НАВЧАЛЬНО-НАУКОВИЙ ЦЕНТР ГУМАНІТАРНОЇ ОСВІТИ

Кафедра іноземних мов

ЕЛЕКТРИЧНИЙ ТРАНСПОРТ

МЕТОДИЧНІ ВКАЗІВКИ

з розвитку навичок читання та
комунікативної компетенції

(англійська мова)

Харків – 2014

Методичні вказівки розглянуто та рекомендовано до друку на засіданні кафедри іноземних мов 12 грудня 2012 року, протокол № 5.

Методичні вказівки підготовлено відповідно до програми навчальної дисципліни і є складовою частиною навчально-методичного комплексу дисципліни “Англійська мова”.

Основна мета методичних вказівок – подальший розвиток усного мовлення, систематизація та розширення словникового запасу із теми «Електричний транспорт» та подальший розвиток усного спілкування. Вправи націлені на засвоєння лексичного матеріалу, набуття міцних навичок у всіх видах мовної діяльності.

Методичні вказівки призначені для студентів 2 курсу механічного факультету.

Укладачі:

старші викладачі Л.І. Золотаревська,
І.Б. Абрамська

Рецензент

доц. С.І. Нешко

ЕЛЕКТРИЧНИЙ ТРАНСПОРТ

МЕТОДИЧНІ ВКАЗІВКИ
з розвитку навичок читання та
комунікативної компетенції

(англійська мова)

Відповідальний за випуск Золотаревська Л.І.

Редактор Решетилова В.В.

Підписано до друку 15.01.13 р.

Формат паперу 60х84 1/16. Папір писальний.

Умовн.-друк.арк. 2,0. Тираж 25. Замовлення №

Видавець та виготовлювач Українська державна академія
залізничного транспорту,
61050, Харків-50, майдан Фейєрбаха, 7.
Свідоцтво суб’єкта видавничої справи ДК № 2874 від 12.06.2007 р.

УКРАЇНСЬКА ДЕРЖАВНА АКАДЕМІЯ ЗАЛІЗНИЧНОГО ТРАНСПОРТУ

НАВЧАЛЬНО-НАУКОВИЙ ЦЕНТР ГУМАНІТАРНОЇ ОСВІТИ
Кафедра іноземних мов

МЕТОДИЧНІ ВКАЗІВКИ

«Електричний транспорт»
з розвитку навичок читання та комунікативної компетенції для студентів 2 курсу механічного факультету

(англійська мова)

Харків - 2014

Методичні вказівки підготовлено відповідно до програми навчальної дисципліни і є складовою частиною навчально-методичного комплексу дисципліни “Англійська мова”.

Основна мета методичних вказівок – подальший розвиток усного мовлення, систематизація та розширення словникового запасу із теми «Електричний транспорт» та подальший розвиток усного спілкування. Вправи націлені на засвоєння лексичного матеріалу, набуття міцних навичок у всіх видах мовної діяльності.

Методичні вказівки призначені для студентів 2 курсу механічного факультету.

Методичні вказівки розглянуто та рекомендовано до друку на засіданні кафедри “Іноземні мови” 12 грудня 2012 року, протокол № 5.

Укладачі:

старші викладачі Л.І. Золотаревська
І.Б. Абрамська

Рецензент

доц. С.І. Нешко

UNIT 1

Exercise 1. Read and memorize the following words and word combinations.
vehicle – *n.* транспортний засіб,
refer to – *v.* посилатися на, згадувати,
electric drive – електрична повідня (електричний привід),
propulsion – *n.* рух уперед,
propeller - *n.* двигун, пропелер,
rotary motor – ротаційний (обертальний) двигун,
tracked – *adj.* рейковий,
linear – *adj.* лінійний,
come into existence – виникати, з'являтися,
gasoline – *n.* газолін,
internal combustion engine – двигун внутрішнього згоряння;
commonplace – *n.* звичайне явище,
fossil fuel – викопне паливо,
renewable – *adj.* відновлюваний,
tidal – зв'язаний з припливами та відливами,
wireless – *adj.* бездротовий, радіо-… ,
onboard – *adj.* бортовий, встановлений на борту,
flywheel – *n.* маховик,
supercapacitor – *n.* суперконденсатор,
fuel cell – паливний елемент (батарея),
hybrid – *adj.* гібридний,
recover – *v.* повертати,
braking energy – енергія гальмування,
grid – *n.* електрична мережа,
dump – *v.* скидати, звалювати,
waste – *adj.* непотрібний, непридатний, відпрацьований,
concern – *n.* турбота, хвилювання,
peak – *v.* чахнути, виснажуватись,
as such – по суті.

Exercise 2. Translate the following word-combinations.
An electric vehicle, tracked vehicles, linear motors, electric spacecraft, preferred methods, a level of comfort, ease of operation, propulsion method, electric power, fossil fuel-powered vehicles, a wide range of

sources, nuclear power, renewable sources, tidal power, solar power, wind power, overhead lines, wireless energy transfer, connection through an electrical cable, derive their energy, non-renewable fossil fuels, key advantage, hybrid electric vehicles, waste heat, a greater efficiency gain, increased concern, environmental impact, petroleum-based transportation infrastructure, peak oil, renewed interest.

Exercise 3. Match the words and word-combinations in the left column with their definitions in the right one.

1) vehicle	a) any machine designed to convert energy, especially heat energy, into mechanical work.
2) electric motor	b) a heavy wheel that stores kinetic energy and smoothes the operation of a reciprocating engine by maintaining a constant speed of rotation over the whole cycle.
3) propulsion	c) a wire or bundle of wires that conducts electricity.
4) engine	d) any conveyance in or by which people or objects are transported, especially one fitted with wheels.
5) tidal power	e) two or more primary cells connected together, usually in series, to provide a source of electric current / another name for accumulator.
6) cable	f) the act of propelling or the state of being propelled.
7) flywheel	g) a machine that converts electrical energy into mechanical energy by means of the forces exerted on a current-carrying coil placed in a magnetic field.
8) fossil fuel	h) a source of power.
9) energy	i) any naturally occurring carbon or hydrocarbon fuel, such as coal, petroleum, peat, and natural gas, formed by the decomposition of prehistoric organisms.
10) battery	j) the use of the rise and fall of tides involving very large volumes of water at low heads to generate electric power.

Exercise 4. Read and translate the following text.

Introduction

An electric vehicle (EV), also referred to as an electric drive vehicle, is a vehicle which uses one or more electric motors for propulsion. Depending on the type of vehicle, motion may be provided by wheels or propellers driven by rotary motors, or in the case of tracked vehicles, by linear motors. Electric vehicles can include electric cars, electric trains, electric airplanes, electric boats, electric motorcycles and scooters, and electric spacecraft.

Electric vehicles first came into existence in the mid-19th century, when electricity was among the preferred methods for automobile propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. At one time the internal combustion engine (ICE) had completely replaced the electric drive as a propulsion method for automobiles, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

Electric vehicles are different from fossil fuel-powered vehicles in that they can receive their power from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, and wind power or any combination of those. However it is generated, this energy is then transmitted to the vehicle through use of overhead lines, wireless energy transfer, or a direct connection through an electrical cable. The electricity may then be stored onboard the vehicle using a battery, flywheel, supercapacitor, or fuel cell. Vehicles making use of engines working on the principle of combustion can usually only derive their energy from a single or a few sources, usually non-renewable fossil fuels. A key advantage of electric or hybrid electric vehicles is their ability to recover braking energy as electricity to be restored to the on-board battery or sent back to the grid. When fossil fuel vehicles brake, they simply dump the energy into the environment as waste heat. This gives electric vehicles a greater efficiency gain in city traffic.

At the beginning of the 21st century, increased concern over the environmental impact of the petroleum-based transportation infrastructure, along with the spectre of peak oil, led to renewed interest in an electric transportation infrastructure. As such, vehicles which can potentially be powered by renewable energy sources, such as hybrid electric vehicles or pure electric vehicles, are becoming more popular.

