Unit 1

Locomotive Basics

Learning Objectives

After learning this unit, you'll be able to know:

1. the definition of the locomotive;
2. the working mechanism of steam locomotives, diesel locomotives and electric locomotives;
3. the rules of wheel arrangements of modern locomotives and ancient steam locomotives;
4. the main technical parameters of electric locomotives.

Part One Lead-in

Directions: Look at the following locomotives and point out their types and any features you know about them.

Pictures	Types and Features
	Type:_____ Features:_____ _____
	Type:_____ Features:_____ _____
	Type:_____ Features:_____ _____

Part Two Reading Materials

Material A

Introduction to Locomotives

The locomotive is a kind of rail vehicle that can provide motive power for the train. Generally speaking, it does not carry goods or people directly. Its only function is to pull the train along the track. Besides, there are also many self-propelled and load-carrying rail vehicles called Electric Multiple Units (EMU) or Diesel Multiple Units (DMU). They are mainly used for passenger trains and rarely for freight trains.

The power of locomotives comes from fuel or from other extra sources. Generally, locomotives can be classified into three types according to their power sources: steam locomotives, diesel locomotives and electric locomotives.

1 Steam Locomotive

Steam locomotives are powered by steam. In a steam locomotive, water in the boiler is heated and the pressure generated by the steam drives the piston to move within the cylinder. Then the wheels are turned by the piston through a mechanical device. As a result, the locomotive moves. Figure 1-1 is the conceptual diagram of the steam locomotive by Newton.

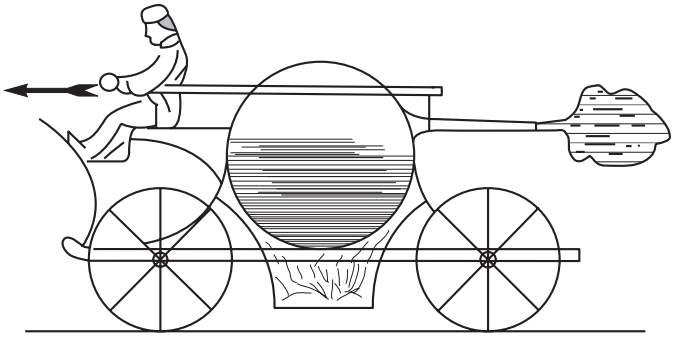

Figure 1-1 Conceptual diagram of the steam locomotive by Newton

2 Diesel Locomotive

Diesel locomotives are powered by diesel engines. The major types of diesel locomotives usually include diesel-electric locomotives, diesel-hydraulic locomotives and diesel-mechanical locomotives.

Power is transmitted to the wheels through mechanical devices in a diesel-mechanical locomotive. The wheels of a diesel-electric locomotive are driven by electric motors, and the diesel engine is used to drive the generator to produce electric energy for the electric motor.

3 Electric Locomotive

Electric energy for electric locomotives is taken from the overhead contact system (OCS) which can supply direct currents (DC) or alternating currents (AC) to the locomotive, and AC can be either single-phase AC or three-phase AC. According to the nature of their respective currents, electric locomotives can be further divided into three types: early DC-DC electric locomotives, AC-DC electric locomotives and AC-DC-AC electric locomotives.

As the first traction power unit, steam locomotives had been used for more than 100 years. Some of the later ones were streamlined and the "Mallard" was one of them. In 1938, it set a world record of over 200 km/h.

After the Second World War, diesel locomotives began to be used. Their engines were similar to those used in buses and lorries, but much bigger.

Compared with steam locomotives, diesel locomotives were more powerful and cleaner. They could pull expresses or heavy-haul freight cars.

Later, diesel-electric locomotives appeared, which were faster and more efficient, such as the Inter City 125.

Inter City 125 was one type of intercity high-speed train, which was built

between 1975 and 1982 for the British Rail. Driven by two Class 43 locomotives, the train could pull 7 to 8 trailers in the middle. It ran at a speed of up to 125 mph (≈201 km/h) and its test speed reached 148 mph (≈238 km/h), making it the world's fastest diesel multiple unit.

Electric locomotives were the latest ones widely used. For many years, trains driven by electric locomotives were only used for short-distance transportation around big cities. Later, due to the 25,000 V high-voltage power supply, electric locomotives began to cover longer distances.

The earliest electric locomotive looked like an ordinary carriage, but it had a small compartment for the driver and an electric motor underneath. Electric locomotives took currents from overhead cables, or from third rails.

In some countries such as Switzerland, electric power could be produced at a very low cost, so electric locomotives were used for all trains.

