisha engineer, one Kudo Hyojiro, and was equipped with a smoke-tube-type locomotive boiler that operated at a normal steam pressure of 11.2kg/cm^2, with motive power being transmitted by a main connecting rod just as with standard steam locomotives. The mechanisms in the Ganz steam car were delicate and steam pressure was high, so that once there was a malfunction, repair was difficult. The Kudo car's lower steam pressure gave it lower output but also made it popular for being simpler to operate and repair. It also shows how low the level of operating technology was in Japanese railroads at that time.[3]

The first cars introduced that were powered by internal-combustion engines used petrol for fuel. The petrol-engine cars were small locomotives with a single cylinder, semi-diesel (hot-bulb) engine for the power source. These engines were widely used for fishing boats and other small boats before World War II. Experiments were conducted on their use in trains of Zuso Manpower Tramway (running between Odawara and Atami) in 1898–1899, but they were not put into actual service. Their first operation was on the Chikugo Horse Tramway (914 mm gauge; later renamed Chikugo Tramway) in 1905. Up to around 1910, the horse-drawn railroads of northern Kyushu, particularly in the Saga Plain, were seeking more efficient means of motive power and one after another began to introduce the petrol engines that were supplied by Fukuoka Ironworks in Osaka. Fukuoka Ironworks produced locomotive running gears and railway car bodies, and it built Mietz and Weiss model cars with two-cycle hot-bulb ignition and an output of about 10 horsepower.

The petrol-engine cars weighed about 2.5 tons, had two drive axles, and usually one locomotive pulled one passenger coach. However, the use of these cars was limited, with most of them being used in northern Kyushu; they were almost never seen elsewhere. The basic reason for the lack of wider use must have been their extremely low horsepower and poor reliability.

The only tests for the introduction of railroad cars powered by gasoline engines were the test runs on branch lines of Keihin Electric Railway made in 1919. And there was only one company that put these cars into actual operation, the Yoshima Tramway near Taira in Fukushima Prefecture, which began runs in 1921.

Barriers to Faster Train Speeds

In July 1889, when the entire length of the Tokaido Line was opened for service, it took a train travelling at a scheduled speed of 30.1 kph 20 hours and 5 minutes to make the run directly from Shimbashi to Kobe. The first express train, run in August 1898, took 16 hours and 27 minutes, at a scheduled speed of 36.7 kph, to make the same run. That shortened the time somewhat, but it was reduced again in April 1906 when express trains covered the route in 13 hours and 40 minutes at a scheduled speed of 44.2 kph.

Beginning 15 June 1912 the Railway Agency ran special express trains between Shimbashi and Shimonoseki. Tickets were limited to either first or second class, and the trains were made up of seven cars including a dining car, sleeping cars, and an observation car. Trains from Shimbashi to Shimonoseki made the run in 25 hours and 8 minutes at a scheduled speed of 45.1 kph (12 hours and 45 minutes and 47.3 kph for the section between Shimbashi and Kobe). This was the fastest train in Japan at that time and also the one most luxuriously accoutred.

However, the speed of trains on the Tokaido Line was not improved much more during this period. By August 1928, the scheduled speed had been raised just slightly to 47.6 kph. And the scheduled speed between terminals for long-distance trains on other trunk routes had not even reached 40 kph.

The reason there were no further increases in speed, despite the appearance of powerful locomotives, was the large number of 25‰ gradient sections along the routes. Gradients were the biggest factor working against increased speed. Some construction of long tunnels and new routes was started in the Tokaido Line's zone through Hakone and other trunk railroad sections where steep grades retarded speed and transport capability, but it was not until the next period that genuine improvements were made.

Railroad Electrification and the Development of Electric Trains

The first electric railroad in Japan was the Kyoto Electric Tramway, whose lines operated within Kyoto and between Kyoto and Fushimi; it started op-

eration in 1895. Electric trams began plying the streets of other major cities after 1898.

The Kobu Railway (a company operating a steam-powered railroad between Iidamachi and Hachioji in the city of Tokyo) electrified its route between Iidamachi and Nakano and started running trains at 10-minute intervals on 21 August 1904. In contrast to most of the previous electric railroads that had been built on streets or roads, this one was formed by connecting electric power lines along tracks built for steam trains and was the first instance in Japan of electric and steam trains running on the same tracks. The electric trains were now starting to run on railroad tracks and had features and equipment, such as multiple-unit control and automatic signals, that had not been seen in any previous electric railways operating in Japan. This equipment was indispensable in getting the electric trains off tracks that were laid on roads and onto their own special tracks.

Kobu Railway's operating route was later extended to between Ochanomizu and Nakano, a route that the government took over in October 1906 and that became the first line on which the National Railways operated electric trains.

Attempts to take advantage of the electric train's superior service by building new tracks especially for these trains and electrifying the steam railroads were taken up rapidly in areas where demand for transportation was high, most important of them the Tokyo-Yokohama, Nagoya, and Kyoto-Osaka-Kobe areas. The electric trains that first started operations within these cities gradually began to carry passengers between the cities and to suburban areas.

The first interurban electric railway was the Hanshin Electric Railway, which began operating lines connecting Osaka's Deiribashi with Sannomiya in Kobe on 12 April 1905. Trains running at 12-minute intervals stopped at 32 stations along the line to cover the entire route in 90 minutes. The government-operated railway ran trains at 40- to 60-minute intervals between Osaka and Sannomiya and had only three stations along the line, at Kanzaki, Nishinomiya, and Sumiyoshi. Fares on the electric train were cheaper, and, obviously, the larger number of stations between the two cities was much more suited to handling large numbers of passengers. For this reason many passengers shifted their allegiance from the government-operated railway to the private Hanshin Line and greatly reduced the passenger level for the government line.

