Automation of Ticket Issuing and Checking in Japan

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Introduction

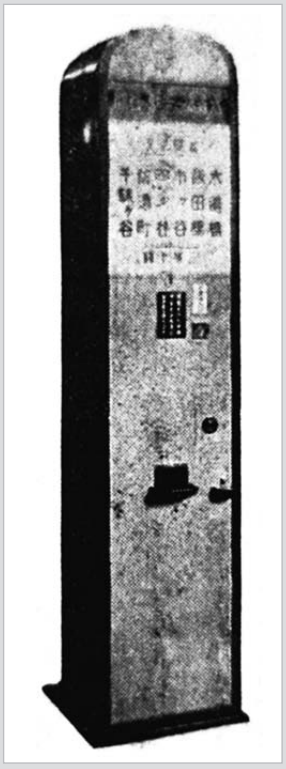
Station operations are typical works among the labour intensive business of the railway as a whole. The core operation of issuing and checking tickets involves a lot of direct contact with customers, so it has long been a target for automation. This article mostly describes progress in ticket systems from the 1960s, when advances in automation started, with a focus mainly on the former Japanese National Railways (JNR) and today's Japan Railways (JR) group of operators.

Early Automation of Ticketing and Checking

The history of ticket vending machines as labour-reduction measures starts in 1926 with the introduction of four German machines for issuing platform tickets at Tokyo Station and two at Ueno Station. These early machines were operated manually by the customer who inserted coins and pressed a lever to get the ticket. Later developments progressed to trial use in 1929 of a domestic, manually operated machine for issuing platform and short-distance tickets at Tokyo Station. It handled platform tickets as well as two tickets for the flat fare (5 sen or ¥0.05) and the next fare section. Domestic ticket vending machines were used later at major stations on the Yamanote Line, but their use was suspended during WWII. Automatic ticket gates were introduced in 1927 at the opening of Tokyo Underground Railway (today's Tokyo Metro Ginza Line) when a 10-sen coin was inserted for the flat fare (see photo on P.55). At that time, JNR did not consider automation due to the variety of tickets and because it did not have flat fares.

Early Ticket Vending Machines before WWII

Platform ticket vending machine in 1927 (The Railway Museum)



