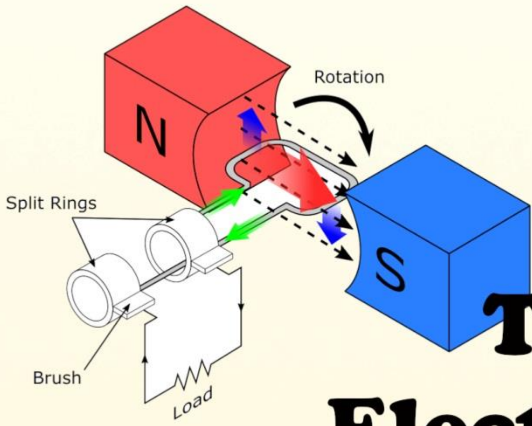
The Power Of Knowledge Series

2nd part



The Way to ....
Electric Dynamo Car

Prepared by:
Dr. Andrew Akoula Girges

The power of knowledge series

2nd part

The Way to .... Electric Dynamo Car

Presented to:

High school science division students

An Introduction:

It is an innovative idea to combine the motor and the dynamo in one device, so that we take advantage of the electric motive force generated by the dynamo to charge the electric car battery almost continuously or permanently. Thus, there is a self-charging complete circuit inside the car body that does not need an external source to recharge it with reliance on some software solutions for modern smart cars' systems such as: Android Auto or Apple Car Play or others.

About the Writer:

- Name: Andrew Akoula Girges
- Graduated from the Faculty of Medicine
- He is currently studying ENT
- Very fond of science and technology
- He likes to read poetry and practice football
- Mathematics and physics of favorite materials

He loves hiking amidst greenery and landscapes

Content of the book:

1 Electric Current

Electric current: A flow of electrical charges, such as electrons or ions. According to the International System of Units, the electric current is measured in amperes. While the electric current is measured by an ammeter device, it can be measured by one of the motor meters. The electric current is symbolized by the letter I, not C, and the reason is due to Ampere's law developed by the French scientist Ampere, which linked the magnetic field generated around a closed coil to the electric charge that flows in the coil. Ampère decided to call the rate of charge flow “current,” and the amount of current as “current intensity,” or as it is in French, intensité de courant. Therefore, the letter I was taken as a symbol for the intensity of the current, and the symbol moved from France to Britain, where it became a standard symbol. But then in books, "current intensity" was shortened to "current" even though some old books were still writing it in its entirety, This is what led to confusion for some that the current symbol is I and not C, and some in Britain demanded to amend the symbol to C, but this was not done, perhaps because the symbol I had been accustomed to or to prevent the confusion with the symbol of "electrical capacitance." capacitance "which is C which was used at the same time.

A solid, electrically conductive metal contains a large group of moving or free electrons. These electrons are bound to a network of metal wires but are not bound to any single atom. Even in the absence of an external electric field, these electrons move randomly to some extent due to thermal energy. When a metal wire is connected to both ends of a DC voltage source such as a battery, the source will generate an electric field across the conductor. As soon as the metal wire is connected, the free electrons are pushed towards the positive terminal of the conductor by this electric field. Thus, the free electrons represent the conductor of electrical current in a typical solid conductor. In a current of 1 ampere, 1 coulomb of electric charge (consisting of about 6,242 electrons multiplied by 10 to the power of 18) is rushed every second across any flat surface through which the conductor passes.

At any constant flux, the current **(I)** measured in amperes can be calculated using the following equation**: I = Q / t**

:Where

Q is the electric charge, measured in coulombs

t is the time in seconds

More generally, electric current can be defined as the time rate of change of electric charge, or **I = dQ / dt**

In solid metals, electricity flows due to the movement of electrons, from lower voltage to higher voltage (note that the electric current is inversely defined, meaning that the electrons are pointing from the top to the lowest, but electrical engineers consider the positive current that it is from the lowest to the highest, meaning that the current is in fact moving From the negative pole, which is the lowest, to the positive, which is the highest).

In any other medium, any flow of an electrically charged object can generate an electric current: for example, currents in electrolytes are streams of atoms with electric charges (ions), positive or negative. In any of the known electrochemical cells containing lead acid, the electrical currents consist of positive hydrogen ions (protons) flowing in one direction, and negative sulfate ions flowing in the other direction.

Ohm's Law: It is a basic principle in electricity. It was named after its German physicist, George Simon Ohm.

Ohm conducted experiments to measure the voltage applied to simple electrical circuits and the intensity of the electric current passing through them, with changing the length of the wire used in them. He concluded some complex equations, which were modified until they reached their simple form shown later.

This law states that the electric potential difference between the two ends of a metal conductor is directly proportional to the intensity of the electric current passing through it.

V α I

The constant ratio between the voltage difference and the current intensity is defined by the electrical resistance and is denoted by the Latin letter **R**. It is noted that the resistance **R** of a conductor is nothing but a constant value and does not change with the change of the potential difference between its terminals. This principle is expressed through the following equation: **R = V / I**

The same equation can also be expressed in another form: **V = I. R**

:Where

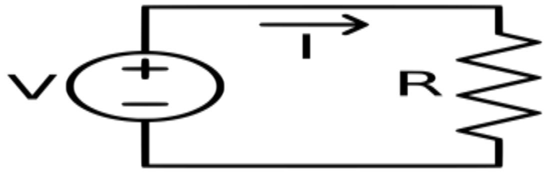
V: is the electric potential difference between the two ends of the metal conductor (resistance) and is measured in a unit called volts, and it is denoted by the symbol **(V)**.

I: is the electric current passing through the conductor and is measured in a unit called amperage, and it is denoted by the symbol **(A)**.

R: is the conductor resistance to current and is measured in unit called ohms, and denoted by symbol **(Ω)**.

The previous law can be formulated according to electrical units as follows:

1Ω = 1V / 1A



Electric Power (P): It is the time rate of flow of electrical energy in an electrical circuit, and power is a quantity of a unit of measurement according to the International System of Units is watts.

The power lost due to electrical resistance is calculated according to Joule's law:

Where: **P = V x I**

P is the power (Watt)

V is the potential difference at both ends of the resistance (volts)

I is the current through the resistance (ampere)

Electric Power according to Ohm's Law:

$$P = I^2 . R = V^2 / R$$

R is the value of resistance Ohm **Ω**

Watts (symbol: W): is a derived unit of power in the SI system, named according to the Scottish engineer James Watt (1736-1819). One watt is defined as 1 joule per second, and it is a unit of measurement for the rate at which energy is transferred or converted from one form to another.

The unit watt is used widely in calculating electrical power, in direct current (DC) it is the power exerted by a constant current of one ampere with the effect of an electrical voltage of one volt equivalent to one watt

1 watt = 1 volt x 1 amp = 1 joule / second

In alternating current (AC), then multiplying the instantaneous value in amperes by the instantaneous value in volts results in the instantaneous value in watts. The algebraic mean of the instantaneous powers in a complete cycle (mean power) is equal to the power in watts.

In terms of electromagnetism: one watt is the rate at which a work is performed when a current of intensity one ampere **(A)** travels through an electric potential difference equal to one volt **(V)**.

$$\mathbf{W = V \cdot A}$$

Two additional unit transformations of watts can be deduced using the above equation and Ohm's law:

$$\mathbf{W = V^2 / \Omega = A^2 . \Omega}$$

Where the **(ohm Ω)** is a unit derived from the international system of electrical resistance measurement.