Exercise A

1. Directions: Read the text and translate the following terms with the help of dictionaries or the Internet.

(1) steam locomotive _____

(2) diesel locomotive _____

(3) electric locomotive _____

(4) diesel-electric locomotive _____

(5) diesel-hydraulic locomotive _____

(6) diesel-mechanical locomotive _____

(7) express _____

(8) heavy-haul freight car _____

(9) overhead contact system (OCS) _____

(10) intercity high-speed train _____

2. Directions: Draw a sketch of each following locomotive to show their main features.

Locomotive	Sketch
Steam Locomotive	
Diesel Locomotive	
Electric Locomotive	

Mini-project A

Directions: Work in groups. Give a short speech either about the working mechanisms of the steam locomotive, diesel locomotive and electric locomotive, or the history of railways in a certain country such as China. When introducing the working mechanisms of locomotives, please cover their types and features as well as their advantages and disadvantages.

Material B

Wheel Arrangements

The wheel arrangement notation system is a simple method to describe the structural characteristics of the locomotive running gear with numbers or letters, such as how the driving and trailing wheels are distributed under the

locomotive. Different countries have different notation systems.

We can learn how the wheel arrangement notation system has developed from that of steam locomotives.

In the era of steam locomotives, the wheel arrangements were described totally numerically. In the US and UK, it was usual at first to refer to a steam locomotive type by its wheels rather than its axles. In this notation system, the wheel arrangement notation uses three numbers, which successively refer to the number of the leading wheels, the driving wheels and the trailing wheels. In 1900, a wheel arrangement notation system invented by Frederic M. Whyte was presented in this order. For example, 4-4-0 means four leading wheels, four driving wheels, and no trailing wheel. If "o" is used to indicate a pair of leading wheels or trailing wheels, and "O" is a pair of driving wheels, 4-4-0 can be expressed as ooOO. Similarly, 4-6-2 can be expressed as ooOOOo, 0-4-2 as OOo, 0-6-0 as OOO, and 2-10-2 as oOOOOOo. Figure 1-2 shows the wheel arrangements of the 4-6-2 steam locomotive.

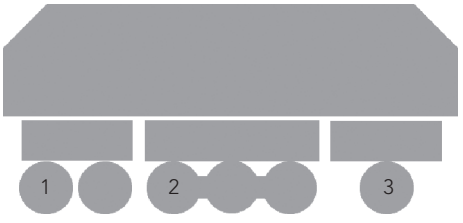

Figure 1-2 Wheel arrangements of the 4-6-2 steam locomotive

Notes:

1. leading wheel 2. driving wheel 3. trailing wheel

Later, some European countries modified the Whyte system, replacing the number of wheels with the number of axles, therefore 4-6-2 became 2-3-1. This was further developed by the French who used the numbers for non-driven axles and letters for driven axles, thus 2-3-1 became 2C1. This was rearranged by a British locomotive designer Bullied who placed the non-driven axles first in the order, then the driven axles, and thus 2C1 became 21C.

In the era of diesel locomotives and electric locomotives, the wheel

arrangement notation system evolved, and a more general representation was gradually formulated. There were two basic rules in it. First, the wheels were not individually identified anymore, only the axles; numbers are used to represent trailing wheels and letters used to represent driving wheels. The letters or numbers referred to the number of axles in a single bogie.

For example, the wheel arrangements of a locomotive with two bogies, each bogie having two axles, can be described as B_O-B_O or B-B, as shown in Figure 1-3.

Figure 1-3 B_O-B_O wheel arrangements

The difference between the two notations B_O-B_O and B-B is that the two wheel sets in the B bogie are coupled together and driven by the same electric motor. Over the years, some confusion had arisen because of the vibrations in B bogies. The two wheel sets in a B_O bogie were independent and driven by different electric motors, thereby the interaction force between the wheel sets and the vibrations were greatly reduced, so B_O bogies were widely used in various locomotives.

In European countries, the "- (hyphen)" has been replaced by a "' (apostrophe)", so the notation B_O-B_O is described as B_O'B_O'. The "- (hyphen)" is used to represent two seperated bogies, and the "' (apostrophe)"is used to represent a swiveling bogie, independent of the locomotive.

This notation system is also used to describe the wheel arrangements of the Electric Multiple Unit (EMU). For example, the notation 2'2'B_O'B_O'2'2' refers to a three-car unit with the front one a trailing car, the middle one a driving car and the back one a trailing car.

Further confusion had arisen because of the French way of describing wheel arrangements. For example, they widely used B'B' to describe the wheel arrangements, regardless of whether it was in fact B'B' or B_O'B_O'. So it caused a lot of confusion unless you know the French traction system very well.