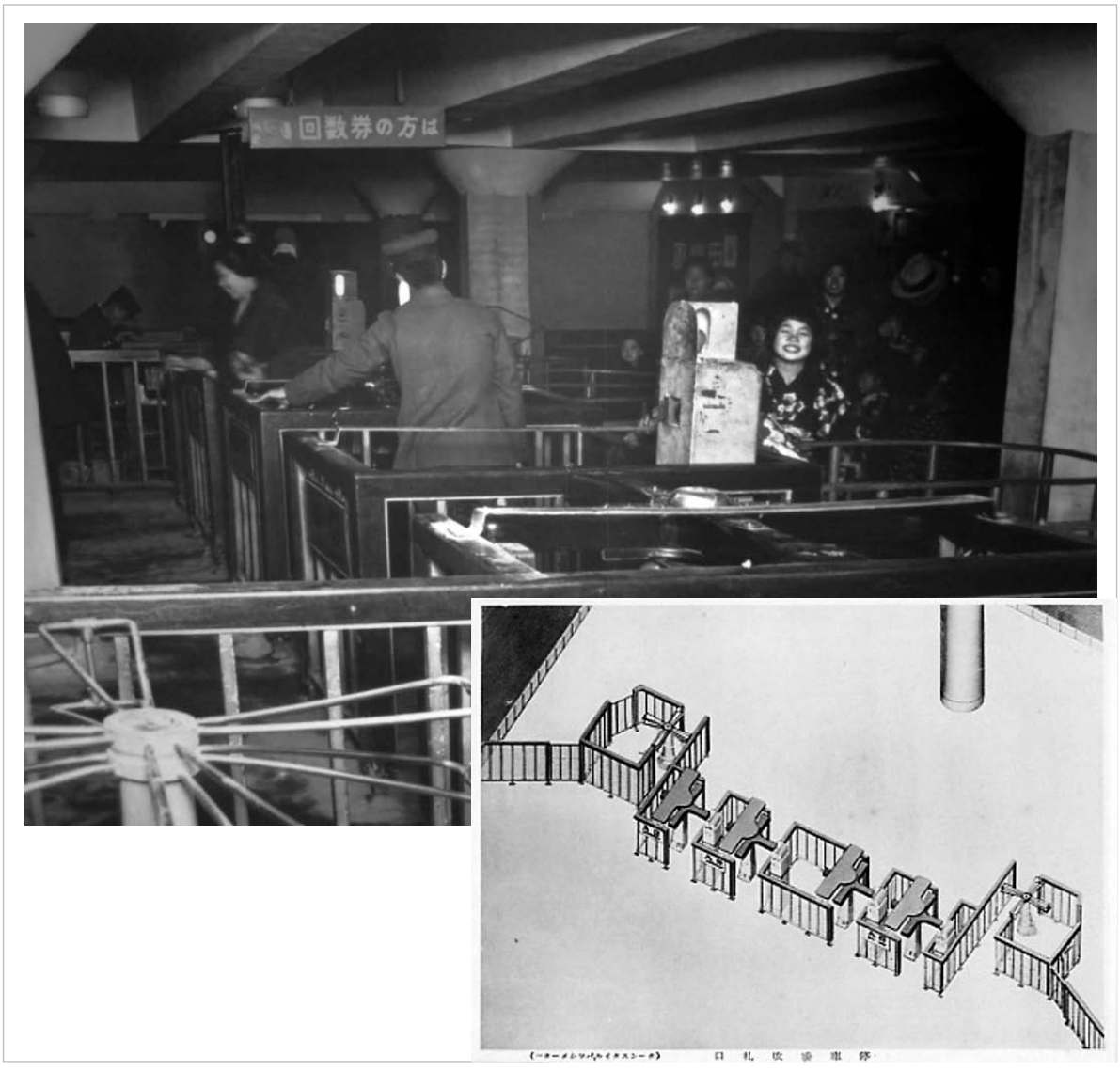
Ticket vending machine in 1929 (The Railway Museum)

German ticket vending machine introduced in 1926 (The Railway Museum)

The postwar industrial recovery led to modernization of the railway industry too. The first postwar machines were 50 manual ticket vending machines introduced in 1952 at major stations in Tokyo's 23 wards. They sold platform tickets and third-class ¥10 short-distance train tickets. Standalone single-function machines for platform tickets and short-distance tickets were introduced and improved successively with electric-powered ticket vending machines entering regular use by the 1960s.

Development of Ticketing Systems

International developments gained momentum using information technologies that had seen remarkable developments since the 1950s, especially in cybernetics technology proposed by Norbert Wiener. February 1962 saw a request via French National Railways (SNCF) President Louis Allemand for Japan to attend the November 1963 international symposium held by the International Union of Railways (UIC). Taking this opportunity, JNR and related companies established the Congress of Japan Railway Cybernetics (CJRC) on 22 April 1963 as a subsidiary of the Japan Railway Engineers Association (JREA) to be the Japanese counterpart to the symposium. CJRC requested articles from the Japanese railway industry and institutions and conducted doubling as preliminary screening for the symposium. Although international symposiums fizzled out after a few times, CJRC continued holding domestic symposiums and is currently composed of four committees, including one that hosts domestic symposiums and makes a great contribution to development of Japan's railway information technologies. The CJRC marked its 50th anniversary in 2013 with a commemorative event on 24 May. The Ticket Issuing and Checking System Committee of CJRC and its predecessor the Standards Working Group have played a key role in technical developments as well



Tokyo Underground Railway turnstile ticket gates (lower right: layout) (Tokyo Metro Museum)

First Practical application of ticket gates (Hankyu Kitasenri Station) (CJRC)

as in standardization and dissemination of ticket systems in Japan.