2 Magnetic fields

Magnetic field: It is a magnetic force that arises in the space surrounding the magnetic object or conductor that an electric current passes through, or in simpler terms it can be described as the area surrounding the magnet and appears in it (on certain materials).

If you put a compass needle in a magnetic field of some strength, it directs itself in a specific direction in every part of the field, and the lines drawn in the direction of the needle at different points determine the general position of the lines on which the magnetic force is in the field.

The distribution of the magnetic field can be seen by scattering iron filings on a sheet placed on a magnetic rod or a sheet of paper through which an electric current passes through a wire. The external currents move from north to south and the internal currents move from south to north. A magnetic field can be created by passing an electric current through a wire, whereby magnetic circuits are formed around the wire and centered on the wire itself. As the electric current creates a magnetic field and vice versa. We can know its direction using the right-hand rule, where the thumb points in the direction of the current and the rest of the fingers point in the direction of the magnetic field. And the magnetic field can be enlarged by enlarging the vibrations coming out of the material by passing an electric current from north to south.

Magnetic field and electric current: All moving charged particles produce a magnetic field around them. Some particles, such as electrons, produce complex but well-known magnetic fields that depend on the charge, velocity and acceleration of the particles.

Magnetic lines form in "concentric circles" around a wire that an electric current passes through. The direction of such a magnetic field can be determined using the "right-hand rule". The strength of the magnetic field decreases in inverse proportion to the square of the distance from the wire.

The current-carrying wire is bent into a ring, which concentrates the magnetic field inside it, and the emerging magnetic field lines go outside the ring and rotate and return from the other side of the ring through which the current passes, where the magnetic field lines complete their cycle. Outside the wire loop, its strength decreases.

When we wind the wire into several rings to form a coil, this causes an increase in the strength of the resulting magnetic field despite the constant intensity of the electric current passing through the coil. The strength of the arising magnetic field increases with the number of turns.

When a piece of iron is placed inside a coil in which a current passes, the field increases due to the magnetic property of iron (ordinary iron consists of small grains that have a magnetic self, but are spaced out). And it creates a strong and controllable magnetic field. Iron is a ferromagnetic material, as its magnetism resides in small grains, but the magnetic directions in the grains are randomly distributed so that the magnetic sum of the iron piece is equal to zero. When the piece of iron is placed in a magnetic field inside a coil with an electric current, this magnetic field of the coil affects the piece of iron, and "most" of the magnetic directions of the grains stand in the direction of the external magnetic field, which increases the magnetic field greatly. And when the current is cut off, the current is cut off, the force affecting the magnetism of the grains disappears, the magnetic directions of the grains return to their random directions, and the magnetism of the piece of iron disappears. That is why we say that a piece of iron has a "latent" magnetism. Ferromagnetic property appears in iron, cobalt, nickel and their alloys. The ferromagnetic property of iron, cobalt and nickel is due to their atomic structure, as each atom of them has a self-magnetic character. An infinitely long electromagnet has a uniform magnetic field inside it, but not one outside it. The electromagnet of limited length creates the same magnetic field as a regular "permanent magnet" of the same size and shape, and its strength and polarity depend on the electric current passing through the coil and its direction.

Symmetric poles and different poles: The magnetic field affects magnets and materials that are magnetized (such as the ferromagnetism of some non-metallic materials, called ferrites, and ferromagnetic materials such as iron and nickel). Rectangular magnets and rectangular iron samples orient themselves to orient or reverse direction of external magnetic field lines, that is, in the south pole of a magnet takes the direction of the field lines to the north pole of the acting magnet. This effect is exploited, for example, in the compass, where the compass pointer consists of a magnet with two poles, and the south pole of the needle points to the north direction of the Earth's magnetic field. Magnets are also frequently used for tension and transport, and electromagnets are used to lift weights in cranes. Due to the attraction of different poles and repulsion of the same poles, the two different poles of two magnets are close to each other. And in the case of two magnets with "heterogeneous" fields, that is, the strength of their field varies greatly from place to place, in which case the two magnets are attracted. The reason for these two phenomena is that the two magnets are trying to take a position in which the energy is reduced - forces always interact in such a way that the total energy of the field decreases with it when the magnets follow it. When describing this force by the mathematical formula, we calculate the gradient of the magnetic field.

When the magnets and magnetic objects are directed in the direction of a magnetic field, they exchange energy with it - when the object follows the applied force, the sum of the field energies decreases and mechanical work is created. To move two magnets apart, we must perform mechanical work, and thus increase the field energy of the emerging total field. The magnetism remains and is not lost. If two objects are magnetized by two coils, electrical energy can also be exchanged between them.

The Earth's magnetic field: Earth and Mercury are the only two rocky planets that have a magnetic field arising from the movement of molten minerals in their interior, while other planets in our solar system have other forms of gravity, some of which may be represented in the so-called strong magnetic crust fields as is the case on the surface of Mars.

Earth is the only rocky planet in the solar system that has a magnetic field. It is formed by the action of electrically charged magma moving inside the earth in the mantle layer (according to the rule that an electric current generates a magnetic field). This magnetic field is of great importance to life on Earth, because the solar wind causes the erosion of the atmosphere (this is what happens in the rest of the rocky planets in the solar system, where a large part of their atmosphere has eroded). The Earth's magnetic field protects it from the solar wind and prevents it from reaching the atmosphere. In addition, had it not been for the magnetic field, the compass would not have been invented (because the compass is heading towards the magnetic north pole of the Earth), which has been of great importance over the ages in knowing directions during travel.

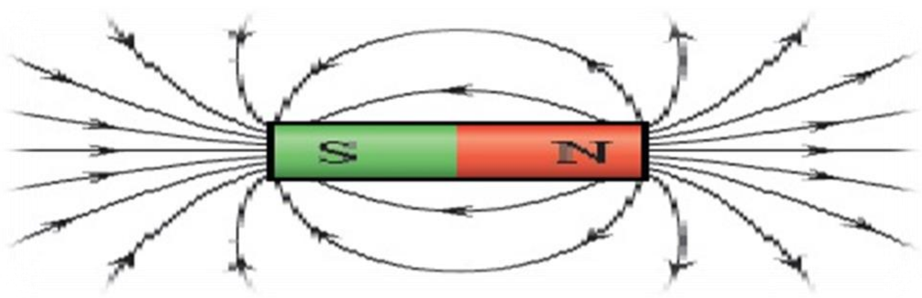
Magnet properties:

1- It has north and south poles, when suspended freely, it .points north and south

2- The force of magnetic attraction is concentrated in its .poles and less in other areas

3- The poles of different types attract and the same type repels each other.

4- If the magnet is cut from any area in it, it will have two poles, and it cannot practically have a single pole.



Magnetic fields of a magnet. Magnetic field lines indicate the direction of the field at different points.