Exercise 5. Answer the questions.

1 What is an electric vehicle? 2 By what means may motion be provided, depending on the type of vehicle? 3 What can electric vehicles include? 4 When did electric vehicles first come into existence? 5 What is the difference between electric vehicles and fossil-fuel vehicles? 6 What renewable sources of energy do you know? 7 Through the use of what means is energy transmitted to the vehicle? 8 What is a key advantage of electric or hybrid electric vehicles? 9 What led to renewed interest in an electric transportation infrastructure?

Exercise 6. Translate the italicized part of the sentence into English.

1 (*Електричний транспортний засіб)*, also referred to as an electric drive vehicle, is a vehicle which uses one or more electric motors for (*рух уперед)*. 2 Electric vehicles first *(з'явились)* in the mid-19th century. 3 At one time *(двигуни внутрішнього згоряння)* had completely replaced the electric drive as a propulsion method for automobiles. 4 Electric power *(залишилася звичайним явищем)* in other vehicle types, such as trains and smaller vehicles of all types. 5 Electric vehicles are different from *(транспортних засобів на викопному паливі)* in that they can receive their power from a wide range of sources. 6 However it is generated, this energy is then *(передається)* to the vehicle through use of *(надземна контактна лінія)*, *(бездротове передавання енергії)*, or a direct connection through an *(електричний кабель)*. 7 The electricity may then be stored onboard the vehicle using a *(акумулятор, маховик, суперконденсатор або паливний елемент)*. 8 *(Головна перевага)* of electric or hybrid electric vehicles is their ability to *(повертати енергію гальмування)* as electricity to be restored to the on-board battery or sent back to the *(електрична мережа)*.

Exercise 7. Write an annotation to the text.

UNIT 2

Exercise 1. Read and memorize the following words and word combinations.
motive power – рушійна сила, тяговий рухомий склад,
galvanic cells – гальванічний елемент,
exhibit – *v*. показувати, виставляти на огляд,
prevent – *v*. запобігати, запобігти,
reach – *v*. досягати,
trolley – *n.* вагонетка, тролейбус, (*Amer*.) трамвай,
locomotion – *v*. пересування, пересунення, переміщення,
urban – *adj.* міський,
noxious – шкідливий, нездоровий, отруйний, згубний,
inclined – *adj.* схильний,
prompt – *v*. збуджувати; штовхати, штовхнути,
clause – *n.* стаття, пункт,
enabling act – закон про надання надзвичайних повноважень,
power supply – енергопостачання, електропостачання; джерело електроживлення / енергії,
of choice – кращий, найкращий,
abet – *v*. стимулювати, збуджувати, сприяти,
multiple-unit train – моторвагонний потяг,
force – *v*. змушувати, тиснути,
ordinance – *n.* закон, указ, декрет,
recognize – *v*. визнавати, усвідомлювати, усвідомити,
public network – мережа спільного користування,
rotary phase converter – обертовий перетворювач числа фаз,
edge – *n.* границя, край,
downtown – *n.* центр, ділова частина міста,
issue – *n.* проблема, результат,
public nuisance – порушення громадського порядку, джерело небезпеки або незручності для оточення,
collision – *n.* зіткнення,
outlaw – *v*. оголосити протизаконним, забороняти,
shift – *v*. переміщувати, пересувати,
difficult – *adj.* скрутний, тяжкий, важкий,
readily available – легкодоступний,
steep – *adj.* крутий,
from scratch – із нуля, на порожньому місці, без переваг.

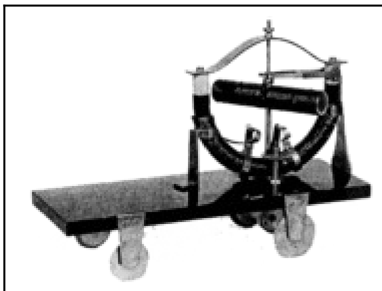
Exercise 2. Translate the following word-combinations.
Electric motive power, electric power available from batteries, to be supplied through a third isolated rail, a stationary dynamo, noxious smoke from steam locomotives, to be prompted by a clause in an enabling act, the power supply of choice, to be forced to convert by ordinance, high-voltage three phase alternating current motors and generators, a rotary phase converter suitable for locomotive usage, a four-mile stretch, to require a series of tunnels, a major operating issue and a public nuisance, to be focused on mountainous regions, to bring a revival of electrification, to be built from scratch, to be associated with dense urban traffic.

Exercise 3. Find pairs of synonyms among the below given words.
Motor, discomfort, exhibit (*v*), move (*v*), outlaw (*v*), reach (*v*), constrain (*v*), circular, engine, locomotion, achieve (*v*), noxious, transportation, incline (*v*), dispose (*v*), prohibit (*v*), round, abet (*v*), show (*v*), force (*v*), harmful, nuisance, incite (*v*), shift (*v*).

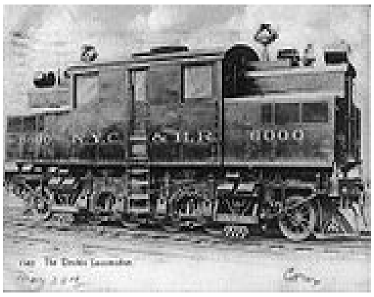
Exercise 4. Read and translate the following text.

History

Electric motive power started with a small railway operated by a miniature electric motor, built by Thomas Davenport in 1835. The first known electric locomotive was built by a Scotsman, Robert Davidson of Aberdeen in 1837 and was powered by galvanic cells ('batteries'). Davidson later built a larger locomotive named Galvani which was exhibited at the Royal Scottish Society of Arts Exhibition in 1841. It was tested on the Edinburgh and Glasgow Railway in September of the following year, but the limited electric power available from batteries prevented its general use. The first electric passenger train was presented by Werner von Siemens at Berlin in 1879. The locomotive was driven by a 2.2 kW motor and the train which consisted of the locomotive and three cars reached a maximum speed of 13 km/h. During four months the train carried 90,000 passengers on a 300 meter long circular track. The electricity was supplied through a third


Electric vehicle model by Ányos Jedlik,

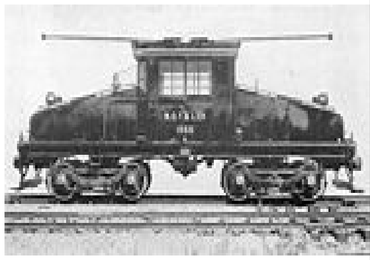
isolated rail situated between the tracks. A stationary dynamo nearby provided the electricity. The world's first electric tram line opened in Lichterfelde near Berlin, Germany, in 1881. It was built by Werner von Siemens. In the US, electric trolleys were pioneered in 1888 on the Richmond Union Passenger Railway, using equipment designed by Frank J. Sprague.



Alco-GE Prototype Class S-1, NYC & HR no. 6000 (DC)

Much of the early development of electric locomotion was driven by the increasing use of tunnels, particularly in urban areas. Smoke from steam locomotives was noxious, and municipalities were increasingly inclined to prohibit their use within their limits. Thus the first successful working, the City and South London Railway underground line in the UK, was prompted by a clause in its enabling act prohibiting use of steam power. This line was opened in 1890, using electric locomotives built by Mather and Platt. Electricity quickly became the power supply of choice for subways, abetted by the Sprague's invention of multiple-unit train control in 1897. Surface and elevated rapid transit systems generally used steam until forced to convert by ordinance.

