

EXPLORING THE WORLD'S GREATEST RAILWAYS

蘇昭旭的世界鐵道大探索

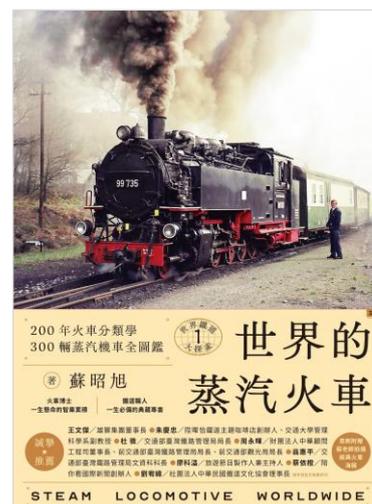
Taiwan's most-widely published expert on rail transportation Su Chao-Hsu has distilled a career's worth of knowledge and insights into this landmark four-book reference series. Get the lowdown on faraway exotic and scenic travel destinations while becoming comfortably conversant with "all things railroad".

Trains and railways, the mainstay of large-scale land transport for two centuries, are naturally associated with countless fascinating stories. This latest work by railway expert Su Chao-Hsu is a compendium reference on "all things railroad" that invites readers on a globe-spanning adventure exploring the history, evolution, and diversity of steam trains; traveling popular tourist train lines; and visiting train-themed museums and iconic train stations on every continent.

Volume one examines in bright, engaging detail the 300 or so types of steam engines developed over the past two centuries. The text is well seasoned with the author's own pictures as well as engine schematics and rarely seen contemporary models.

In volume two, readers take a captivating deep-dive into world railway heritage, learning along the way about the state of railway heritage preservation in various countries and embarking on eye-opening tours of some of the world's best rail scenery and tourist rail lines – quite a few of which are UNESCO World Heritage sites.

Volume three takes readers through some 70 railway-related museums around the world. The author also plumbs the merits of establishing a Taiwan railway museum, discussing its ideal scale, character, and mode of operation and pondering on how some of its more iconic collection items might best be presented.



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In volume four, readers learn all about railway stations and stops, starting with differences among building, track, and platform elements; then distinguishing among functional, architectural, scenic, and design characteristics; and finally ending with introductions to over 300 of the world's most iconic stations.

The closely interwoven narrative, photographs, and illustrations in this series compellingly reflect the fruits of a career's worth of dedicated work and research. This is both the perfect travel guide and educational reference book for casual readers and hard-core train enthusiasts alike.

Su Chao-Hsu 蘇昭旭

Born in 1967, Su Chao-Hsu has visited over 50 countries and published over 50 books in pursuit of his life's mission to create the definitive reference series on the railways of Taiwan, becoming in the process the most-prolific writer on the subject of trains and railways in the Chinese-speaking world.

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By Su Chao-Hsu

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Author's Preface: Classifying Steam Locomotives and Broadening Your Train Worldview

What exactly is a steam locomotive? From their birth in 1804 to the first-ever engine-hauled passenger train built by George Stephenson in 1825 all the way up to the present day, steam locomotives span over 200 years of history and are still going strong as an indispensable part of tourist railways all over the world. As well as being a crucial part of modern history, they also necessitated the creation of a completely new word in English: *Loco* from the Latin meaning “from a place” and *motivus* meaning “causing motion.” So what are steam locomotives? They are one of the most significant inventions in human transportation which, just like the birth of the Industrial Revolution, fundamentally changed human history and influenced industrial development for the two centuries that followed.

In my opinion, steam locomotives are as diverse as living organisms. They have evolved over such a long period of time and exist in so many different types that it's impossible to describe them all in a single sentence, making it very difficult indeed to get a complete picture of them without some kind of taxonomy. There are several internationally standardized classification methods such as the Whyte Notation and the UIC system, the latter of which is managed by the International Union of Railways and provides a practical taxonomic approach based on axle configuration. While these provide useful points of reference, they still leave a long way to go for readers wanting to understand steam locomotives from scratch.

There are some fundamental concepts for classifying steam locomotives, including: Tank vs. Tender; Saturated vs. Superheated; Two-Cylinder vs. Multi-Cylinder; Inside Frame vs. Outside Frame; Track Gauge Classification; as well as different categories for various Articulated, Geared, Rack, and Specially Modified locomotives. These are all simple, basic ways to categorize steam locomotives, and I believe it is crucial to include them if we're going to establish a system of locomotive classification.

Why should we establish a classification system for steam locomotives? Anyone who knows me will tell you that I have long been calling for the preservation and revitalization of Taiwan's railways as a cultural asset. The preservation of steam locomotives, a global trend for both private and government rail networks alike, is the only way to revitalize railway lines as a cultural asset. From our neighbors in Japan to countries in Europe and the Americas, the movement to preserve steam locomotives for tourism purposes has achieved dazzling results. In Taiwan, we are somehow more than a decade behind the rest of the world, and, even now, our vision of preserving steam trains still seems to be faltering. So, what is causing these problems in Taiwan?