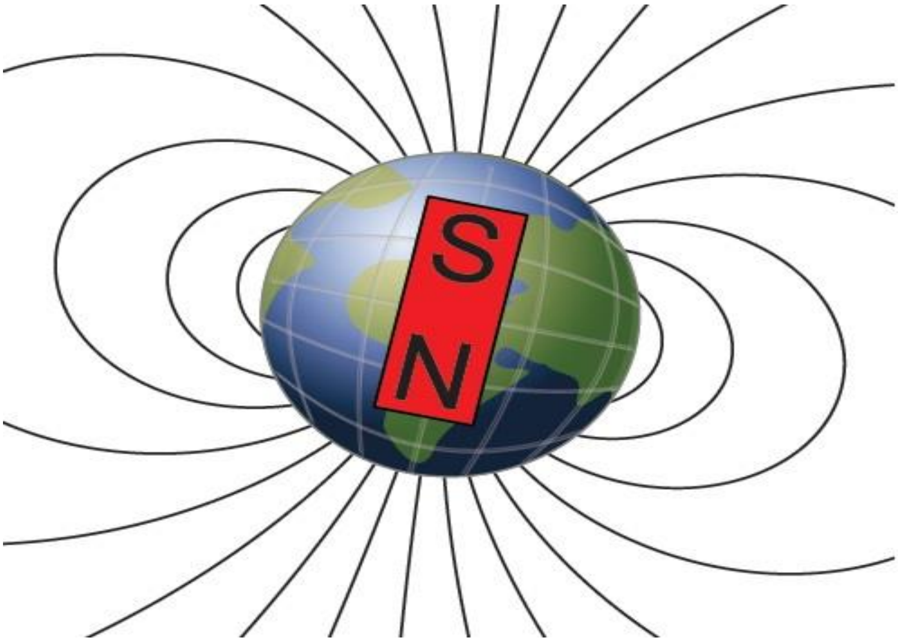


Illustration of the Earth's magnetic field.

3 Contributions of some scientists to Electricity Science

1 (Hans Christian Ørsted)

From August 14, 1777 to March 9, 1851, he was a Danish physicist and chemist who predicted the existence of a relationship between electricity and magnetism, which led him to discover the magnetic effect of electric current in 1820, where he conducted an experiment that showed that a magnetic field can affect the compass generated around the wire if it is passed in this wire an electric current.

In the field of chemistry, Ørsted is the one who produced aluminum and founded the Alba Company for the first time in history in 1825. He wrote the book The Spirit of Nature (1850 AD). Ørsted was born in Rudkoping, Denmark.

He studied medical and physical sciences at the University of Copenhagen and obtained his doctorate in 1799, and in 1806 he became professor of chemistry and physics at the same university.

Ørsted was interested in electric currents and acoustics in his early research. In 1819, he discovered in one of his experiments, when he brought a compass close to a conductive wire, that the needle of a magnetic compass was deflected perpendicular to the wire. This experiment was clear laboratory evidence of the relationship between magnetism and electricity.

While honoring this discovery, he mentioned that his discovery was made by pure chance, which made one of his colleagues present say to him: "The coincidence only comes to those who deserve it".

He later showed that the electromagnetic effect does not change by placing a barrier of glass or other non-magnetic metals between the compass needle and the conductive wire. Other scientists have worked to carefully investigate the most important results of Ørsted, including Ampère and Faraday, who realized the importance of this discovery and neglected investigations related to other phenomena and devoted themselves to the study of electromagnetism. Ørsted conducted other experiments with electricity, such as photovoltaics (batteries) and thermoelectricity (energy generated by heating metal wires).

In the field of chemistry, Ørsted made other discoveries. In 1820 he discovered piperine (one of the active ingredients in pepper). The discovery of this substance is one of the important contributions to chemistry as an auxiliary material in the preparation of aluminum. In

1825 he was able to isolate aluminum In powder form. Ørsted then turned his attention to the properties of fluids and proved that gases are not evenly compressible.

Ørsted was a well-known teacher and lecturer and author of a number of important articles. In 1824 he founded an association whose aim was to spread scientific knowledge among the public. Since 1908, this association has been awarding a medal in the name of the "Ørsted Medal" to Danish physicists who make a significant contribution to the physics sciences. In 1932 the name Ørsted was given to one measuring the strength of a magnetic field.

2 (Michael Faraday)

(1791--1867) is an English chemist and physicist. One of the participants in the Electromagnetic field science and Electrochemical science.

Faraday studied the magnetic field on a conductor (a solenoid) carrying a constant electric current and thus laid the foundations for electromagnetism. He is the discoverer of the theory of inductance, magnetic propagation and the laws of electrolysis. He said that magnetic waves affect light rays and laid the foundations for the link between the two phenomena. His invention of electromagnetic devices is the beginning of electric motors technology. In so doing, he becomes the first to make electricity a thing of technological use.

As for Faraday as a chemist, he was the first to discover benzene. And he studied the issue of gas hydrates and invented the gasoline burning machine, and he was the one who used the terms anode, cathode, pole and ion.

Although Michael Faraday did not teach mathematics in schools, of which only a few, he was an exceptional scientist who was classified as one of the greatest scientists in history. In the international system of units, we calculate the value of the capacitor and measure it in the Farad unit, after his name, ie Michael Faraday. There is also a faradic constant named after him which is equal to 96.485 Coulomb and is the charge of one mole of electrons.

Also named after him is Faraday's law of induction, which says that changing magnetism in time creates electric motive forces. Faraday was the first to hold the position of Fullerian Professor of Chemistry at the Great Royal Institution in Britain. Faraday was a devout Christian and was a member of the Sandmanian Church.

3 (James Clerk Maxwell)

June 13, 1831 - November 5, 1879) was a famous Scottish physicist for his important contributions explaining the emergence of electromagnetic waves.

(King's College London 1860-1865):

The years Maxwell spent at King's College were some of the most productive years of his scientific career; in it, Maxwell was awarded the Rumford Medal from the Royal Society in 1860 for his research on colors, and in the following year (1861) was elected a member of the same association. During that period Maxwell displayed the world's first color photograph, developed his ideas about the viscosity of gases, and presented a system for describing physical quantities, called dimensional analysis, and Maxwell attended lectures at the Royal Institution, which gave him the opportunity to get close to the scientist, Michael Faraday, who was 40 years older than him.

It was also during this period that Maxwell discovered his great discoveries that contributed to the advancement of the scientific understanding of electromagnetism. He dealt with the research on the nature of electromagnetic fields in a two-part scientific paper published in 1861, and he was the first to reach an equation between magnet and electricity, and he explained the action and reaction and its rates are simple and comprehensive. He pointed out that the waves are not limited and that their speed is 299792.458 km / s, which is the speed of light, and he pointed to the existence of other waves. This is what Hertz came up with and Marconi used it in radio. Maxwell's equations are the basis of optics and he died in 1879.

In the year 1871 he took up the Cavendish Chair in Physics at the University of Cambridge, and he was the first to occupy this chair from among the professors, and was entrusted with the development of the Cavendish Laboratory.

Maxwell died in Cambridge on November 5, 1879, at the age of forty-eight, of cancer in the digestive system, and was buried in Barton Church. His biography was published under the title "The Life of James Clerk Maxwell" by his friend Professor Lewis Campbell in 1882, and the Cambridge University Press published his complete work in two volumes in 1890, including the series of articles he wrote on the properties of matter. Such as "atom", "gravity", "capillarity", "diffusion", "ether" etc.

4 (Hendrik Antoon Lorentz)

July 18, 1853 - February 4, 1928) was a Dutch physicist) who won the 1902 Nobel Prize in Physics equally with Peter Zeeman for discovering and theoretically explaining the Zeeman effect. He later deduced the transformation equations that Albert Einstein used to describe space and time.