In December 1905, Keihin Electric Railway began service between Tokyo's Shinagawa and Yokohama's Kanagawa. These terminal stations were quite distant from the centres of Tokyo and Yokohama but were connected by tram to the city centre, which helped to overcome their deficiencies. The operation of this train line, too, had a hard impact on the government-operated railroad.

Subsequent interurban electric railroads were the Nankai Railway, electrified in 1907 on its line between Namba and Wakayama City, on which it had operated steam trains, and the Keihan Electric Railway, which began

operation in 1910 between Gojo (later extended to Sanjo) in Kyoto and Temmabashi in Osaka. Many railroad extensions out into the suburbs followed. Separate from the question of the electrification of lines on which steam trains had been operating, there was the question of administration: through the provisions of the Tramway Ordinance, the Home Ministry was charged with directing the operations of electric railroads, but beginning in October 1908 both the Home Ministry and the Railway Agency became jointly responsible for their supervision. Initially, electric trains were run at high speeds even though they did not have the proper signals and safety equipment. In October 1911, however, the maximum speed for trains running on train-only thoroughfares was set at 40 kph. Later, in 1913, the railroads were required to install and use automatic signals.

The National Railways was moving ahead with electrification of its railroads in the Tokyo vicinity: the Yamanote Line, which described a semicircle around Tokyo's western section, was electrified in 1909, and the Tokyo-Yokohama segment of the Tokaido Line was electrified in 1914.

The underframes and car bodies for electric trains were domestically built, but electrical components and trucks were all imported. The main suppliers were the American companies General Electric and Westinghouse, the German company Siemens Schuckert, and the British company English Electric. The manufacturer Shibaura Seisakusho had been attempting domestic production of electric motors for railroad use since the beginning of the century, but was not able to get them into mass production. The outbreak of World War I meant great difficulties in getting imports from Europe, but it also gave Japanese manufacturers an opportunity to go into full-scale domestic production. One such manufacturer was the National Railways, which started test producing 50-horsepower motors in 1916 and successfully mass-producing them beginning in the following year. Domestic electric machinery manufacturers developed rapidly, but not rapidly enough to keep up with the demand created by the expansion in electric railroads, and imports of electrical components continued until around 1930.

Notes

1. Wide gauge originally meant a gauge wider than the international standard gauge of 4 feet 8½ inches (1,435 mm), but in Japan at this time "wide gauge" meant the international standard; consequently, I have used international gauge to avoid confusion.
2. E.A. Ziffer, "*Der Dampferzeuger, System Serpollet, und dessen Anwendung beim Betriebe von Strassenbahnen*," *Zeitschrift für Kleinbahnen*, vol. 2 (1895), pp. 14–18.
3. On the development of steam cars, *see* no. 256 of *Tetsudo Pikutoriaru*, a special issue on the steam railcar. The following articles are published in that issue: Aoki Eiichi, "Jōkidōsha no shisō to sono keifu" (Concept and development of the steam railcar); Nakagawa Koichi, "Nihon ni okeru jōkidōsha no enkaku" (History of the steam railcar in Japan); Taniguchi Yoshitada, "Kyūshū no jōkidōsha

oboegaki" (Memorandum on steam railcars in Kyushu); Ichigami Ichiji, "Kudō-shiki jōkidōsha" (The Kudo system steam railcar); Imamura Kiyoshi, "Jōkidōsha no hoshu o kaerimite" (Reflections on the maintenance of steam railcars); Imashiro Mitsuhide, "Shūmatsuki ni okeru shitetsu no jōkidōsha" (The last of private railroad steam railcars). There is also Imashiro Mitsuhide's "Jōkidōsha ni tsuite," (Steam railcars), in *Meiji-ki Tetsudo Shi Shiryo Geppo* (Monthly bulletin of materials on railroad history in the Meiji period), no. 12 (1981), which has a table comparing the operating expenditures of steam cars and steam-locomotive trains.

Roads

Hirofumi Yamamoto

Developments in Mixed Transportation

Road transportation in the 1910s and 1920s was a situation of increasing mixture in means of transport, with bicycles, motor cycles, motor cars, lorries, and buses, the new modes, sharing the road with traditional horse-drawn carts, ox carts, handcarts, and rickshaws. Of course the phenomenon of mixed transport was in itself not new, having begun in the 1870s with traditional horse, palanquin, and pushcart transport being used at the same time as horse-drawn carts, horse-drawn railways, and other imported modes. From the 1870s to around 1900, vehicles powered by man and beast gradually became more uniform. However, as we move into the 1910s, motor cycles and motor cars begin running on the roads to add motorization to the highly mixed, heterogeneous combination of human- and animal-powered transport. The figures in table 5 give some idea of what it was like for vehicles operating in Japan at the time: bicycles, motor cycles, lorries, motor cars, and buses rapidly increasing in the 1910s and 1920s, but traditional vehicles – horse-drawn freight carts, ox carts, and human-powered carts also continuing to increase. Of course, the coexistence of these new and old transport modes is an indication in itself that the time was getting closer for the new to supplant the old, but in this era, there was fierce competition between the two and the situation of mixed transport was intensifying.

Of all the new transport modes, the one that increased most rapidly during this period was the bicycle. As mentioned earlier, bicycle manufacturing in Japan began to develop around 1900 with the production of the safety bicycle, which combined traditional technology and imported components. The use of imported machine tools and electric motors gradually led to the building of a base for domestic production. With the suspension of the import of finished bicycles and parts during World War I, the process of domestication of production was virtually fixed.

Domestic production of bicycles rapidly increased the number of vehicles owned from 240,000 in 1910 to 4,070,000 in 1925, a ratio of vehicles to people of 1:15 (1 bicycle for every 3 households). The increase in vehicles