In 1962, during advances in computerization, a ticket printing and issuing machine was developed to automate ticket sales at manned counters. It used Edmondson cardboard railway tickets pre-printed with the backgrounds, and necessary extra information was printed at the counter. This greatly simplified ticket handling compared to the previous method where tickets were printed and managed accountwise. It served a major role in cutting labour for consolidating accounts for medium- and long-distance tickets, managing stock, accounting, auditing, and more. Ticket vending machines were improved too and trials of a multifunction ordinary machine that could sell multiple ticket types were held at Musashisakai Station on the Chuo Line and Kobe Station on the Tokaido main line in March 1965. The trial machine was eventually adopted for everyday use.

Full-scale automated ticketing and checking occurred in 1968 with introduction of a mechanism for printing tickets on and cutting tickets from paper rolls to multifunction ticket vending machine instead of printing on stiff cardboard tickets. These 'flexible tickets' were developed with feeding to automatic ticket gates in mind, and their appearance promoted automated station operations. Ticket vending machines were established mainly for short-distance tickets, and a format for unified management of multiple types of ticket vending machines was developed in 1970. When printing and issuing machines entered full-scale use in July 1970, a system was established to switch sales of short-distance tickets completely to customer-operated ticket vending machines while tickets for medium and long distances not handled by vending machines were sold by printing and issuing machines at manned counters, cutting labour greatly.

Advancements in Automatic Ticket Gates

Research in automating ticket gates also advanced around the same time as advances in ticket issuing operations. The Railway Technical Research Institute (RTRI), Kintetsu Research Institute, and others started R&D in 1963 for commuter passes, which made up 65% of all ticket gate use in Japan. Coincidentally, this was the same year that automatic ticket gates were introduced on the London Underground. The first tests were at Kintetsu's Abenobashi Station in 1966, followed by Tokyu Corporation's Motosumiyoshi Station, Kokubunji Station on JNR's Chuo Line, and others. Practical trials were run in 1967 at Kitasenri Station of Keihan Kyuko (now Hankyu Railway) in the Kansai region (see photo above). Since commuter passes for automatic gates used a punchcard format, mixed use with ordinary train tickets was difficult. This format did not catch on and research switched to a magnetic film coated ticket. An automatic ticket gate using magnetic tickets, introduced on a test basis at Gakuen-mae Station by Kintetsu Corporation, marked the start of practical use of that format.

CJRC later decided to adopt the magnetic format. Based on a proposal for station codes for all stations in Japan including JNR and private railways, a so-called Cybernetics Standard was established in 1971, supporting widespread use of automatic ticket gates. Such gates were set up from the start at all stations of newly opened railways such as the Sapporo Municipal Subway Namboku Line (December 1971), Yokohama Municipal Subway (December 1972), and Hokuso Development Railway (March 1979). Introduction in earnest was seen in the Kansai region at major stations of Keihan Railway, Kintetsu Corporation, Hankyu Railway, and others from the early 1970s. By the 1980s, automatic ticket gates had become the norm on most lines in the region. By contrast, in the Kanto region, JNR was hesitant about putting automatic ticket gates into full-scale practical use despite its technical lead. As a result, about the only examples were test use by Tokyu Corporation and a few others. A major factor was the labour situation of the time with the Kanto region facing much more crowding during rush hour. Also, the railway network was segregated into spokes with the JNR Yamanote Line loop as the hub, creating a situation where private railways could not expect a return on the investment of installing such ticket gates. The feeling at JNR was that a switch to automatic ticket gates would cause a drop in service levels, so the only commercially introduced gates were on the Musashino Line in April 1973. The objective was to observe technical and social results on a relatively low-traffic line.

Japan's automatic ticket gates need comparatively higher performance than those in Europe and North America due to the traffic situation. The required gate performance of 60 persons per minute is about double that of Europe and North America. Since traffic through manned ticket gates was estimated to be more than 80 persons a minute it was assumed that more ticket gates would be needed. Unlike the sturdy gate doors in Europe and North America, Japanese gates were designed for easy flow and are softer to prevent contact injury.