Practical life:

In 1878, at the age of only 24, Hendrik Anton Lorentz was appointed professor of theoretical physics at Leiden University. On January 25, 1878, he gave his first lecture on particle theories in physics. In his first twenty years in Leiden, Lorentz was primarily interested in the theory of electromagnetism to explain the relationship between electricity, magnetism, and light; thereafter his research extended to much broader fields while remaining focused on theoretical physic. Among his publications, notable contributions were to mechanics, thermodynamics, fluid science, theories of motion, solid-state theory, light, and diffusion. His most important contributions were in the field of electromagnetism, electron theory, and relativity. Lorentz theorized that an atom could contain charged particles and suggested that the fluctuation of these particles is the source of light. When his colleague, Peter Zeeman, discovered the Zeeman's effect in 1896, Lorentz provided that discovery with theoretical interpretation. Their practical and theoretical discoveries won the Nobel Prize in 1902. The name Lorentz is related to the Lorentz formula, the Lorentz force, the Lorentz distribution, and the Lorentz transformations.

The Institute for Theoretical Physics was later called the Lorentz Institute. Besides the Nobel Prize, Lorentz won numerous awards for his outstanding work. In 1905 Lorentz was awarded the Fellowship of the Royal Society by election. The Society awarded him the Rumford Medal in 1908 and the Copley Medal in 1918. Lorentz passed away in Harlem, Netherlands. The

Netherlands' respect for him is shown in the description of his funeral:

The funeral took place on the afternoon of Friday, February 10. The telephone and telegraph services were suspended for three minutes to mourn the greatest man the Netherlands has ever had. Many of his colleagues and physicists from many countries attended the funeral. The President, representing the Royal Society, gave a speech on Lorentz appreciating his achievements.

5 (Nikola Tesla)

July 10, 1856 - January 7, 1943) Serbian-American) inventor, physicist, electrical engineer, mechanical engineer and futurist, best known for his contributions to the design of the main alternating current system.

Tesla gained experience in telephony and electrical engineering, before immigrating to the United States in 1884 AD to work for Thomas Edison in New York City. Tesla soon split from Edison and set up his own laboratories and companies to develop a number of electrical devices. George Westinghouse bought the rights to Tesla's patent for the induction and inverter motor, and Westinghouse briefly appointed him as his advisor. Tesla's work for years developing electric power was part of the "war of currents" between proponents of alternating current and direct current, as well as the patent war. In the year 1891 AD, Tesla obtained American citizenship.

Tesla continued to work on his ideas about wireless lighting, high-voltage electrical distribution, and high-frequency energy experiments, and in 1893AD he declared the possibility of wireless communication with his devices. Tesla attempted to implement his ideas by attempting to create intercontinental radio transmissions, in his unfinished project The Wardenclyffe Tower. In his lab, he also conducted a series of experiments with mechanical oscillators and generators, electrical drainage tubes, and initial attempts at X-ray imaging. He also built a radio-controlled boat, a unique event of its kind at the time.

Tesla is best known for his accomplishments and appearances that ultimately earned him a reputation in popular culture as a "mad scientist". His patents earned him a great deal of money, and he spent a large portion of it to finance his own projects, whose successes varied. Tesla lived most of his life in a chain of New York hotels until his retirement. Tesla died on January 7, 1943.

Tesla's work was a bit remembered after his death, until the year 1960 AD when the General Conference on Weights and Measures named the International Unit for Measuring Magnetic Field "Tesla unit" in his honor. Since the 1990s, there has been a renewed interest in Tesla and his business.

4 The Magnetic Field and Lorentz's Law

The Electromagnetic field: It is a physical field that arises due to electrically charged particles, so that any charge that penetrates or passes from this field is affected by a magnetic force whose direction is perpendicular to the direction of its velocity, and the direction of the field together, in addition to An electric force has the same direction toward the field, and the resultant of these two forces can be called the Lorentz force.

The magnetic force acting on the charge passing through the field is given by this relationship: **Fb = q. v x B**

While the electric force is given by the following relationship: **Fe = q. e**

The Lorentz force is the magnitude and the direction of the directional combination of the two forces.

Classically, electric and magnetic fields are thought to result from the smooth movements of charged bodies. For example, oscillating charges produce variations in electric and magnetic fields that can be considered smooth, continuous, and wavy. Energy in this case is constantly transferred through the electromagnetic field between any two locations. For example, metal atoms in a radio wave transmitter show continuous energy transfer.

The dynamic theory of the electromagnetic field:

In the past, electrically charged bodies were thought to produce two different, unrelated types of fields depending on the type of charge. An electric field is produced when the charge is constant with respect to an observer measuring the properties of the charge. When the charge moves with respect to the observer, the magnetic field, electric field, and electric current are produced.

It is realized over time that the electric and magnetic fields are formed within the large circuit (the electromagnetic field). Until the year 1820, electricity and magnetism were seen as unrelated phenomena, until the Danish physicist Hans Christian Ørsted showed the magnetic effect of an electric current, as he conducted an experiment that showed that a magnetic field can affect the compass that is generated around the wire if an electric current passes through this wire. The scientist Michael Faraday observed in 1831 that changing magnetic fields over time could generate electric currents. Then James Clerk Maxwell published his famous paper The Dynamic Theory of the Electromagnetic Field in 1864.

Once this electromagnetic field is produced from a given charge distribution; Charged or other magnetic particles in this field may experience force, and if these charges and other currents are similar in size and value to the sources producing the electromagnetic field, a new electromagnetic field will be produced, and thus the electromagnetic field can be viewed as a dynamic entity that leads to the movement of other charges and currents, and is affected by them Also. These interactions are described by Maxwell's equations and Lorentz's force law.

Mathematical description:

There are different mathematical approaches to mathematically describing the electromagnetic field. The first method is to consider the electric and magnetic fields as three-dimensional field vectors. Each of these field vectors has a specific value at each point in time and space, and thus are often functions of space and time. Example: The electric field ((E (x, y, z, t)), and the magnetic field ((B (x, y, z, t)) are written.

If only the electric field **(E)** is non-zero and is time constant; the field is said to be an electrostatic field. Likewise, if only the magnetic field **(B)** is non-zero and is time constant; the field is said to be a static magnetic field. If either electric or magnetic fields are time dependent; both fields must be considered together as an electromagnetic field using Maxwell's equations.

Lorentz force

(Law of electromagnetic forces):

Lorentz force is the force acting on an electric charge that moves in an electric or magnetic field. It is named after the Dutch scientist Hendrik Lorentz who discovered it. In a magnetic field, the Lorentz force is greatest when the direction of movement of the charge is perpendicular to the magnetic field lines. If the charge moves in a direction parallel to the direction of the magnetic field lines, the Lorentz force does not arise. The Lorentz force is always perpendicular to the direction of motion of the charge and to the magnetic field lines.

In physics: the electromagnetic force is the force that an electromagnetic field exerts on electrically charged particles. The electromagnetic force is responsible for the attraction of electrons and protons in an atom.

To detect or achieve the electromagnetic force, we insert a copper rod inside an electrical circuit and a magnetic rod in two scrolls. When placing the copper rod in the magnetic field and closing the circuit, we notice the rolling of the rod. We conclude that the rod is affected by the electromagnetic force.