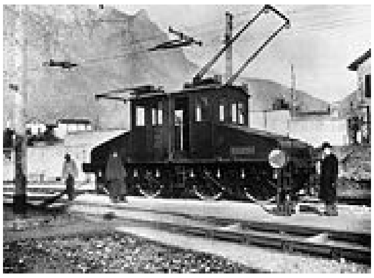
In 1894, the Hungarian engineer Kálmán Kandó developed high-voltage three phase alternating current motors and generators for electric locomotives; he is known as "the father of the electric train". His work on railway electrification was done at the Ganz electric works in Budapest. He was the first who recognised that an electric train system can only be successful if it can use the electricity from public networks. After realising that, he also provided the means to build such a rail network by inventing a rotary phase converter suitable for locomotive usage.



A GE steeplecab electric locomotive. This example is fitted with trolley poles for service on an interurban railroad.

The first use of electrification on a mainline was on a four-mile stretch of the Baltimore Belt Line of the Baltimore and Ohio Railroad (B&O) in 1895. This track connected the main portion of the B&O to the newly built line to New York, and it required a series of tunnels around the edges of Baltimore's downtown. Parallel tracks on the Pennsylvania

Railroad had shown that coal smoke from steam locomotives would be a major operating issue, as well as a public nuisance.



The world's first AC locomotive in Valtellina (1898-1902). Power supply: 3-phase 15 Hz AC, 3000V, (AC motor 70km/h). It was designed by Kálmán

Railroad entrances to New York City required similar tunnels, and the smoke problems were more acute there. A collision in the Park Avenue tunnel in 1902 led the New York State legislature to outlaw the use of smoke-generating locomotives south of the Harlem River after July 1, 1908. In response, electric locomotives began operation in 1904 on the New York Central Railroad. In the 1930s the Pennsylvania Railroad, which also had introduced electric locomotives because of the NYC regulation, electrified its entire territory east of Harrisburg, Pennsylvania. However, electrification in the United States was more associated with dense urban traffic, and the center of development shifted to Europe, where electrification was widespread.

In Europe, electrification projects initially focused on mountainous regions for several reasons: coal supplies were difficult and hydroelectric power was readily available; and electric locomotives gave more traction on steeper lines. For example, today 100% of Swiss lines are electrified.

A Milwaukee Road class ES-2, an example of a larger steeplecab switcher for service on

Italian railways were the first in the world to introduce electric traction (designed by Kálmán Kandó at the Ganz electric works, Budapest) for the entire length of a mainline rather than just a short stretch.

In 1923, the first electric locomotive with a phase converter was constructed on the basis of Kandó's designs in Hungary, and serial production began soon after.

The 1960s saw the electrification of many European main lines (Eastern Europe included). European electric locomotives technology had improved steadily from the 1920s onwards. Locomotives capable of commercial passenger service at 200 km/h appeared in Germany and France in the same period. Further improvements resulted from the introduction of electronic control systems, which permitted the use of increasingly lighter and more powerful motors.

In the 1980s, development of very high-speed service brought a revival of electrification. The Japanese Shinkansen and the French TGV were the first systems for which devoted high-speed lines were built from scratch. Similar programs were undertaken in Italy, Germany and Spain; in the United States the only new mainline service was an extension of electrification over the Northeast Corridor from New Haven, Connecticut to Boston, Massachusetts, though new light rail systems, using electrically powered cars, continued to be built.
On 2 September 2006 a standard production Siemens Electric locomotive of the Eurosprinter type ES64-U4 (ÖBB Class 1216) achieved a speed of 357 km/h, the record for a locomotive-hauled train, on the new line between Ingolstadt and Nuremberg.

Exercise 5. Answer the questions.
1 What did electric motive power start with? 2 Who built the first known electric motor what was it powered by? 3 When and where was the first electric passenger train presented? Who did it? 4 What was much of the early development of electric locomotion driven by? 5 Why was the use of steam locomotives prohibited by the municipalities? Tell about all the cases you know. 6 What made the electricity become the power supply of choice for subways? 7 Who and why is known as “the father of the electric train”? 8 Where was the first use of electrification on a mainline? 9 What was electrification in the United States more associated with? 10 Why did electrification in Europe initially focus on mountainous regions? 11 What brought the revival of electrification?

Exercise 6. Find some information about the following people, whose names you have already met in the text.
Thomas Davenport, Robert Davidson, Werner von Siemens, Frank J. Sprague, Peter Mather and John Platt, Kálmán Kandó.

Exercise 7. Translate the italicized part of the sentence into English.
1 *(Електрична рушійна сила)* started with a small railway. 2 *(Перший відомий)* electric locomotive was built by a Scotsman, Robert Davidson of Aberdeen in 1837 and *(надавався рух від гальванічних елементів (батарей))*. 3 The electricity *(подавалася через ізольовану третю рейку)* situated between the tracks. 4 A *(стаціонарна динамо машина)* nearby provided the electricity. 5 *(Дим)*from steam locomotives was

(шкідливий). 6 The first successful working underground line in the UK was prompted by a *(пунктом у законі про надання надзвичайних повноважень)* prohibiting use of steam power. 7 Electricity *(швидко стала найкращим джерелом енергії)* for subways. 8 Kálmán Kandó was the first who *(усвідомлював)* that an *(система електричного потяга)* can only be successful if it *(зможе користуватися електрикою з мережі спільного користування)*. 9 The first use of electrification on a *(магістралі)* was on a *(чотиримильному відрізку)* of the Baltimore Belt Line of the Baltimore and Ohio Railroad (B&O) in 1895. 10 It *(вимагала серію тунелів)* around the edges of Baltimore's *(ділової частини міста)*. 11 Coal smoke from steam locomotives was a *(головною експлуатаційною проблемою)*, as well as a *(джерелом небезпеки для оточення)*. 12 *(Запаси вугілля були скрутними)* and hydroelectric power was *(легкодоступною)*. 13 *(Подальші вдосконалення виникли внаслідок)* the introduction of *(електронних систем регулювання)*. 14 In the 1980s, development of very *(швидкісного обслуговування)* brought a *(відродження електрифікації)*.

Exercise 8. Project. Find out the information about the history of electrification on our Ukrainian railways. Use the Internet or some other sources of information and make a presentation.

Exercise 9. Write an annotation of the text.

UNIT 3

Exercise 1. Read and memorize the following words and word combinations.

energy storage system – енергоакумулювальна система
overhead wire – контактний провід, повітряний провід,
alternating current – змінний струм,
direct current – постійний струм,
couple – *v.* зчіплювати,
driving wheels – тягове колесо, повідне колесо,
large currents – струми великої сили,
high current – сильний струм; *ant.* **low current –** слабкий струм,
transformer – *n.* перетворювач,
voltage – *n.* електрична напруга; електрорушійна сила,
regenerative braking – рекуперативне гальмування, динамічне гальмування,
descend – *v.* спускатися, сходити (вниз); *ant.* **ascend –** *v.* підніматися, сходити на,
sliding shoe – лижа струмоприймача,
pickup – *n.* струмознімач; захоплювальний пристрій,
accommodate – *v.* підганяти, прилаштовувати,
trackwork – *n.* колійні праці,
clearance – *n.* проміжок, просвіт, кліренс, габарит,
catenary – *n.* контактний провід /підвіска,
trolley pole – штанга струмоприймача,
bow collector – дуговий струмоприймач,
hinged frame – суставна рама,
collecting shoe – контактний підкладень; лижа струмоприймача,
fixed geometry – незмінна геометрія постійної форми,
drive system – система привода,
devise – *v.* розроблювати, винаходити,
output – *n.* відбій,
jackshaft – *n.* проміжний/сліпий вал,
gear – шестірня (триб); передавальний механізм, трибова передача,
mature – *v.* удосконалювати; доводити до довершеності,
quill drive – втулково-пружинний привід; гнучка повідня; привід тягового двигуна з порожнистим валом,
reduction gear – уповільнююча/знижувальна передача,

motor armature – якір двигуна, ротор електричного двигуна,
field assembly – монтажне складання,
field pole – полюс збудження,
counterpart – *n.* дублікат, копія,
journal – *n.* шийка осі/вала,
protuberance – *n.* випуклість, виступ,
bogie bolster – колискова балка поворотного візка,
torque reaction – реакція від крутильного моменту, реактивний момент,
spur gearing – циліндрична трибова передача,
pinion – *n.* шестірня (триб),
bull gear – зубчасте колесо (триб) для багато потокової трибової передачі; триб для важких умов праці,
liquid-tight – *adj.* герметичний**,**
gear ratio – коефіцієнт передачі**.**