First and foremost, we don't have a database of steam locomotives that we can use to understand them. Without this understanding, we tend to perceive them as representatives of a

bygone mode of transportation without realizing their value, and, on the off chance we do manage to recognize their value, still lack the requisite knowledge about how to preserve and utilize them as cultural assets. Perhaps then the answer lies in understanding and analyzing steam locomotive success stories from other countries.

However, the world is so big and Taiwan has a relatively small and limited collection of different steam locomotive types. However, my lifetime love of trains has driven me, with biologist-like passion, to diligently harvest “samples”. I discovered these “organisms” may be categorized by “leg” (i.e., wheel) number and arrangement, which can tell us how a steam locomotive moves, its intended operating environment, and track gauge size. They can also be categorized by “shape”, with their outward appearance revealing trains of the same class or regional pedigree. An interesting byproduct of this research is that, by looking at how these steam locomotives were invented, manufactured, and modified over time, we can learn the stories behind the development of related technologies and about shifts in contemporary geopolitics.

I would have never been able to write a book on a topic as vast as the classification of steam locomotives had I not spent over twenty years of my life amassing this information, traveling to more than fifty countries and collecting photographs from all over the world. Over the last two decades, I have built up a railway database and a “taxonomy” of railway knowledge in a deliberative process quite similar to creating an encyclopedia. I call it “Unabridged Railway Knowledge” and it’s available for the public to browse online via the Taiwan National Science and Technology Museum’s internet portal. I frequently speak at various organized events, sharing without reservation my experiences and research. In the beginning, most of my books were either about Taiwan’s railways or popular tourist railways around the world. Now, hoping that Taiwan’s railways may earn increasing recognition as international cultural assets, I have been using my own research and statistics on railways around the world in various analytical case studies. This new four-book series, *Exploring the World’s Greatest Railways*, is the culmination of this effort, providing readers with a new perspective on Taiwan’s railways and their place in world railway heritage.

I am grateful for the support received over the years from railway workers and train fans from all walks of life. Thank you to Ecus Publishing House for giving me the chance to publish this book, and, as the final result of my twenty-plus years of research and hard work goes to press, I sincerely hope it will benefit readers by offering a totally new perspective that will broaden their appreciation and understanding of trains.

Chapter 1: Understanding the Wonderful World of Steam Locomotives

Basic Classifications of Steam Locomotives



What are steam locomotives? They are one of the most significant inventions in human transportation which, like the Industrial Revolution, fundamentally changed human history and influenced industrial development for the two centuries that followed.

The Relationship Between Steam Locomotives and Rail Transportation

Mankind's use of railways has a long, storied history dating back to before the sixteenth century, when mines in Europe employed horse-drawn vehicles that used wooden tracks and wheels fitted with flanges. Utilizing tracks to reduce friction may have been the original impetus behind the creation of railway transportation itself. The later discovery that iron rails and steel wheels further reduced friction was critical to enabling the long-distance railway transportation networks we have today.

The mining railways used in continental Europe spread to England during the early seventeenth century. Then, at the dawn of the Industrial Revolution in 1760, the ironmaster Abraham Darby II managed to stabilize a roadbed with railroad ties at his Coalbrookdale Foundry and went on to invent L-shaped metal plates as a replacement for wooden tracks to reduce friction further while increasing efficiency. Later in the eighteenth century, the iron rails and wheels introduced to reduce friction also allowed the transport of increasingly heavier loads.

The Birth of the First Steam Locomotive

The invention of the steam locomotive was closely related to mining. During the second half of the seventeenth century, more mines opened to keep up with the demand for metal, and increasingly powerful pumping motors were required to excavate the deep underground pits. To improve rail transportation in these mines, steam locomotives gradually replaced human and horse-powered carts and, eventually, began to be employed above ground as well.

In 1769, the French engineer Nicolas-Joseph Cugnot built the world's first steam-powered three-wheeled vehicle. It could carry four passengers at four kilometers per hour on open roadways and, although not running on tracks, it signaled the era of train travel was imminent. In 1776, James Watt built a fully functional steam engine, the widespread use of which vastly improved train performance and became a driving force behind the Industrial Revolution. Another key driver of steam locomotive development was the European-wide war against Napoleonic France that had begun in the waning years of the eighteenth century. The widespread military requisitioning of horses had driven up prices for these animals, encouraging mine owners to seek alternatives leveraging the potential of new steam-driven train technologies.

On February 21st, 1804, Richard Trevithick successfully built the world's first steam locomotive on rails, which regularly conveyed passengers and their luggage through Wales at

speeds of up to eight kilometers per hour. Although this attracted worldwide attention, the technology had yet to reach the stage where it was commercially viable.