In modern books, the Lorentz force is generally considered to be the force that an electromagnetic field exerts on a point charge. If a charged particle **q** moves with velocity **v** in the presence of an electric field **E** and a magnetic field **B**, then it is affected by a force of:

$$\mathbf{F = q\ (E + V\ x\ B)}$$

This is the basic equation for Lorentz's force, and it combines two parts: the Lorentz force, which is the effect of a magnetic field on a charge moving, and an electric part arising from the effect of an electric field on a charge, and the electric force is called the coulomb force.

Means in the equation:

F is the force (Newton)

E is the electric field (volts per meter)

B is the magnetic field (Tesla)

q is the electric charge of the particle (coulomb)

v is the linear velocity of the particle (meters per second)

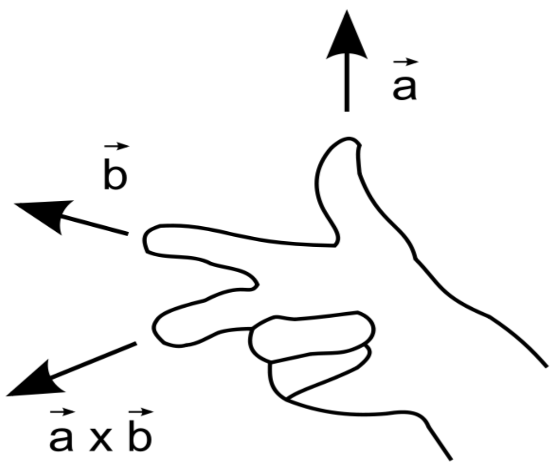
The electric force arising from an electric field is in the direction of the particle’s movement and increases its velocity, and the force arising from the magnetic field does not increase the velocity of the particle, but - according to the striking signal - it is perpendicular to the magnetic field lines and perpendicular to the direction of the particle’s movement.

The right-hand rule in directional kicks:

The multiplication **(v x B)** is called directional product. Noting that the letters written in bold are vector quantities. For example, charge q is not a vector quantity. The rest are all vector quantities: force, particle velocity, electric field, and magnetic field.

The direction of Lorentz's magnetic force follows the rule of three fingers. We use the left hand fingers for negative charges, and the right hand for positive charges, to designate the direction of the force.

The force acting on a charge moving in an electromagnetic field has wide applications. It is responsible for producing electrical energy from motion energy, as in power stations and electric generators, and for producing movement from electric current, as in an electric motor, metro, electric shaver, and others.



The effect of the Lorentz force on a moving charged particle:

Charged particles used in physics are electrons, protons, or other charged elementary particles, such as alpha particles moving in a vacuum or also ions in a solution.

Since the direction of the Lorentz force depends on the signal of the charge, it is opposite according to the type of charge, given that the direction of the initial charges is the same. This can happen to positive ions in a liquid exposed to an external magnetic field

The Lorentz force (magnetic slit):

$$Fl = q \times v \times B \sin \alpha \quad \text{or} \quad v \times B = v \, . \, B \sin \alpha$$

Where **α** is the angle between the direction of movement of **q** and the direction of the magnetic field, or the magnetic flux density **B.**

If the movement of the charged particles is perpendicular to the magnetic field lines, then **(Sin α = 1)**, and the equation becomes in its simplified form: **Fl = q. V. B**

Some ancient books differentiate between the "Lorentz force" **Fl** and the Coulomb force **Fc**. The first is the force of a "magnetic field" effect on charged moving particles, and the Coulomb force is the effect of an "electric field" on moving charged particles. As for recent books, they tend to describe force in two components: a "magnetic vehicle" **FB** and an "electric vehicle" **FE** for the Lorentz force, meaning they see the Lorentz force as the result of **FB + FE**.

If an electric charge q moves with a velocity of v in an electromagnetic field, the total force (Lorentz force) acting on the charge is calculated as a compound net as :follows

$$\mathbf{F} = \mathbf{F_B} + \mathbf{F_E} = \mathbf{q\,(E + v \times B)}$$

Where: **E** for the effect of electric field strength, and **B** for the effect of magnetic flux density.

Special cases:

1- When there is no electric field **E = 0**: the force **F** is perpendicular to **v** and **B**, which is the product of

$\mathbf{v \cdot F = q \times v \cdot (v \times B) = 0}$. And unlike the particle's deflection when it is under the influence of an electric field, no work is produced, meaning that the kinetic energy of a charged particle moving in a "constant" magnetic field does not change, and therefore the velocity of the particle in its path that has become curved does not change.

2- If the charged particle is moving in the direction of the magnetic field lines (vectors **v**, **B** are parallel or opposing) then **F = 0**, meaning that if the movement of the charged particle with a charge **q** is parallel to the magnetic field or opposite to its direction, then the particle does not deviate from the straight path.

The Lorentz force produced by the magnetic component is given by the equation: $\mathbf{F_L = q\,(v \times B)}$

Hence the Coulomb force resulting from electric field acting on a moving charged particle: **Fc = qE**

Effect of Lorentz force on an electric wire:

The Lorentz force is the primary reason for converting electrical energy into kinetic energy and vice versa: if a current passes in a wire perpendicular to the magnetic field lines around it, it causes a mechanical movement of the wire. And vice versa: if a wire moves perpendicular to the magnetic field lines around it, an electric voltage is created on it, that is, an electric current passes through it induction.

In these processes, the conduction electrons move in the conductive metal wire and produce a circular magnetic field around it. If its field lines interact with another external magnetic field, the charges will shift sideways.

This may also happen in a solution that carries ions and electrons as it does in a conductive wire. This force also affects charges that move in vacuum or air. They are all shifted sideways perpendicular to the lines of the outgoing magnetic field and to the direction of their movement.

1- If a current (electrons) passes through a conductive wire and moves perpendicular to the magnetic field lines, the electrons will be shifted aside, thus displacing the wire as a whole.

2- If a wire moves transversely with respect to the lines of an external magnetic field, the conducting electrons in the wire are affected by the force of Lorentz and moved to one end of the wire, so the electrons multiply at one end of the wire and decrease at the other end of the wire, and as a result, an electric voltage is created between the two ends of the wire. This voltage is historically called an Electric Force Drive.

3- If we now connect the two ends of the wire to a resistance from the outside that is not moving with respect to the magnetic field, the circuit is completed and a current is passed to equal the generated voltage.

In an electric motor and in an electric generator, the magnetic field is only an intermediate - no energy exchange occurs with it. The current that a motor consumes in it is converted into kinetic energy (the wire is shifted sideways) due to the Lorentz force. And vice versa: in the case of an electric generator, the motion to which we extend the wire, the kinetic energy through the Lorentz force is converted into electrical energy.

In a hydroelectric power station, water drives a turbine and a generator and produces electrical energy. And that electrical energy can be converted in factories and homes into thermal energy.

Likewise, in a coal-fired power plant, the heat from coal combustion generates thermal energy and produces high-pressure water vapor, directs the high-pressure water vapor to a steam turbine and runs it, and the steam turbine runs an electric generator that produces electricity.