Exercise 2. Translate the following word-combinations.
Rechargeable energy storage system, a stationary source, a marked contrast, an onboard diesel engine, a distinguishing design feature, to couple the traction motors to the driving wheels (drivers), the most fundamental difference, run at relatively low voltage, relatively massive equipment, to transmit sufficient power, large transmission system losses, to become the predominant type, to be proportional to, the use of regenerative braking, to feed back into the lines, to be particularly advantageous in mountainous operations, multiple pickups, to accommodate the breaks in the third rail, to prefer overhead lines, in a fixed geometry, both overhead and third rail collection, a number of drive systems, to mount directly on the axles, a fully-spring loaded system, disconnected from the driving wheels, to be coupled to the axle through a reduction gear and a semi-flexible shaft (the quill), to fall out of favour, to be attached to the truck (bogie) in a fixed position, to be of limited value, to compensate for the problem, axle-hung traction motors, plain bearings, to be integral to the axle, a tongue-shaped protuberance, a liquid-tight housing.

Exercise 3. Match the terms in the left column with their definitions in the right column.

1) third rail 2) voltage 3) alternating current 4) direct current 5) driver 6) electric current 7) brakes 8) generator 9) catenary 10) pantograph 11) bogie 12) gear	a) a continuous electric current that flows in one direction only, without substantial variation in magnitude. b) a flow of electric charge through a conductor. c) a method of providing electric power to a railway train, through a continuous rigid conductor placed alongside or between the rails of a railway track. d) any device for converting mechanical energy into electrical energy by electromagnetic induction, especially a large one as in a power station; a device for producing a voltage electrostatically; any device that converts one form of energy into another form. e) a sliding type of current collector, esp a diamond-shaped frame mounted on a train roof in contact with an overhead wire. f) a continuous electric current that periodically reverses direction, usually sinusoidal. g) a toothed wheel that engages with another toothed wheel or with a rack in order to change the speed or direction of transmitted motion. h) a device for slowing or stopping a vehicle, wheel, shaft, etc., or for keeping it stationary, esp by means of friction. i) an assembly of four or six wheels forming a pivoted support at either end of a railway coach. It provides flexibility on curves. j) an electromotive force or potential difference expressed in volts. k) a mechanical component that exerts a force on another to produce motion. l) the hanging cable between pylons along a railway track, from which the trolley wire is suspended.

Exercise 4. Read and translate the following text.

Power supply of electric locomotives

An electric locomotive can be supplied with power from:

- *Rechargeable energy storage systems (RESS)*, as battery or ultracapacitor-powered mining locomotives.
- *A stationary source*, such as a third rail or overhead wire.

This is in marked contrast to a diesel-electric locomotive, which combines an onboard diesel engine with an electrical power transmission or store (battery, ultracapacitor) system.

The distinguishing design features of electric locomotives are:

- The type of electrical power used, either alternating current or direct current.
- The method for store (batteries, ultracapacitors) or collecting (transmission) electrical power.
- The means used to mechanically couple the traction motors to the driving wheels (drivers).

Direct or alternating current. The most fundamental difference lies in the choice of direct (DC) or alternating current (AC). The earliest systems used direct current as, initially, alternating current was not well understood. Direct current locomotives typically run at relatively low voltage (600 to 3,000 volts); the equipment is therefore relatively massive because the currents involved are large in order to transmit sufficient power. Power must be supplied at frequent intervals as the high currents result in large transmission system losses.

As alternating current motors were developed, they became the predominant types, particularly on longer routes. High voltages (tens of thousands of volts) are used because this allows the use of low currents; transmission losses are proportional to the square of the current (e.g. twice the current means four times the loss). Thus, high power can be conducted over long distances on lighter and cheaper wires. Transformers in the locomotives transform this power to a low voltage and high current for the motors. A similar high voltage, low current system could not be employed with direct current locomotives because there is no easy way for DC to do the voltage/current transformation so efficiently achieved by AC transformers.

Electric traction allows the use of regenerative braking, in which the motors are used as brakes and become generators that transform the motion of the train into electrical power that is then fed back into the lines. This system is particularly advantageous in mountainous operations, as descending locomotives can produce a large portion of the power required for ascending trains.

While recently designed systems invariably operate on alternating current, many existing direct current systems are still in use.

Power transmission. The original Baltimore and Ohio Railroad electrification used a sliding shoe in an overhead channel, a system quickly found to be unsatisfactory. It was replaced with a third rail system, in which a pickup (the "shoe") rode underneath or on top of a smaller rail parallel to the main track, somewhat above ground level. There were multiple pickups on both sides of the locomotive in order to accommodate the breaks in the third rail required by trackwork. This system is preferred in subways because of the close clearances it affords.

However, railways generally tend to prefer overhead lines, often called "catenaries" after the support system used to hold the wire parallel to the ground. Three collection methods are possible:

- *Trolley pole*: a long flexible pole, which engages the line with a wheel or shoe.
- *Bow collector*: a frame that holds a long collecting rod against the wire.
- *Pantograph*: a hinged frame that holds the collecting shoes against the wire in a fixed geometry.

Of the three, the pantograph method is best suited for high-speed operation. Some locomotives are equipped to use both overhead and third rail collection (e.g. British Rail Class 92).

Driving the wheels. During the initial development of railroad electrical propulsion, a number of drive systems were devised to couple the output of the traction motors to the wheels. One of the earliest methods was the jackshaft drive. In this arrangement, the traction motor is mounted within the body of the locomotive and drives the jackshaft through a set of gears. This system was employed because the first traction motors were too large and heavy to be mounted directly on the axles. Due to the number of mechanical parts involved, frequent maintenance was necessary.

Several other systems were devised as the electric locomotive matured. The *Buchli drive*[*] was a fully-spring loaded system, in which the weight of the driving motors was completely disconnected from the driving wheels. It was first used in electric locomotives from the 1920s. The quill drive was also developed about this time, and mounted the traction motor above or to the side of the axle and coupled to the axle through a reduction gear and a semi-flexible shaft (the quill). Again, as traction motors continued to shrink in size and weight, quill drives gradually fell out of favour.

Another drive example was the "bi-polar" system, in which the motor armature was the axle itself, the frame and field assembly of the motor being attached to the truck (bogie) in a fixed position. The motor had two field poles, which allowed a limited amount of vertical movement of the armature. This system was of limited value since the power output of each motor was limited. The EP-2 bi-polar electrics used by the Milwaukee Road compensated for this problem by using a large number of powered axles.

Modern electric locomotives, like their Diesel-electric counterparts, almost universally use axle-hung traction motors, with one motor for each powered axle. In this arrangement, one side of the motor housing is supported by plain bearings riding on a ground and polished journal that is integral to the axle. The other side of the housing has a tongue-shaped protuberance that engages a matching slot in the truck (bogie) bolster, its purpose being to act as a torque reaction device, as well as a support. Power transfer from motor to axle is effected by spur gearing, in which a pinion on the motor shaft engages a bull gear on the axle. Both gears are enclosed in a liquid-tight housing containing lubricating oil. The type of service in which the locomotive is used dictates the gear ratio employed. Numerically high ratios are commonly found on freight units, whereas numerically low ratios are typical of passenger engines.

Wheel arrangements. *The Whyte notation system*[**] for classifying steam locomotives is not adequate for describing the varieties of electric locomotive arrangements. The *UIC*[***] classification system was typically used for electric locomotives, as it could handle the complex arrangements of powered and unpowered axles, and could distinguish between coupled and uncoupled drive systems.