Progress was made in magnetic ticket media with the appearance of commuter passes not requiring plastic coatings and cards with high coercivity to prevent demagnetizing by metal objects, such as handbag catches. These ticket media along with magnetized roll paper used in ticketing vending machines were adopted into revisions to the Cybernetics Standard in 1990.

Ticketing and Checking Automatic Fare Collection System

The second event with a massive impact on station operations was the start of the MARS (Magnetic-Automatic Reservation System) seat reservation system. MARS1, the first system put into practical use, was a seat reservation system developed by RTRI in 1960 (before CJRC started) and was independent from actual ticket issuing and checking. It was the world's first online real-time system, able to make reservations for 15 days for 3600 seats on limited express trains between Tokyo and Osaka. The MARS101 developed next was Japan's first full-scale online real-time information processing system using general-purpose computers, replacing MARS1 in February 1964. In October 1965, the successor MARS102 was added with online reservation terminals at 152 stations across Japan. At the end of 1965, reservations for 8 days for 127,000 seats on 238 trains were available. The MARS system was gradually improved with a large update in September 1972 as MARS105 (see photo on P58). It started operation handling 700,000 seats a day, later increasing to 1.4 million.

The significance of MARS105 was more than its quantitative performance. It had become a general passenger sales system capable of selling all sorts of tickets for railways, not just reserved seats. Consequently, the meaning of the acronym was changed to Multi-Access Reservation System. As far as I can see, it greatly affected ticket issuing and checking operations by revolutionizing the conventional station operation consisting of ticket issuing/checking as the front duty and the other back-office operations. The concept of a total station operations system including management or AFC (automatic fare collection) was reshaped, with counter machines positioned as POS terminals for station operations. The development focus changed from cutting labour to system oriented.

Immediately after the 1987 JNR division and privatization, JR East completed a companywide station revenue management system, allowing revenue from all stations to be consolidated next day. Customer-operated ticket vending machines were connected to MARS, allowing them to buy medium- and long-distance tickets in addition to short-distance tickets and improving usability (see photo on P. 58 below). Staffed counters handling medium- and long-distance tickets were integrated with ticket offices handling reserved seats. Since 1990, ticket vending machines have been able to handle reserved seats and related long-distance tickets.

JR East started full introduction of automatic ticket gates in 1990. Although JNR had been hesitant about automatic ticket gates as previously mentioned, a change in thinking occurred with the successful division and privatization. Automatic ticket gates were introduced along with major renovations to stations, starting with the Yamanote Line forming the hub of metropolitan Tokyo. Technologically, revisions to the Cybernetics Standard, including the shift to high-coercivity magnetic film, played a major role in advancing automation of ticket gates nearly overnight

MARS 105 system (JR Systems)

Ticket vending machines of typical medium station (Asagaya Station) (JR East)

in metropolitan Tokyo with approximately 3000 gates introduced by 14 railway operators in April 1992.

A method allowing multiple tickets to be inserted and scanned simultaneously by an automatic ticket gate was developed, and automatic ticket gates for shinkansen were introduced in earnest in 1998. Thus, a new service was achieved at JR East, eliminating onboard ticket checking by conductors of correctly seated reserved-seat and non-reserved-seat passengers.

Ceremony commemorating the start of SUICA service (JR East)

Contactless IC Card Tickets

Traditionally, JNR had stuck to business based on a cash-in-advance system. However, the global trend was to switch to credit cards and cashless transactions, so JNR issued its own JNR Card credit card (later partnered with other credit card companies), allowing credit-card purchase of tickets. The same year, it also introduced a prepaid magnetic card (Orange Card) allowing purchase of short-distance tickets at ticket vending machines. The number of issued Orange Cards increased in line with trends of the time.