The Contributions of George and Robert Stephenson

On September 27th, 1825, George Stephenson introduced the first-ever steam locomotive capable of towing passenger cars. This train carried more than 600 passengers from Darlington to Stockton at a top speed of twenty-four miles per hour, covering the twenty-five-mile journey in three hours. That twenty-five-mile rail line was both the world's first public transportation railway and first commercially operated railway. At that time, steam locomotives were mainly used to transport goods, while people commuted using horse-drawn carriages. However, starting with Stephenson, long-distance passenger transportation slowly began to gravitate towards passenger railways. It was a moment tantamount to announcing the arrival of a new era: the age of trains and public transportation.

Subsequently, Britain authorized the construction of a railway from Manchester to Liverpool in 1826, and the Rainhill trials were held near Liverpool to determine which locomotives would be used on the line. Stephenson's *Rocket*, built by George and his son Robert's company, emerged as the best of the five competitors and was awarded a prize of 500 pounds for its top speed of thirty miles per hour. This win also served to formally grant the Stephensons the contract to produce the railway's steam locomotives. The Liverpool and Manchester Railway (also known as the L&MR) officially opened on September 15th, 1830, and was the world's first railway to be built with a standard gauge of 1,435mm, which came to be known as the "Stephenson Gauge." The Stephenson valve gear confirmed its operational reliability, allowing stable control of the train in both forward and reverse travel, thus ushering in a new phase in which steam locomotives were commercially viable and could be mass-produced.

This series of events not only enshrined steam locomotives' place in history but also changed the English language, with the term "locomotive" being born from a combination of the Latin words *Loco* ("from a place") and *motivus* ("causing motion"). The term "rail" originally referred to railings, while the word "railway" denotes the arrangement of railroad ties into a continuous track, and "rolling stock" is a phrase that is now used to describe railway vehicles. From the new connotations of these words, it is easy to see just how important steam locomotives have been in the development of human civilization. However, to truly understand locomotives, we must start with the inner workings of the steam engine and its constituent valve gear structures.

Classifying Steam Locomotives

Since that first recorded journey in 1804, steam locomotives have persevered for more than 200 years and today remain an integral part of tourist railways around the world. Over the years, steam locomotives have been catalysts in major historical events and evolved to encompass thousands of different types, making it difficult to get a complete picture of them without some kind of taxonomy.

In general, steam locomotives may be categorized by structure, track gauge, and application, and are often distinguished using six feature-based categories: Tank vs. Tender; Saturated vs. Superheated; Two-Cylinder vs. Multi-Cylinder; Inside Frame vs. Outside Frame; Track Gauge Classification; and Specially Modified Mountaineering locomotives. Several international bodies have issued classification standards for steam locomotives that resemble how different species are classified in the biological sciences. These include the Whyte Notation and the UIC system, the latter of which is managed by the International Union of Railways and uses its own set of practical classifications based on axle configuration.

Each section of this book explores one of these classification standards in detail to provide a comprehensive overview of steam locomotives around the world.

The Composition of Steam Locomotives and Valve Gear Structures

While most people refer to steam locomotives as steam “trains”, steam locomotive is the proper scientific term for these steam-engine-powered vehicles. The earliest locomotives lacked precise control over forward and backward momentum, requiring the development of a set of mechanisms able to control the steam-powered piston. These mechanisms are collectively known as valve gears, and it was their invention that made steam locomotives practical to use.

Many different types of valve gears have appeared over time and they can be organized into four main categories: Stephenson, Allan, Joy, and Walschaerts. All four types are found on steam locomotives in Taiwan. Of these four, Walschaerts is the most common type of valve gear worldwide.

Stephenson Valve Gear

To accurately control the piston in a steam locomotive, the valve gear is operated by the axis of the driving wheel, which is equipped with an eccentric disk that feeds back along the eccentric rod to either open or close the valve gear. This design, known as the Stephenson Valve Gear, first appeared in 1829 on Stephenson's *Rocket*, which hid the valve gear and the feedback mechanism on the inside of the driving wheel. This type of valve gear was dominant in locomotives produced during the nineteenth century. The design concealed the complicated connecting rods inside, with all of the complex parts hidden inside the frame. Both the No.9 Locomotive and CK58 preserved

by the Taiwan Railway Corporation use Stephenson valve gears and require regular inspection and repair to maintain their internal structures.

Allan Straight Link Valve Gear

It was not until the invention of the Allan straight link valve gear at the end of the nineteenth century that the eccentric wheels were moved to the outside of the frame to ease maintenance. The *Teng-yun*, Taiwan's very first steam locomotive, uses this type of valve gear. The Allan valve gear was invented by the Scottish engineer Alexander Allan in 1855, and was in most respects a modification of existing valve gears. While the Stephenson design used two pairs of eccentric wheels mounted in the center of the axle for forward and reverse control, the Allan valve gear had these mounted on the outside of the train's wheels. A key advantage of this was that the whole mechanism was exposed and thus easier to maintain.