[*]*Buchli drive - is a transmission system used in electric locomotives. It was named after its inventor, Swiss engineer Jakob Buchli.*

[**]*The Whyte notation system - The Whyte notation for classifying steam locomotives by wheel arrangement was devised by Frederick Methvan*

Whyte and came into use in the early XXth century encouraged by an editorial in "American Engineer and Railroad Journal" (December 1900).
****UIC - International Union of Railways (Union Internationale des Chemins de fer).*

Exercise 5. Answer the questions.
1 What sources of electric locomotive power supply do you know? 2 What is the difference between a diesel-eclectic and an electric locomotive? 3 What are the distinguishing design features of electric locomotives? 4 What does the most fundamental difference lie in? 5 Why did alternating current motors become predominant? 6 What is a third rail system? 7 What methods of collecting power from 'catenaries' do you know? 8 What method is the best suited for high-speed operation? 9 What drive systems do you know? Characterize them. 10 What notation systems for classifying locomotives do you know? What system was typically used for electric locomotives?

Exercise 6. Translate the italicized part of the sentence into English.
1 The most fundamental difference lies *(у виборі постійного або змінного струму)*. 2 High voltages (tens of thousands of volts) are used because *(це дозволяє використовувати слабкий струм)*. 3 Electric traction *(дозволяє використовувати рекуперативне гальмування)*. 4 Motors are used as brakes and become generators *(які перетворюють рух потяга в електричну енергію, яка потім повертається до ліній)*. 5 This system was employed because *(перші тягові мотори були занадто великими та важкими, щоб бути встановленими прямісінько на осях)*. 6 *(Мотор мав два полюсу збудження)*, which allowed a limited amount of vertical movement of the armature. 7 The EP-2 bi-polar electrics used by the Milwaukee Road *(вирішив цю проблему використовуючи велику кількість осей з силовими двигунами)*. 8 Both gears are enclosed in a *(герметичний корпус, який містить мастильну оливу)*. 9 The type of service in which the locomotive is used *(визначає коефіцієнт передачі, який повинен використовуватись)*. 10 The Whyte notation system for classifying steam locomotives *(не припустима для відображення усього різноманіття будов електричних локомотивів)*.

Exercise 7. Complete the following sentences. Find the necessary information in the text.

1 A diesel-electric locomotive combines … . 2 … typically run at relatively low voltage. 3 … were developed, they became the predominant types. 4 The system of regenerative braking is particularly advantageous … . 5 This system is preferred in subways because … . 6 Railways generally tend to prefer … . 7 … is best suited for high-speed operation. 8 Some locomotives are equipped to use both … . 9 One of the earliest drive systems was … . 10 Modern electric locomotives almost universally use … .

Exercise 8.

a) Make reports about the people mentioned in the text.

b) Find the information and tell the group about the classification systems of locomotives by wheel arrangement. Consult the Internet or all the other sources.

Exercise 9. Write an annotation to the text.

UNIT 4

Exercise 1. Read and memorize the following words and word combinations.
wiring – *n.* електропровідня,
feeder station – живильна станція,
from above – *adv.* зверху,
messenger wire – несучий трос,
dropper – *n.* струна контактного дроту; *syn.* – **drop wire**,
pulley – *n.* шків, блок, ролик,
link – *n.* сустав, передатний важіль, кільце,
clamp – *n.* затискач, скоба, клема,
subject – *v.* підлягати, піддавати,
tension – *n.* Натягнення,
carbon – *adj.* Вуглецевий,
insert – *n.* вкладень, перекладка,
even – *adj.* рівний, рівномірний,
notch – *n.* карб, борозна, щербина,
successive – *adj.* наступний, подальший,
simple equipment – одинарна підвіска,
conceive – *v.* задумувати,
stitched equipment – ромбоподібна ресорна підвіска,
compound equipment – подвійна підвіска,
auxiliary wire – допоміжний трос,
oscillation – *adj.* коливання,
standing wave – стояча (нерухома) хвиля,
virtually – *adv.* фактично,
sag – *v.* прогинатись, провисати,
hog – *v.* вигинатися, жолобитись,
transition – *n.* сполучення, перехідна ділянка,
section break – кінець секції,
neutral section – нейтральна вставка,
phase break – обрив фази,
back-to-back – *adj.* той, що слідує безперервно; *adv.* щільно, впритул,
jar – *v.* стрясати.
at full throttle – на повній швидкості,
coast – *v.* рухатися накотом, по інерції,
level – *adj.* рівний, горизонтальний,
short circuit – коротке замикання,
Exercise 2. Translate the following word-combinations.

Energy supply point, overhead wires, feeder stations, high-voltage electrical grid, the contact wire geometry, to be subjected to a mechanical tension, the carbon surface of the insert on top of the pantograph, going around a curve, to tend to have, to enable higher speeds, more conductive but less wear-resistant metal, the pantograph causes oscillations, electrically separated portions, to prevent arc damage to the insulator, different voltages or frequencies, to consist of two section breaks back-to-back, to belong to neither grid, the sudden loss of power, parallel to the rail tracks, to be especially suited to high-speed operations, bipolar overhead lines, high risk of short circuits.

Exercise 3. Find pairs of synonyms among the words given below.
Catenary *n.*, straining *n.*, overhead wiring, following *adj.*, expose *v.*, tension *n.*, cramp *n.*, successive *adj.*, sheave *n.*, even *adj.*, horizontal *adj.,* vibration *n.*, subject *v.*, clamp *n.*, secondary *adj.*, uniform *adj.*, pulley *n.*, back-to-back *adj.*, oscillation *n.*, consecutive *adj.*, auxiliary *adj.*, level *adj.*.

Exercise 4. Read and translate the following text.

Overhead lines

Overhead lines or overhead wires are used to transmit electrical energy to trams, trolleybuses or trains at a distance from the energy supply point. These overhead lines are known variously as

- *Overhead contact system (OCS)*—Europe, except UK
- *Overhead line equipment (OLE or OHLE)*—UK
- *Overhead wiring (OHW)*—Australia
- *Catenary*—United States, Singapore (North East MRT Line) and Canada.

Overhead line is designed on the principle of one or more overhead wires situated over rail tracks, raised to a high electrical potential by connection to feeder stations at regular intervals. The feeder stations are usually fed from a high-voltage electrical grid.

Construction. To achieve good high-speed current collection it is necessary to keep the contact wire geometry within defined limits. This is usually achieved by supporting the contact wire from above by a second wire known as the messenger wire (UK & Europe) or catenary (US & Canada). This wire is attached to the contact wire at regular

intervals by vertical wires known as droppers or drop wires. The messenger wire is supported regularly at structures, by a pulley, link, or clamp. The whole system is then subjected to a mechanical tension.
As the contact wire makes contact with the pantograph, the carbon surface of the insert on top of the pantograph is worn down. Going around a curve, the "straight" wire between supports will cause the contact wire to cross over the whole surface of the pantograph as the train travels around the curve, causing an even wear and avoiding any notches. On straight track, the contact wire is zigzagged slightly to the left and right of centre at each successive support so that the pantograph wears evenly.
Depot areas tend to have only a single wire. Such equipment is known as *simple equipment*. When overhead line systems were first conceived, good current collection was possible only at low speeds, using a single wire. To enable higher speeds, two additional types of equipment were developed:

- *Stitched equipment* uses an additional wire at each support structure, terminated on either side of the messenger wire.
- *Compound equipment* uses a second support wire, known as the auxiliary, between the messenger wire and the contact wire. Droppers support the auxiliary from the messenger wire, and additional droppers support the contact wire from the auxiliary. The auxiliary wire can be constructed of more conductive but less wear-resistant metal, increasing the efficiency of power transmission.

Dropper wires traditionally only provide physical support of the contact wire, and do not join the catenary and contact wires electrically. Contemporary systems use current-carrying droppers, which eliminate the need for separate wires.

