

## Featured Articles

# Development of Ultra-high-speed Elevator and Establishment and Use of Patent Portfolio in China

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*OVERVIEW: The market for elevators and escalators continues to expand in China and other Asian nations based on a background of economic development and steadily rising urban populations. The Urban Planning and Development Systems Company of Hitachi, Ltd. has entered the Chinese market with an ultra-high-speed elevator it developed with the world's fastest speed of 1,200 m/min. In addition to strengthening its patent portfolio in China by using patents to protect the technology developed for the elevator, Hitachi is also including patents in its development of a technology brand, using them as a tool for marketing products to customers in its external promotions.*

## INTRODUCTION

THE Urban Planning and Development Systems Company of Hitachi, Ltd. is responsible for expanding its elevator and escalator business providing vertical mobility infrastructure to cities as part of a move to strengthen the global operations of Hitachi's Social Innovation Business.

The G1TOWER<sup>(1)</sup>, the world's tallest\*<sup>1</sup> (213 m) elevator research tower, commenced operation in 2010 at Mito Works, Hitachi's manufacturing and development base in Japan. Since then, it has been used for experimentation and testing in the development of technology for products that are designed for safety, comfort, and environmental performance in order to meet the rising global demand for elevators with high speed and large capacity. One outcome from the work at the G1TOWER is the supply by the Urban Planning and Development Systems Company and Hitachi Elevator (China) Co., Ltd. of ultra-high-speed elevators (with the world's fastest\*<sup>2</sup> speed of 1,200 m/min or 72 km/h) to the Guangzhou CTF Finance Centre (height 530 m), a high-rise building complex currently under construction in Guangzhou, China that is scheduled to fully open in 2016<sup>(2)</sup>.

As part of the global operations of its elevator and escalator business, the Urban Planning and Development Systems Company is establishing a portfolio of patents covering development work in

conjunction with its Intellectual Property Division, and is taking steps to utilize the portfolio in its business. This article describes market trends in the elevator and escalator business, the development of the ultra-high-speed elevator for the Chinese market, and the use of the intellectual property that supports the business.

## MARKET TRENDS AND DEVELOPMENT OF AN ULTRA-HIGH-SPEED ELEVATOR

### Role of China in Market for New Elevators and Escalators

The market for new elevators and escalators continues to demonstrate steady growth due to expanding demand for buildings in China and other nations in Asia and elsewhere that are experiencing economic development and rising urban populations. Total global demand is expected to rise from approximately 759,000 units in 2013 to approximately 905,000 units in 2015, with approximately 78% of this demand coming from the Asian Belt region (Japan, China, Southeast Asia, India, and the Middle East). The Urban Planning and Development Systems Company of Hitachi, Ltd. is focusing on business growth in this region (see Fig. 1).

In particular, China alone accounts for approximately 60% of global demand, making it the most important market, with considerable activity in the construction not only of office buildings and high-rise apartments, but also of high-rise buildings of 300 m or more.

\*1 As of April 21, 2014, based on research by Hitachi.

\*2 As of April 21, 2014, based on research by Hitachi.

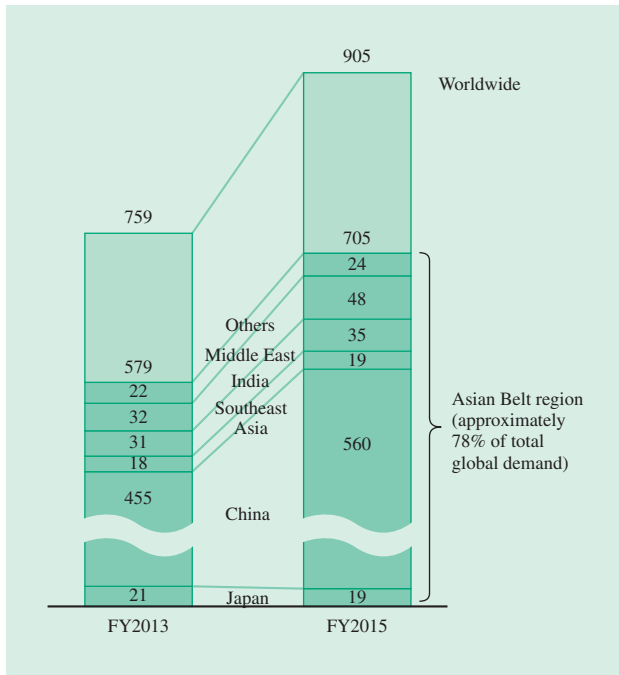


Fig. 1—Trends in Market for New Elevators and Escalators ( $\times 1,000$  Units, Based on Hitachi Research).