1- Converting electrical energy into kinetic energy:

In order to describe these properties in mathematical equations in a simple way, we take a straight piece of wire into account of its length **(L)** and assume that it crosses across lines of a uniform magnetic field that has a magnetic flux density **(B)**. We are now passing an electric current **(I)** from the outside as the conduction electrons move in the wire at a uniform velocity of **(v)**. If the current **(I**) passes through a period of time **(t)**, the amount of charge that we have passed during this time in the wire is: **q = I t** at velocity **v = L / t** from one end of the wire to the other. Given that the charge passing through is **q. v = I. L** is the sum of the Lorentz forces acting on all conduction electrons in the current, and therefore in the piece of wire is:

$$FL = q \times (v \times B) = I \times (L \times B)$$

The absolute magnitude of this equation is:

$FL = I.\ L.\ B \sin \alpha$, where α is the angle between the length of the wire, i.e. the direction of the current **I**, and the direction of the magnetic field lines - and thus the direction of the magnetic flux density **B**. If the wire is perpendicular to the magnetic field lines, the equation is shortened as $\sin \alpha = 1$ to:

$$F_L = I \cdot L \cdot B$$

So the effect of the Lorentz force on the electrons passing through the wire causes the wire to move. By choosing a cylindrical shape for the magnetic system and replacing the straight wire with a coil made of a large number of turns of the wire, we have an electric motor. The engine rotates with an electric current and produces a movement that we use mechanically. According to the last equation, the Lorentz force created on the wire (or coil) is proportional to the intensity of the current exerted from the outside and is also proportional to the magnetic field strength and the length of the wire.

2- Converting motion energy into electrical energy:

When a wire of length **L** moves at a constant velocity **v** in the direction of the magnetic field lines **B**, two forces arise: the Lorentz force acts to drive electrons in the wire from one end to the other, and the other force is the coulomb force F_C that affects the electrons due to the electrical potential created by the separation of electrons at the ends of the wire:

$$F_L + F_C = 0 \quad , F_C = - F_L \quad , q E = - q (v \times B)$$

These two forces are equal and opposite. Summarizing the total charge **q** in the equation and the triple line of the wire length vector **L**, we get (inductive voltage **U ind**) =

$$\mathbf{L. E = - L (v \times B)}$$

If the three vectors are perpendicular to each other:

That is, the inductance voltage is directly proportional to the magnetic field strength, the length of the wire, and the velocity of the wire in the magnetic field.

The negative sign in the equation means that (the inductive voltage **U ind**) is always in the direction of the induction current (Lorentz's rule). When we connect both ends of the wire to a resistance **R** (which does not move in the magnetic field), an electrical circuit is formed in which the inductance voltage is equal. At the same time, the product is: **(I ind x R = 0)** (according to Kirchhoff's second law), we obtain:

$$U_{ind} + I_{ind} \times R = 0 \quad , \quad I_{ind} = - U_{ind} / R$$

$$I_{ind} = - L (V \times B) / R$$

That is, the resulting inductance current **(I ind)** is directly proportional to the magnetic field strength, the length of the wire and the velocity of the wire's passage through the magnetic field, and inversely proportional to the external resistance.

Applications of Lorentz force in technology:

1- In electric motors, generators, and bike dynamos.

2- Electron diffraction and orientation systems in cathode-ray tubes and in massive electronic valve televisions (models until 2003 before the appearance of thin televisions).

3- Hydro power stations.

4- In loudspeakers and microphones.

Lorentz force in natural phenomena:

A solar wind is deflected by the magnetic field in the Van Allen radiation belt away from the Earth by the Lorentz force. The solar wind consists of high-speed (high-energy) charged particles that keep it away from reaching the surface of the earth, thus damaging the living things on it. Part of those particles is also directed by the Earth's magnetism, to land on the Earth from the side of the poles, and it creates the aurora phenomenon.

5 Dynamo (Electric Generator)

Dynamo: a name that was originally given to the electric generator, except that it now refers to DC generators that depend on the electric exchanger (electric inverter).

Dynamos were used in the production of electrical energy before the invention of alternating current generators, which were later overshadowed by the shortcomings of the electric exchanger and the ease of use of semiconductors.

Description: The dynamo consists of rotating coils of conductive wires and a magnetic field to convert rotational motion into pulses of direct current according to what is called Faraday's law.

The fixed part of the dynamo machine is called the stator, and its function is to create a static magnetic field, while the moving part of the machine is called the rotor or armature, which rotates within the lines of magnetic flux.

In small generators, a constant magnetic field is obtained by means of permanent magnets, while in large generators this field is generated by the electric magnets (also called flux coils or feed coils).

The electric generator was invented by the English scientist Michael Faraday in 1831 A.D.

Basic principles:

A generator does not create energy, but rather converts mechanical energy into electrical energy, so each generator is powered by a turbine, diesel engine, or any machine that produces mechanical energy. For example, a car generator is driven by the same engine that drives the car.

Engineers usually refer the mechanical device that drives a generator to the primary engine. In order to get additional electrical energy from the generator, the primary engine must expend additional mechanical energy. If the primary engine was a steam turbine, for example, more steam would be required in the turbine to obtain more electricity.

The electric generator works on the principle of electromagnetic induction, which is the basis for generating inductive current. The generators industry has developed a lot in terms of producing inductive current rectified to a very high degree, and the electric generator directs the electric current to flow through an external electrical circuit, and the sources of the electric generator are many, including the reciprocating motor, including the turbines that use steam engines in their work or by falling water in turbines, which are known as hydropower, internal combustion engines, wind turbines, hand elbows, compressed air, or any other source of mechanical energy. Generators power nearly all electrical networks.

The reverse conversion of electrical energy to mechanical energy is done by the electric motor, generators and electric motors have many similarities, and many electric motors can be mechanically driven to generate electricity, and motors often make generators acceptable in practice.

How does the generator set works:

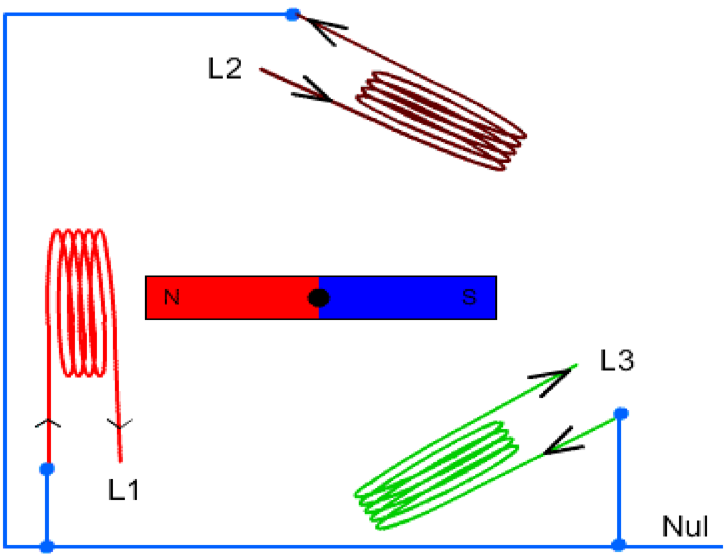
When a coil rotates around a magnetic field (or a magnet around a coil), electrical energy is produced, and this is known as electromagnetic induction, mechanical energy is used in the rotation of a coil or magnet, for example, a bicycle generator uses the force of rotating the wheel to produce electrical energy that lights the bike lamp. As for power plants, renewable energies are used, such as water, wind, and others, while large turbines are used to convert the flow of water into electricity.