Tensioning. Catenary wires are kept at a mechanical tension because the pantograph causes oscillations in the wire, and the wave must travel faster than the train to avoid producing standing waves that would cause the wires to break. Tensioning the line makes waves travel faster.
For medium and high speeds the wires are generally tensioned by means of weights, or occasionally by hydraulic tensioners. Either method is known as auto-tensioning (AT), and ensures that the tension in the

equipment is virtually independent of temperature. Tensions are typically between 9 and 20 kN per wire.

For low speeds and in tunnels where temperatures are constant, fixed termination (FT) equipment may be used, with the wires terminated directly on structures at each end of the overhead line. Here the tension is generally about 10 kN. This type of equipment will sag on hot days and hog on cold days.

Breaks. To allow maintenance to sections of the overhead line without having to turn off the entire system, the overhead line system is broken into electrically separated portions known as sections. The transition from section to section is known as a section break and is set up so that the locomotive's pantograph is in continuous contact with the wire.

For bow collectors and pantographs, this is done by having two contact wires run next to each other over a length about four wire supports: a new one dropping down and the old one rising up until the pantograph smoothly transfers from one to the next. The two wires never touch (although the bow collector/pantograph is briefly in contact with both wires). In normal service the two sections are electrically connected, but this can be broken for servicing.

On overhead wires designed for trolley poles this is done by having a neutral section between the wires, requiring an insulator. The driver of the tram or trolleybus must turn off the power when the trolley pole passes through, to prevent arc damage to the insulator.

Sometimes on a larger electrified railway, tramway or trolleybus system it is necessary to power different areas of track from different power grids, the synchronisation of the phases of which cannot be guaranteed. (Sometimes the sections are powered with different voltages or frequencies.) There may be mechanisms for having the grids synchronised on a normal basis, but events may cause desynchronisation. This is no problem for DC systems, but for AC systems it is undesirable to connect two unsynchronised grids. A normal section break is insufficient to guard against this since the pantograph briefly connects both sections.

Instead, a phase break or neutral section is used. This consists of two section breaks back-to-back so that there is a short section of overhead line that belongs to neither grid. If the two grids are synchronized, this stretch of line is energized (by either supply) and trains run through it normally. If the two supplies are not synchronized, the short isolating

section is disconnected from the supplies, leaving it electrically dead, ensuring that the two grids cannot be connected to each other.
The sudden loss of power over the phase break would jar the train if the locomotive was at full throttle, so special signals are set up to warn the crew. When synchronization is lost and the phase break is deenergized, the train's operator must put the controller (throttle) into neutral and coast through an isolated phase break section.
Overhead catenary. A catenary is a system of overhead wires used to supply electricity to a locomotive, streetcar, or light rail vehicle which is equipped with a pantograph.
Unlike simple overhead wires catenary systems use at least two wires. One wire, called the catenary or messenger wire, is hung at a specific tension in the shape of a mathematical catenary between line structures. The second wire is held in tension by the messenger wire, and is attached to it at frequent intervals by clamps and connecting wires. The second wire is straight and level, parallel to the rail tracks, suspended over it as the roadway of a suspension bridge is over water.
Simple wire installations are common in light rail applications, especially on city streets, while more expensive catenery systems are especially suited to high-speed operations.
Multiple overhead lines. There are and were some railways that used two or three overhead lines, usually to carry three-phase current to the trains. On these railways the two conductors of the overhead lines are used for two different phases of the three-phase AC, while the rail was used for the third phase. The neutral was not used.
On DC systems bipolar overhead lines were sometimes used to avoid galvanic corrosion of metallic parts near the railway.
All systems of multiple overhead lines have the disadvantage of high risk of short circuits at switches and therefore tend to be impractical in use, especially when high voltages are used or when trains run through the points at high speed.

Exercise 5. Answer the questions.
1 What are overhead lines are used for? 2 What other names of overhead lines do you know? 3 What principle is overhead line designed on? 4 How to achieve good high-speed current collection? 5 What is to be done with contact wire to make the pantograph wear evenly? 6 Which two additional types of equipment were developed to enable higher

speeds? 7 Why are catenary wires kept at a mechanical tension? 8 Why is the overhead line broken into separated portions known as sections? 9 What is a section break? 10 Why is a phase break or neutral section used? 11 What is the difference between simple overhead lines and catenary systems? 12 Why are multiple overhead lines used?

Exercise 6. Complete the sentences.

1 … are used to transmit electrical energy to trams, trolleybuses or trains at a distance from the energy supply point. 2 The feeder stations are usually fed from … 3 … it is necessary to keep the contact wire geometry within defined limits. 4 … is attached to the contact wire at regular intervals by vertical wires known as ... 5 ... uses an additional wire at each support structure, terminated on either side of the messenger wire. 6 ... uses a second support wire, known as the auxiliary, between the messenger wire and the contact wire. 7 Catenary wires are kept at a mechanical tension because … 8 For medium and high speeds the wires are generally tensioned by means of ... 9 To allow maintenance to sections of the overhead line without having to turn off the entire system, … 10 … is known as a section break. 11 A catenary is … 12 Unlike simple overhead wires catenary systems use ... 13 All systems of multiple overhead lines have the disadvantage of …

Exercise 7. Scan the text and give definitions of the following notions:

Overhead lines (overhead wires), feeder station, messenger wire (catenary), dropper (drop wire), stitched equipment, compound equipment, auxiliary wire, weight (hydraulic tensioner), section break, neutral section, phase break.

Exercise 8. Write an annotation to the text.

UNIT 5

Exercise 1. Read and memorize the following words and word combinations.

rigid – *adj.* жорсткий, нерухомо закріплений,
additional rail – додаткова, допоміжна рейка,
conductor rail – контактна рейка,
mass transit – громадський транспорт,
rapid transit – швидкісний транспорт (особливо міський – метро або монорейкові дороги),
alignment – *n.* розташування по одній лінії, вирівнювання,
segregated – *adj.* ізольований,
running rail – робоча рейка,
insulator – *n.* ізолятор; ізоляційний матеріал,
bracket – *n.* кронштейн, скоба (*кріпильна*),
shoe – *n.* колодка; башмак,
diversity – *n.* розмаїтість; різноманіття,
affect – *v*. впливати (*на що-небудь*),
build-up – *n.* нагромадження; нарощування,
generating station – електростанція,
leakage – *n.* витікання, просочування,
rubber tyre – гумова шина, покришка,
live – *adj.* під напруженням, підключений до джерела живлення,
guide bar – напрямна штанга,
feed – *v*. живити, постачати,
effect – *v*. здійснювати; робити; виконувати; запроваджувати,
conventional track – традиційна, звичайна колія,
wire bond – дротове з'єднання,
spacing – *n.* інтервал, відстань; розміщення,
composite – *adj.* складовий, складний,
running face – ходова/робоча поверхня,
wear – *n.* зношування,
level crossing – схрещення доріг на одній площині; перехрестя без тунелю; переїзд зі шлагбаумом,
crossover – *n.* перехід; шляхопровід,
ramp – *n.* пандус, рампа,
transition – *n.* перехід,
cost-effective – *adj.* рентабельний,
power unit – блок живлення,

traffic density – інтенсивність дорожнього руху; вантажонапруженість,
overbridge – *n.* шляхопровід, перехід над дорогою або залізницею,
clearance – *n.* зазор, просвіт, кліренс,
intrusion – *n.* вторгнення,
hazard – *n.* ризик, небезпека,
feasible – *adj.* підходящий, можливий,
at-grade – на одному рівні,
grade crossing – перетинання залізничної колії з шосе на одному рівні,
to be prone to – *v.* бути схильним до чого-небудь,
stranded – *adj.* у скрутному становищі, який сидить на мілині,
obsolete – *adj.* застарілий, який вийшов із вжитку,
people mover (PM) – пасажирський маршрутний транспорт (ескалатор),
revive – *v.* відроджувати, пожвавлювати; воскрешати,
arcing – *n.* іскріння; утворення або горіння дуги,
exacerbate – *v.* посилювати,
main – *n.* магістраль.