The market for elevators and escalators is expected to grow from approximately 759,000 units in FY2013 to approximately 905,000 units in FY2015. The Asian Belt region (Japan, China, Southeast Asia, India, and the Middle East) accounts for approximately 78% of this demand.

As its most important market, Hitachi Elevator (China) is seeking to increase sales of new equipment and extend its network of sales and service centers in China in its role as regional coordinator. In FY2013, it won orders for 67,000 new units (a 15% share of the Chinese market). To meet this demand, it is increasing its production capacity, having opened its fourth manufacturing plant in Chengdu in the west of China, adding to its existing plants in Guangzhou, Tianjin, and Shanghai.

Major examples of the company's elevators operating in China include the double-decker elevators at the Shanghai World Financial Center, with a speed of 480 m/min in 2008 and the ultra-high-speed elevators at the Long Wish Hotel International of Huaxi, with a speed of 600 m/min in 2010. It will also supply ultra-high-speed elevators with the world's fastest speed of 1,200 m/min in 2016. Hitachi's strategy for the elevator and escalator business is to enhance its brand value in the Chinese market by developing and commercializing the world's fastest elevators, and by technological differentiation through the wider deployment of the ultra-high-speed technology, and to use this as a way to expand its business.

## Development of Ultra-high-speed Elevator

The 1,200-m/min elevators to be supplied to the Guangzhou CTF Finance Centre, which can travel the 440 m from level 1 to level 95 (the "up-down stroke") in approximately 43 s, are being built based on a combination of technologies and equipment development work<sup>(3)</sup>.

The traction system that delivers the world-leading speed incorporates a 330-kW permanent magnet (PM) motor traction machine, the largest class ever used in an elevator; a brake with brake pad material that has a high tolerance for heat; and a high-strength rope with a strength-to-weight ratio approximately 30% higher than before.

Hitachi has developed a 2,200-kVA control unit consisting of two inverters in parallel, each of which has four parallel-connected insulated-gate bipolar transistors (IGBTs), and is using it as the control system that supplies the power to the traction machine (see Fig. 2).

Hitachi has also used the G1TOWER elevator research tower for structural and vibration design to achieve a high level of ride comfort with low levels of vibration and noise when traveling at ultra-high speed. This included the development of a fluid commutating cover that reduces wind noise at ultra-high speeds and an active guide unit that significantly reduces elevator car vibration due to rail curvature.

Traveling on the 440 m up-down stroke at ultra-high speed has a tendency to induce ear blockage and other passenger discomfort caused by air pressure

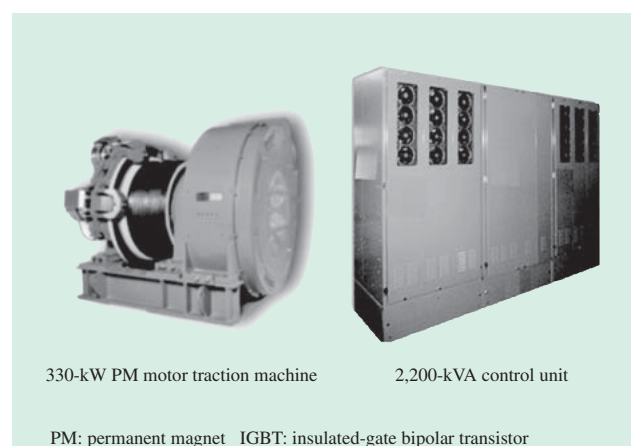


Fig. 2—Traction Machine and Control Unit for 1,200-m/min Ultra-high-speed Elevator.

Hitachi has developed a 330-kW PM motor traction machine, the largest class ever used in an elevator, and a 2,200-kVA control unit consisting of two inverters in parallel, each of which has four parallel-connected IGBTs.

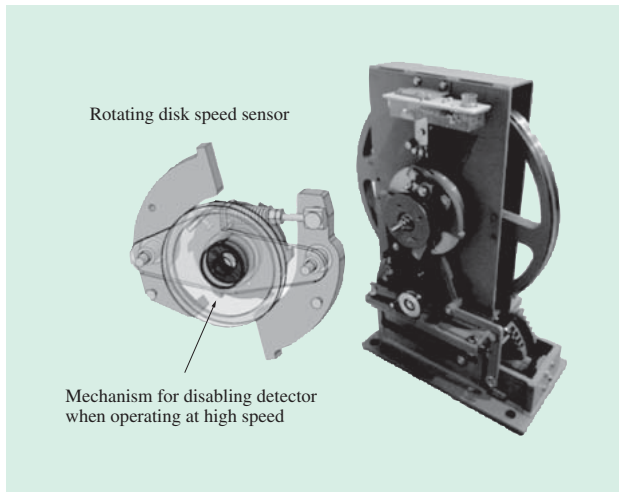


Fig. 3—Governor with Different Speed Limits for Ascending and Descending.