Exercise B

1. Directions: Read the text and translate the following terms with the help of dictionaries or the Internet.

(1) wheel arrangement _____

(2) running gear _____

(3) bogie _____

(4) leading wheel _____

(5) driving wheel _____

(6) trailing wheel _____

(7) non-driven axle _____

(8) electric multiple unit (EMU) _____

2. Directions: Draw a diagram of the wheel arrangements of a steam locomotive, for example the 2-10-2 wheel arrangements. You need to draw the arrangements of the leading wheels, the driving wheels and the trailing wheels.

Mini-project B

Directions: Work in groups. Make a brief introduction to the naming rules of wheel arrangements, and point out the types of locomotives in your country and explain their wheel arrangements.

Part Three Further Development

Material C

Characteristics of Locomotives

This material takes the SS6B electric locomotive as an example to illustrate the main technical parameters of the electric locomotive.

The SS6B electric locomotive was successfully developed by Zhuzhou Electric Locomotive Works in 1994 on the basis of the Shaoshan series locomotives. It is a six-axle heavy-haul freight locomotive with a maximum speed of 100 km/h, a Co-Co wheel arrangement and continuous tractive power of 4800 kW. It is stopped in 2002. Till 2002, a total of 201 units were produced, and Zhuzhou plant produced 148 units (1001-1148), Datong plant 53 units (6001-6053).

The SS6B electric locomotive uses high-strength low-alloy steel welded into the integrally bearing body, the Co-Co bogie, the semi-suspended rolling bearing traction motor, and the single-side straight-toothed drive. The central low inclined drawbar push-pull traction gear is adopted to ensure utilization efficiency of adhesion.

A traction transformer and two rectifiers are installed on the SS6B locomotive. Each rectifier supplies power for three DC traction motors in one bogie, which are connected in parallel and can be separated from each other to ensure normal performance in case of failure so as to improve utilization of tractive power.

Regarding the air braking, DK-1 electro-pneumatic brakes are adopted in Shaoshan series locomotives, and rheostatic brakes are employed for

dynamic braking.

The control system of the SS6B locomotive is controlled by the microcomputer, which can transmit, display and store data for the diagnosis and handling of faults. In addition, complete with phase voltage regulating and step field weakening, this system can continuously control the constant current and accurately regulate the constant speed.

1 Main Technical Parameters

wheel arrangement	C_o—C_o
track gauge	1435 mm
distance between coupler centers	21,416 mm
distance between bogie centers	15,800 mm
fixed wheelbase	2300+200 mm
wheel diameter	1250 mm (new wheel)
locomotive curb weight	138 t
axle load	23 t
single-phase power supply system	AC25 kV, 50 Hz
continuous traction power	4800 kW
cruising speed	50 km/h
max speed	100 km/h
starting tractive effort	485 kN
continuous tractive effort	337.5 kN
max electric braking force	280.0 kN (10-50 km/h)
brake power at wheel rim	4029 kW (50-80 km/h)

2 Advantages

(1) Advanced technology

The microcomputer network control system is introduced, providing complete logic control and network transmission for diagnosis of faults and remote monitoring.

(2) Reliability

This locomotive is designed based on the advanced technology of the

critical components of SS4G and SS6 eletric locomotives. It is highly reliable.

(3) Excellent design and manufacture

Several advanced technologies and high-level manufacture workmanship are employed in the design and manufacture of this locomotive.

Exercise C

1. Directions: Read the text and translate the following terms with the help of dictionaries or the Internet.

(1) axle load _____

(2) cruising speed _____

(3) starting tractive effort _____

(4) continuous tractive effort _____

(5) brake power at wheel rim _____

2. Directions: Draw a sketch of a locomotive and mark the following dimensions in the drawing.

(1) track gauge

(2) distance between coupler centers

(3) distance between bogie centers

(4) fixed wheelbase

Part Four Workshop

Directions: Visit factories or workshops to learn about a certain type of locomotive, including its type, wheel arrangements, traction power, operation speed and other main technical parameters, and write an essay of at least 200 words on it.

Self-assessment

Directions: Check the boxes (☺, 😐 and ☹) given for each learning objective and tick the one that best matches your performance.

Learning Objectives	My Performance		
	☺	😐	☹
Know the definition of the locomotive			
Know the working mechanism of steam locomotives, diesel locomotives and electric locomotives			
Know the rules of wheel arrangements of modern locomotives and ancient steam locomotives			
Know the main technical parameters of electric locomotives			