Exercise 2. Translate the following word-combinations.
Third-rail electrification system, overhead power supply, through a continuous rigid conductor, mass transit or rapid transit system, to supply direct current electricity, metal contact blocks called "shoes", side running, bottom running, top running, to be affected by the build-up of snow or leaves, live guide bars, to minimise resistance in the electric circuit, to give better wear, relatively cheap to install, less visual intrusion on the environment, to present the hazard of electric shock, to operate dedicated de-icing trains, to deposit an oily fluid on the conductor rail, to prevent the build-up, the positive rail has twice the voltage of the negative rail, to cause electrolytic damage, the water and gas mains.

Exercise 3. Match word and word combinations with their definitions.

1) third rail 2) grade crossing 3) crossover 4) level crossing 5) overbridge 6) conductor rail 7) people mover	a) a place where a railroad track crosses a road at the same level b) a bridge over a railway or road c) a point at which a railway and a road cross, especially one with barriers that close the road when a train is scheduled to pass d) an extra rail from which an electric train picks up current by means of a sliding collector to feed power to its motors e) any of various automated forms of transport for large numbers of passengers over short distances, such as a moving pavement, driverless cars, etc f) a rail transmitting current to an electric train or other vehicle g) a place at which a crossing is made a point of transfer between two main lines

Exercise 4. Read and translate the following text.

Third-rail electrification systems

Third-rail electrification systems are, apart from on-board batteries, the oldest means of supplying electric power to trains on railways using their own corridors, particularly in cities. Overhead power supply was initially almost exclusively used on tramway-like railways, though it also appeared slowly on mainline systems.

A third rail is a method of providing electric power to a railway train through a continuous rigid conductor placed alongside or between the rails of a railway track (they use an additional rail (called a "conductor rail") for the purpose). It is used typically in a mass transit or rapid transit system, which has alignments in its own corridors, fully or almost fully segregated from the outside environment. In most cases, third rail systems supply direct current electricity.

On most systems, the conductor rail is placed on the sleeper ends outside the running rails, but in some cases a central conductor rail is used. The conductor rail is supported on ceramic insulators or insulated brackets, typically at intervals of 10 feet (3 metres) or so.
The trains have metal contact blocks called "shoes" which make contact with the conductor rail. There is considerable diversity about the contact position between the train and the rail. Sometimes the shoe is designed to contact the side (called side running) or bottom (called bottom running) of the third rail, allowing the protective cover to be mounted directly to its top surface. When the shoe slides on top, it is referred to as top running. When the shoe slides on the bottom it is not affected by the build-up of snow or leaves. On many systems an insulating cover is provided above the third rail to protect employees working near the track.
The traction current is returned to the generating station through the running rails and leakage to ground is not considered serious. Where trains run on rubber tyres, live guide bars must be provided to feed the current. The return is effected through the rails of the conventional track between these guide bars.
The conductor rail is usually made of high conductivity steel, and the running rails have to be electrically connected using wire bonds or other devices, to minimise resistance in the electric circuit. One method for reducing current losses (and thus increase the spacing of feeder/sub stations, a major cost in third rail electrification) is to use a composite conductor rail of a hybrid aluminium/steel design. The aluminium is a better conductor of electricity, and a running face of stainless steel gives better wear. The conductor rails have to be interrupted at level crossings and at crossovers, and ramps are provided at the ends of the sections to give a smooth transition to the train shoes.
Electric traction systems (where electric power is generated at a remote power station and transmitted to the trains) are considerably more cost-effective than diesel or steam units, where the power unit is carried on the train. This advantage is especially marked in urban and rapid transit systems with a high traffic density.
So far as first cost is concerned, third-rail systems are relatively cheap to install, compared to overhead wire contact systems, as no structures for carrying the overhead contact wires are required, and there is no need to reconstruct overbridges to provide clearances. There is much less visual intrusion on the environment.

However as third rail systems present the hazard of electric shock, higher system voltages (above 1500 v) are not feasible. Very high currents are therefore used, resulting in considerable power loss in the system, and requiring relatively closely spaced feed points (sub-stations).
The presence of an electrified rail also makes it extremely dangerous for a person to fall into the tracks. This, however, can be avoided by using platform screen doors. Furthermore, third rail systems must either be fully grade-separated, or, if they operate at-grade, they must implement some kind of mechanism to effectively stop pedestrians from walking onto the tracks at grade crossings.
The end ramps of conductor rails (where they are interrupted, or change sides) present a practical limitation on speed due to the mechanical impact of the shoe, and 160 km/h (100 mph) is considered the upper limit of practical third-rail operation.
Third rail systems using top contact are prone to accumulations of snow, and ice formed from refrozen snow, and this can interrupt operations. Some systems operate dedicated de-icing trains to deposit an oily fluid on the conductor rail to prevent the build-up.
Because of the gaps in the conductor rail (at level crossings and crossovers) it is possible for a train to stop in a position where all of its shoes are in gaps, so that no traction power is available. The train is said to be "gapped". In these circumstances a following train is brought up behind the stranded train to push it on to the conductor rail. On some systems this prevents the running of very short trains (which have fewer shoes).
Third rail is not obsolete. There are, however, countries (particularly Japan, South Korea, India, Spain) more eager to adopt overhead wiring to their urban railways. But at the same time there were (and still are) many new third rail systems built elsewhere, including technologically advanced countries (e.g. Copenhagen Metro, Taipei Metro, Wuhan Metro). Bottom powered railways (it may be too specific to use the term 'third rail') are also usually those having rubber-tyred trains, whether it is a heavy metro (except two other lines of Sapporo Subway) or a small capacity people mover (PM). Practically the type of railways where third rail is no longer used in new systems is regional and long distance rail, which require higher speeds and voltages. The third rail technology at street tram lines has recently been revived in the new system of Bordeaux (2004).

The London Underground uses a four-rail system where both conductor rails are live relative to the running rails, and the positive rail has twice the voltage of the negative rail.
This scheme was introduced because of the problems of return currents, intended to be carried by the earthed (grounded) running rails, flowing through the iron tunnel linings instead. This can cause electrolytic damage and even arcing if the tunnel segments are not electrically bonded together. The problem was exacerbated because the return current also had a tendency to flow through nearby iron pipes forming the water and gas mains.

Exercise 5. Answer the questions.
1 What is the oldest means of supplying electric power to trains on railways? 2 What provides electric power through a rigid conductor placed alongside or between the rails of a railway track? 3 Where is it typically used? 4 Where is the contact rail placed? 5 How do trains make contact with the conductor rail? 6 What kinds of contact do you know? 7 What material is the conductor rail made of? 8 What can be done to reduce current losses? 9 What are the advantages of electric traction and third rail systems? How to avoid them? 10 What hazards do third rail systems present? 11 What do some systems do to prevent accumulations of snow? 12 Prove that the third rail is not obsolete. 13 What is the four-rail system? Why was it introduced?

Exercise 6. Scan the text and give definitions of the following notions:
Third-rail electrification system, a third rail, conductor rail, "shoes", side running, bottom running, top running, electric traction system, "gapped" train, four-rail system.

Exercise 7. Complete the sentences.
1 . . . is a method of providing electric power to a railway train through a rigid conductor. 2 In most cases third rail systems supply . . . 3 The traction current is returned to . . . trough . . . 4 . . . is usually made of high conductivity steel. 5 The aluminium is a better conductor of electricity and . . . of stainless steel gives . . . 6 The conductor rail has to be interrupted at . . . and . . . 7. . . . present a practical limitation on speed due to . . . 8 Third rail systems using top contact . . . to . . . of snow and ice. 9 A train that stops in a position where all its shoes are in gaps is said to

be . . . 10 Return current, flowing through the iron tunnel linings instead of . . . can cause . . . and even . . .