The governor incorporates a mechanism for disabling the overspeed limit for descending when the elevator is ascending so that it can detect abnormal overspeed at the respective ascending and descending speed limits.

differences due to altitude. Accordingly, whereas the ultra-high-speed elevators to be supplied to the Guangzhou CTF Finance Centre will travel at 1,200 m/min when ascending, they are speed-limited to 600 m/min when descending, which is the speed above which passengers are most likely to be affected, and are also fitted with devices for controlling the air pressure in the elevator cars. As a consequence, the safety devices need to detect abnormal overspeed at the respective ascending and descending speed limits. To achieve this, Hitachi developed a governor with different speed limits for ascending and descending so as not to treat the ascending speed as exceeding the overspeed limit for descending (see Fig. 3).

## USE OF INTELLECTUAL PROPERTY TO SUPPORT ELEVATOR AND ESCALATOR BUSINESS

Hitachi activities relating to intellectual property include the formulation of an intellectual property master plan for the elevator and escalator business to underpin the growth of the business in China. The following sections describe some of these activities.

### Establishment of Patent Portfolio for Ultra-high-speed Elevators

As described above, the technology for ultra-high-speed elevators can be broadly divided into the traction system, control system, structural and

vibration design, and safety device categories. These technologies enable the high speed, safety, and comfort that are used as promotional features for the elevators. To ensure the comprehensive protection of the key ideas involved in each of these four technical categories, Hitachi's Urban Planning and Development Systems Company, Research & Development Group, and Intellectual Property Division set up a project to apply for patents. In particular, this work was selected in FY2013 as a "flagship patent activity," which designates it as one of the key areas for patenting at Hitachi. This involved identifying technologies from the above four technical categories that are seen as strengths and as providing differentiation, and taking a prioritized approach to defining discoveries in parallel with the progress of research and development. As a result, Hitachi has been able to build up a portfolio of approximately 80 patent applications relating to ultra-high-speed elevators in the key Chinese market.

### Strengthening the Patent Portfolio in China

In addition to all the major elevator and escalator suppliers from Europe, America, and Japan, there are also a very large number of domestic Chinese suppliers operating in the Chinese market. The operation of end-product manufacturers is also complimented by parts manufacturers that specialize in the supply of elevator and escalator parts. China is continuing to grow in importance not only as a market but also as a base for manufacturing. This makes it very important for the elevator and escalator business to build up a patent portfolio in China.

The Urban Planning and Development Systems Company and Hitachi Elevator (China) have been working together to strengthen their patent applications in China (see Fig. 4). As a result, the number of patent applications made by Hitachi in China has grown from about 20 in 2004 to about 140, making Hitachi the leading publisher of patents in China among elevator and escalator manufacturers in 2013 (see Table 1).

In strengthening its patent applications in China, Hitachi has made changes to its application processes. Whereas past practice was to apply for a patent in Japan first, and then to consider whether pursuing a patent application in China was necessary, Hitachi now considers in which countries to apply for patents at the time an invention is created. As a result, Hitachi has also adopted a "China-first strategy" for some patent applications whereby it first applies for a patent in China.