Mechanism of Action:

When the rotor is moved by a spindle connected to the (prime mover), an electromagnetic field is generated from the (rotor) coils, which is transmitted to the (stator) windings, which in turn receive the electromagnetic field, and turn into an electric current within the coils distributed on three sides so that the angle between each face is 120 degrees, after which a steady electric current is produced in the form of (sinusoidal waves).

Method principle:

In a three-phase generator, there are three coils distributed on a circuit, and in the middle of it there is a rotating field, which results in the three windings of three currents shifted from each other at an angle of 120 ° (i.e. three voltages that are reluctant shifted from each other at an angle of 120 °.) In the simple case, a self-magnet is used. It rotates in the center of the three coils (see figure). It is also possible to dismiss the self-magnet with electromagnetism, and this is what is done in most cases. The reciprocating voltages reach their maximum (amplitude) shifted from each other by 1/3 of a cycle. The three conducting wires of these currents have traditionally been called L1, L2 and L3.



To illustrate the operation of a three-phase current generator. A self-rotating magnet produces an inductive voltage in the three conductors surrounding it, and those electrical voltages are symbolized by U_{L1}, U_{L2} and U_{L3}.

There are two main parts of any generator or electric motor, which is a mechanical part and an electrical part:

Mechanical part:

Stator: It is the fixed part of an electrical machine.

The rotor: It is the rotating part of an electrical machine.

Electrical part:

The bearing frame: It is the energy product in the electrical machine, in the electric generator, the alternating current generator, or the electric motor the bearing frame coils generate electrical energy, and the bearing frame is either installed on the stator or on the rotor in the mechanical part.

Field coils: It is the product of the magnetic field in the electrical machine, and we can produce a magnetic field for the generator or alternating current generator using any permanent magnet, and the field coils are placed either on the stator or on the rotor in the mechanical part.

In alternators, the field windings are always on the stator, and the bearing frame is on the rotor.

As for DC machines, they require an electrical exchanger on the axis of the moving part, in order to convert the alternating current produced from the bearing frame into direct current.

The sinusoidal alternating current:

Is an electrical current that reverses its direction periodically and oscillates in place to and fro 50 or 60 times per second depending on the electrical system used. It can only be generated according to Faraday's law by means of an alternating electric generator. The abbreviations AC are often used for alternating current and (DC) for direct current, and may also be expressed with voltage.

Its advantages:

Some may ask why alternating current is used to transmit electrical energy, although it is more complicated than direct current. But alternating current has a number of advantages over direct current:

1- Electric power can be transferred via alternating current to very long distances, and this is what direct current cannot do in an economical or practical way. Where the voltage of the generator set can be lowered and raised by using a device called a transformer that cannot be applied to DC because there is no change in the magnetic flux. The transformer raises the electrical voltage coming from the generator, which is usually between 11-36 kilovolts, and raises it to levels of 110-765 kilovolts, making it possible to transfer it to very long distances between countries or even across continents.

2- Reciprocating currents have the advantage of their ability to transmit information. For example, a loudspeaker converts the information contained in a word into AC power

3- Alternating current is easy to generate from turbines as the coils and rotating magnets produce an alternating current. To obtain direct current from them, a straightening and filtration must be performed, and this process is difficult to achieve in high tensions**.**

4- Electrochemical cells directly produce direct current, but they are impractical to meet the needs of large population areas, while the enormous energy stored behind dams can be used on rivers, exploiting the tidal energy of the oceans, wind energy, fossil fuels, and safe nuclear reactions to spin turbines which in turn run AC generators.

A different view of the scientist (Thomas Edison):

Thomas Edison preferred direct current to alternating current in the transmission of electrical energy in the early days of the establishment of electrical networks, as he established the first commercial station to generate electricity in the world in New York in 1882AD to generate direct current so that the first electrical devices were working on direct current such as Edison lamp, but his colleagues saw that alternating current could work better, and it took Edison time to be convinced of the mistake of his position, but perhaps he knew something his colleagues did not know. There is an increased advantage of direct current in electrical networks when transmitting electrical energy over long distances, as it is transmitted more effectively at higher voltages than alternating current because the wires have a smaller resistance when the DC current passes than when the alternating current passes and also the lost magnetic energy is reduced in the form of a magnetic field around wire. The transmission of power using DC high voltage is very promising in the future, but at the present time the main problem lies in the cost as it requires highly studied energy transmission equipment.

Sinusoidal frequency:

The change of alternating current over time can be described by a sinusoidal equation in the picture:

$$i(t) = \hat{i} \cdot \sin wt$$

Where $\hat{i}$ is the maximum limit of alternating current, is called the current amplitude, **t** is time and **w** is the angular frequency. Note that the angular frequency has a unit of **1 / second** as the frequency **f**, i.e. the frequency is also measured in the unit of **hertz** which is **1 / second**.

AC voltage:

$$u(t) = \hat{u} \cdot \sin wt$$

Where **u** is the maximum voltage and is called the amplitude and **t** is the time, **w** is the angular frequency.

Current and cycle:

The number of vibrations per second is called the frequency, measured in **Hertz**, and abbreviated **Hz.**

6 (Electric Motor)

The Electric Motor: It was invented by the English scientist Michael Faraday in 1821. It is one of the many used devices in our modern era. It drives machines in factories, drives electric trains, runs sewing machines, runs electric washing machines, runs pumps, and so on. There are various types, large and small, to suit every use.

Brief History:

The development of electric motors began at the beginning of the nineteenth century with the discovery of the electromagnet. In the year 1820AD, the Danish physicist Hans Christian Ørsted discovered that a wire through which an electric current passes creates a magnetic field around it (around the current). When the current passes through a loop wire (formed in the form of a ring), the generated magnetic field is more intense inside the ring and the direction of the field is perpendicular to the plane of the ring. In the late 1820s, American physicist Joseph Henry explained that a more powerful electromagnet could be created by wrapping several turns of insulated wires around a piece of iron that takes the path of the magnet.

In 1821 AD, the English physicist Michael Faraday hung a copper wire and dipped it into a vessel of mercury. Mercury had a magnetic rod. When Faraday passed an electric current through the wire, he found that it began to orbit around the magnetism existing in Mercury. And Faraday found that the electric current created a circular magnetic field around the wire. This experiment is used to explain how the electric motor works for students in schools, with mercury being replaced by water with dissolved salt to be conductive, because mercury is a toxic substance and its vapor is also toxic.

In 1827, the Hungarian physicist, Anusch Yelik, conducted an experiment using wire coils. He modified the experiment so that the motor consisted of three components of a DC motor: a stator, a rotor, and an electrical exchanger. This device does not use a self-magnet, but rather produces the two magnetic fields from the two electric currents passing through the stator windings and the rotor windings.

In 1873, the first commercially successful DC motor appeared, with a Belgian electrical engineer named Zenob Theophil Gramm showing it in Vienna. Gramm also presented a case that improved the efficiency of primitive electric motors and generators.

In 1888, a Serbian engineer named Nikola Tesla invented the alternating current motor. And at the beginning of the twentieth century AD, many advanced electric motors were developed.

And in the first decade of the twentieth century, many engineers and inventors experimented with linear electric motors. Instead of spinning, such motors produce an electromagnetic wave that can directly drive a vehicle. The use of the linear actuator became more and more popular thanks to the pioneering work of electrical engineer Eric Lithwaite in the 1950s and 1960s.