Exercise 8. Scan the text again, find the information concerning innovations in third rail systems of the countries and cities mentioned in the text.

Exercise 9. Write an annotation to the text.

SUPPLEMENTARY READING

Electricity

Electricity is the set of physical phenomena associated with the presence and flow of electric charge. Electricity gives a wide variety of well-known effects, such as lightning, static electricity, electromagnetic induction and the flow of electrical current. In addition, electricity permits the creation and reception of electromagnetic radiation such as radio waves.

In electricity, charges produce electromagnetic fields which act on other charges. Electricity occurs due to several types of physics:

- electric charge: a property of some subatomic particles, which determines their electromagnetic interactions. Electrically charged matter is influenced by, and produces, electromagnetic fields.
- electric current: a movement or flow of electrically charged particles, typically measured in amperes.
- electric field (see electrostatics): an especially simple type of electromagnetic field produced by an electric charge even when it is not moving (i.e. there is no electric current). The electric field produces a force on other charges in its vicinity. Moving charges additionally produce a magnetic field.
- electric potential: the capacity of an electric field to do work on an electric charge, typically measured in volts.
- electromagnets: electrical currents generate magnetic fields, and changing magnetic fields generate electrical currents

In electrical engineering, electricity is used for:

- electric power where electric current is used to energise equipment

- electronics which deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits, and associated passive interconnection technologies

Electrical phenomena have been studied since antiquity, though advances in the science were not made until the seventeenth and eighteenth centuries. Practical applications for electricity however remained few, and it would not be until the late nineteenth century that engineers were able to put it to industrial and residential use. The rapid expansion in electrical technology at this time transformed industry and society. Electricity's extraordinary versatility as a means of providing energy means it can be put to an almost limitless set of applications which include transport, heating, lighting, communications, and computation. Electrical power is the backbone of modern industrial society, and is expected to remain so for the foreseeable future.

Electric shock

A voltage applied to a human body causes an electric current through the tissues, and although the relationship is non-linear, the greater the voltage, the greater the current. The threshold for perception varies with the supply frequency and with the path of the current, but is about 0.1 mA to 1 mA for mains-frequency electricity, though a current as low as a microamp can be detected as an electrovibration effect under certain conditions. If the current is sufficiently high, it will cause muscle contraction, fibrillation of the heart, and tissue burns. The lack of any visible sign that a conductor is electrified makes electricity a particular hazard. The pain caused by an electric shock can be intense, leading electricity at times to be employed as a method of torture. Death caused by an electric shock is referred to as electrocution. Electrocution is still the means of judicial execution in some jurisdictions, though its use has become rarer in recent times.

Electrical phenomena in nature

Electricity is not a human invention, and may be observed in several forms in nature, a prominent manifestation of which is lightning. Many interactions familiar at the macroscopic level, such as touch, friction or chemical bonding, are due to interactions between electric fields on the atomic scale. The Earth's magnetic field is thought to arise from a natural dynamo of circulating currents in the planet's core. Certain crystals, such as quartz, or even sugar, generate a potential difference across their faces when subjected to external pressure. This phenomenon is known as piezoelectricity, from the Greek piezein, meaning to press, and was discovered in 1880 by Pierre and Jacques Curie. The effect is reciprocal, and when a piezoelectric material is subjected to an electric field, a small change in physical dimensions take place.

Some organisms, such as sharks, are able to detect and respond to changes in electric fields, an ability known as electroreception, while others, termed electrogenic, are able to generate voltages themselves to serve as a predatory or defensive weapon. The other Gymnotiformes, of which the best known example is the electric eel, detect or stun their prey via high voltages generated from modified muscle cells called electrocytes. All animals transmit information along their cell membranes with voltage pulses called action potentials, whose functions include communication by the nervous system between neurons and muscles. An electric shock stimulates this system, and causes muscles to contract. Action potentials are also responsible for coordinating activities in certain plants and mammals.

Electricity in popular culture

In the 19th and early 20th century, electricity was not part of the everyday life of many people, even in the industrialised Western world. The popular culture of the time accordingly often depicts it as a mysterious, quasi-magical force that can slay the living, revive the dead or otherwise bend the laws of nature. This attitude is manifest in Mary Shelley's Frankenstein (1819), which originated the cliché of a mad scientist reviving a patchwork creature with electrical power.

As the public familiarity with electricity as the lifeblood of the Second Industrial Revolution grew, its wielders were more often cast in a positive light, such as the workers who "finger death at their gloves' end as they piece and repiece the living wires" in Rudyard Kipling's 1907 poem The Sons of Martha. Electrically powered vehicles of every sort featured large

in adventure stories such as those of Jules Verne or the Tom Swift books. The masters of electricity, whether fictional or real – including scientists such as Thomas Edison, Charles Steinmetz or Nikola Tesla – were popularly conceived of as having wizard-like powers.
With electricity ceasing to be a novelty and becoming a necessity of everyday life in the latter half of the 20th century, it required particular attention by popular culture only when it stops flowing, an event that usually signals disaster. The people who keep it flowing, such as the nameless hero of Jimmy Webb's song "Wichita Lineman" (1968), are still often cast as heroic, wizard-like figures.

Hybrid train

A hybrid train is a locomotive, railcar or train that uses an onboard rechargeable energy storage system (RESS), placed between the power source (often a diesel engine prime mover) and the traction transmission system connected to the wheels. Since most diesel locomotives are diesel-electric, they have all the components of a series hybrid transmission except the storage battery, making this a relatively simple prospect.
Surplus energy from the power source, or energy derived from regenerative braking, charges the storage system. During acceleration, stored energy is directed to the transmission system, boosting that available from the main power source. In existing designs, the storage system can be electric traction batteries, or a flywheel. The energy source is diesel, liquified petroleum gas, or hydrogen (for fuel cells) and transmission is direct mechanical, electric or hydrostatic.
Diesel electric locomotives have high potential for energy savings when using dynamic braking, which use the traction motors as generators to stop the train. Without a way to recover and store the braking energy, these engines currently have no option other than to transfer it into the atmosphere as heat, using large electric heating elements and high velocity cooling fans.
Using a storage system means that a non-fully electric train can use dynamic braking, and even shut down the main power source whilst idling or stationary. Reducing energy consumption provides environmental benefits and economic savings. A smaller scale version of the concept is found in hybrid automobiles, such as the Toyota Prius.

Hybrid electric vehicle

A hybrid electric vehicle (HEV) is a type of hybrid vehicle and electric vehicle which combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system. The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. There are a variety of HEV types, and the degree to which they function as EVs varies as well. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors) and buses also exist.

Modern HEVs make use of efficiency-improving technologies such as regenerative braking, which converts the vehicle's kinetic energy into electric energy to charge the battery, rather than wasting it as heat energy as conventional brakes do. Some varieties of HEVs use their internal combustion engine to generate electricity by spinning an electrical generator (this combination is known as a motor-generator), to either recharge their batteries or to directly power the electric drive motors. Many HEVs reduce idle emissions by shutting down the ICE at idle and restarting it when needed; this is known as a start-stop system. A hybrid-electric produces less emissions from its ICE than a comparably-sized gasoline car, since an HEV's gasoline engine is usually smaller than a comparably-sized pure gasoline-burning vehicle (natural gas and propane fuels produce lower emissions) and if not used to directly drive the car, can be geared to run at maximum efficiency, further improving fuel economy.

Ferdinand Porsche in 1901 developed the Lohner-Porsche Mixte Hybrid, the first gasoline-electric hybrid automobile in the world. The hybrid-electric vehicle did not become widely available until the release of the Toyota Prius in Japan in 1997, followed by the Honda Insight in 1999. While initially perceived as unnecessary due to the low cost of gasoline, worldwide increases in the price of petroleum caused many automakers to release hybrids in the late 2000s; they are now perceived as a core segment of the automotive market of the future.