A key event in ticket systems was the 1991 introduction of the iO Card. It was a major innovation, allowing magnetic cards to be used as tickets themselves rather than as a means to purchase tickets. It also was significant in compensating for the drop in service levels due to gate automation. While it used the same concept used by BART in the USA, it was significant in that it was adopted by the nationwide railway network instead of just closed lines. Passengers were relieved of the burden of purchasing tickets for each short-distance trip, and a common ticket system was achieved between different operators. As a result, the convenient iO Card soon ate into the Orange Card's market share.

The Suica (Super Urban Intelligent Card) non-contact smart card, which JR East put into practical use in November 2001 (see photo above), changed the concept of ticket gates and also revolutionized railway management. Research in Suica started at RTRI at about the time JNR was privatized. The technology was perfected after extensive field testing led by JR East and being adopted as the Octopus system of Hong Kong's MRT. Suica launched at 424 stations in greater Tokyo as a new ticket system based on five concepts of increased service, increased security, system change, cost reduction, and business chances.

Suica combines the stored fare function of the iO Card and the commuter pass function in one credit card-sized card that communicates information via short-range radio signals. As a result passengers with just one Suica card simply touch and go to travel without buying individual tickets. Passengers using the Suica commuter pass function have their fare adjusted automatically when travelling beyond the set commuting section, so they enjoy the same convenience at the same discount as conventional commuter passes. Passengers favour Suica's convenience with sales increasing at a pace of 3.7 million cards a year to the extent that sales of other magnetic cards such as the Orange Card and iO Card have been discontinued. In the Kanto region, 23 railway operators and 31 bus operators introduced PASMO non-contact IC cards in March 2006. They are supported by all operators and are compatible

with Suica (from March 2007). The total number of Suica and PASMO cards sold reached 50 million in October 2010. Following that success, non-contact card systems have been adopted by railway operators across Japan. Compatibility between Suica and PASMO with non-contact cards from 9 operators (JR Hokkaido, JR Central, JR West, JR Kyushu, Nagoya City Transportation Bureau, Meitetsu, Fukuoka City Transportation Bureau, Nishitetsu and Surutto Kansai) started in March 2013.

Non-contact IC card systems have benefited railway management in other ways, such as easy deployment on small railways not previously adopting automation due to required facilities investment. In other words, automation can be scaled to company size. In stations with considerable crowding, automatic ticket gates that also use conventional magnetic tickets can be set up along with gates only for smart cards. At small stations and lines where automatic ticket gates cannot be introduced, simplified IC ticketing checking machines without doors and bars that do not handle magnetic tickets can be set up and readers can be installed on trains. Contactless IC cards also allow diversion from the concept of train 'tickets' as is seen with Mobile Suica using mobile phones to create a completely different form of ticket checking. In fact, automatic ticket gates for big cities have been modified to detect an approaching person (on the premise that the person's ticket is being checked and the person is passing through the gate) and track body movement without direct contact. (However, this advance does not deviate from the concept of gate passages.)

Suica is changing the face of railway business in more ways than just switching the ticket issuing and checking system to use radio signals instead of magnetic formats as media for tickets. It can be described as a symbolic success in creating a business for lifestyle services, one of the management objectives of JR East. Services have expanded to include product sales using an e-money function (March 2004), Mobile Suica with Suica functions merged into mobile phones to enable reservations (January 2006), and an auto-recharge function where the stored fare is increased automatically by credit card when the balance becomes lower than prearranged amount. Above all, the e-money function caused a major change that could well be a pinnacle of customer-oriented service. Nationwide use of Suica or equivalent specification transport cards, like PASMO, as e-money reached a remarkable 100 million transactions a month in July 2013, demonstrating that contactless IC cards are on the right track to establishing a major foothold in our social infrastructure. ■

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Dr Miki joined JNR in 1970, after obtaining a Ph.D. in engineering at University of Tokyo in 1970. He led the research and development of IC card system in RTRI. He transferred to JR East in 1991, where he continued to lead the development of SUICA.