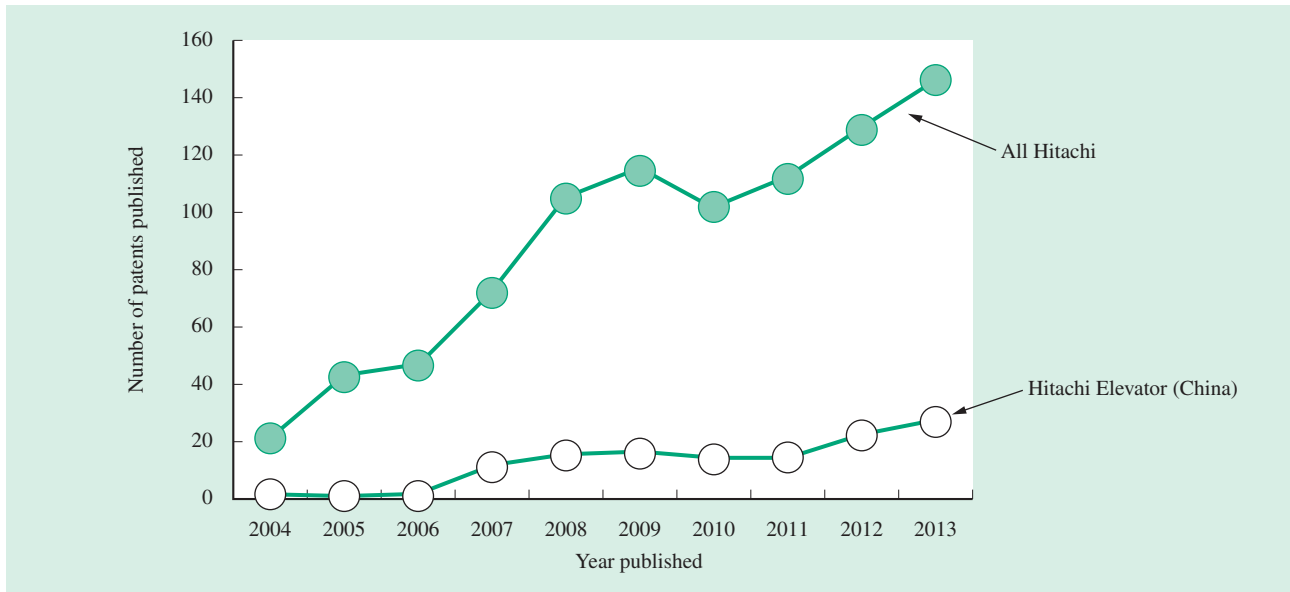


Fig. 4—Trend in Numbers of Patents Published in China (Elevators and Escalators).

Hitachi has strengthened its patent applications in response to the expansion of the Chinese market (based on research by Hitachi using figures from Shareresearch).

TABLE 1. Number of Elevator and Escalator Patents Published in China during 2013 by Equipment Suppliers

Hitachi published more patents in China during 2013 than any other elevator and escalator supplier (based on research by Hitachi using figures from Sharesearch).

Corporate group	Hitachi	Group A	Group B
Number of patents published in China	146	109	90

### Intellectual Property Management at Hitachi Elevator (China)

Management of intellectual property by Hitachi Elevator (China) is essential to the elevator and escalator business.

Hitachi Elevator (China) established its Asia Research & Development Center in 2004 to strengthen development in China. Staff from Japan and China work together at the center to develop technologies and products for expanding the Chinese market.

The intellectual property staff of Hitachi Elevator (China) have been assisting center engineers in undertaking the work required for patent applications, including idea formulation, prior art searches, and application document preparation. This has led to a steady increase in the number of patent applications (see Fig. 4) and is part of the work involved in building a portfolio of patents in China.

Patent applications by Chinese suppliers have also been increasing in recent years, making it important to assess and analyze these patents to avoid the risk of

infringement. Because the language barrier makes it difficult to perform this patent assessment and analysis in Japan, this is another activity that is handled by the Chinese staff at Hitachi Elevator (China). Specifically, Hitachi Elevator (China) identifies and analyzes patents that relate in particular to products it is developing in China. In the case of particularly important patents, it shares information about the products and patents with Japan so that they can jointly conduct a detailed analysis and decide how to proceed.

In this way, Hitachi Elevator (China) plays a vital role both in building a portfolio of patents and in avoiding the risk of infringing other companies' patents. Each year, the Urban Planning and Development Systems Company, Hitachi Elevator (China), and Intellectual Property Division hold an intellectual property strategy conference to share and communicate their intellectual property strategies and facilitate the management of intellectual property.

### Use of Patents in Public Relations

Using the patents that cover a product as a way of promoting that product to customers is sometimes an effective way to foster an appreciation of Hitachi's technical capabilities and differentiate it from other suppliers.

Accordingly, the Urban Planning and Development Systems Company sometimes publishes its patents at public relations events such as technical announcements. For example, Hitachi presented a

technical seminar on the world's fastest 1,200-m/min elevator at the World Elevator & Escalator Expo 2014 (May 2014), the world's leading trade show for elevators and escalators, and included the relevant patent numbers on the presentation slides. This is a case of patents also being used to support the business strategy of building a technology brand by promoting the world's-fastest elevator.

## CONCLUSIONS

This article has described the development of an ultra-high-speed elevator and summarized the associated intellectual property management.

It is anticipated that the demand for elevators and escalators, in their role as vertical mobility infrastructure, will continue to grow in the future due to economic development and rising urban populations

all around the world. Hitachi intends to continue utilizing patents to grow its business by acquiring them to protect its development work in key markets, and by using the acquired patents to enhance awareness of its technology brand.

## REFERENCES

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