The Electric Motor according to the thermodynamic definition:

It is a machine that converts electrical energy into rotational kinetic energy to accomplish work. Electric motors are used to power a variety of electrical machines and mechanical equipment such as washing machines, air conditioners, vacuum cleaners, hair dryers, sewing machines, electric drills and saws. It operates various types of engines on trains, metros and electric public transport buses (trolleybuses), as well as operating factory machinery and robots.

The size of electric motors varies greatly. It could be a small device that functions inside a wristwatch, or a huge engine that powers a heavy locomotive. At a time when mixers and most other kitchen appliances need small electric motors because they only need simple electrical power, trains require the use of larger and more complex motors, because the electric train motor expends a large electrical energy in a short time to produce movement.

Depending on the type of electricity used, there are two main types of motors:

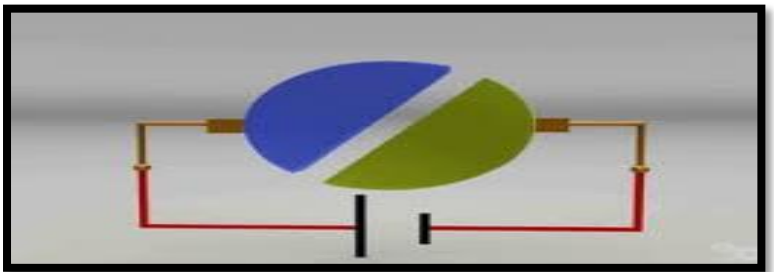
1- AC motors:

The alternating current is reversed in the direction of flow fifty or sixty times per second between negative and positive. It is the current used in homes. AC motors are commonly used to power mechanical equipment in factories. It is also used as a starter in internal combustion engines.

2- DC motors:

DC motors are also commonly used in many instruments such as sphygmomanometers and battery devices. DC current only travels in one direction (not oscillating), and its source is a battery or accumulator.

Alternating current can be converted into direct current. This process is called "rectifying current" and is performed by rectifiers. Conversely, DC can be converted to AC by a similar device, which is the electrical transformer, and there are small and large ones. (See the rectifier "inverter" in the following picture).



DC electric motor work:

Technology of electricity and electric motors is one of the basics of our modern civilization and cannot be dispensed with. The electric motor that operates on direct current consists of three parts: **1-** an electric static member that produces an electric field, **2-** and a rotor consisting of several wire coils that produce a magnetic field opposite to the magnetic field produced by the stator, causing the rotating element to move, **3-** The third part is An electrical exchanger that passes current in the windings of the rotor and "alternates" or "rotates" the windings in receiving electric current, where the two magnetic fields attract or repel each other and the rotor motion occurs. One way to illustrate the relationship between the direction of current in a wire and the direction of the emerging magnetic field is the right-hand rule.

Parts of DC Electric Motor:

A simple electric motor consists of a rotating electrical conductor (rotor), sandwiched between the north and south poles of a fixed, horseshoe-shaped magnet. The conductor is known as the rotor (sometimes called the housing: armature sleeve), while the stator magnet is known as the field structure (stator). There is also an electrical exchanger installed on the rotor axis that supplies current to the rotor windings.

1- Fixed member:

The magnetic field is composed of lines of force that exist between the poles of a fixed magnet. In some larger and more complex motors, the field structure is composed of more than one electromagnet and fed with electricity from an external source. Such electromagnets are called stator field coils.

2- The rotor or preservative:

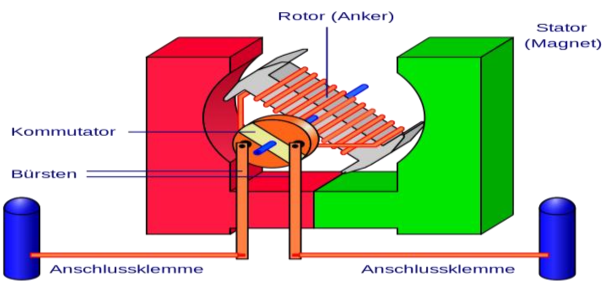
A rotor is a cylindrical coil or several coils in total, cylindrical in shape and they form an electromagnet when current passes through them, and connected to the rotor an axis pivoted on two load chairs, and the load is connected to this axis and the load rotates, as the north magnetic rotor pole attracts with the south pole of the stator, and the southern in this with the north in that. Then the direction of the current reverses to change the north rotor pole to make it a south pole, so the two south poles repel, making the armature do a half turn.

3- Electric exchanger:

The exchanger in a DC motor consists of a loop that is divided into at least two parts and attached to the shaft attached to the rotor. The current coming from the external source is connected to the exchanger through two wires and two small pieces of graphite called "brushes" and touching two opposite parts of the exchanger divisions. Current enters from one brush to the coil, and there is another brush on the other side of the exchanger from which current exits from the coil and the current returns to the source of electricity. And when one of the rings contacts the first brush, it picks up the electric current from the brush and sends it through the case, and when the magnetic poles those form on the case fall into some poles similar to the field magnet, the case rotates half a turn, passing one of the gaps separating the rings. Then the second ring of the exchanger connects with the first brush and becomes a current carrier to the armature, thus reversing the current direction as the position of the electrodes in the case. When the opposite poles of the two magnetic fields of the stator and the armature meet, the armature continues to rotate due to the repulsion of their magnetic fields.

(DC Electric Motor)

(Exchanger consists of two brown parts)



A- Types of DC motors:

There are three main types of DC motors: series, parallel, and combined motors. The main difference between them is in the circuit arrangement between the rotor and the stator.

1- In series motors:

The rotor and the field magnet are electrically connected respectively. Current flows through the field magnet and then into the rotor coils, when the current flows through the structure in this order, the strength of the magnets increases. Series motors start quickly, even if they are operating at a heavy load, although this load will reduce the engine speed.

2- In parallel motors:

Both the magnet and the rotor are connected in parallel. Part of the current flows through the electromagnet, while the other part flows through the rotor coil. A thin insulated wire is wrapped around the field magnet several times in order to increase its magnetism. The creation of the magnetic field in this way causes resistance to current. The strength of the current and the degree of magnetism accordingly depends on the resistance of the wire rather than the load of the motor.

The parallel motor runs at a constant speed regardless of the load, but if the load is too large, problems occur for the motor when starting.

3- For a compound motor:

Two magnetic fields connected to the rotor, one in series and the other in parallel. Compound motors have the advantages of both series and parallel motors, as they are easy to start with a large load and they maintain a relatively constant speed even if the load suddenly increases.

B- Types of AC motors:

Several types of AC motors have been invented to meet simple use, such as in household uses, such as dust extractors, hair dryers, washing machine motors, fans, etc. These work with a normal AC voltage which has capacity about 110 or 220 volts, including the big one that is used to operate factory machinery, or to run public transport metro and electric trains, which reach speeds of 350 kilometers per hour. Those large motors used in metros and trains are called traction motors, and they operate at much higher voltages, up to 3000 volts.

The difference between:

1- Normal AC motor:

Single-phase AC: it runs at a lower capacity and is used in simple machines such as a refrigerator pump motor or in fans and washing machines.

2- Three-phase current drive:

The rotor consists of a squirrel cage rotor. It is widely used in the industry for its durability, economy and sustainability.

The difference between:

1- Induction motor (non-synchronous):

The rotor in an induction motor consists of a squirrel cage rotor, which is a cylindrical iron core with holes in its longitudinal side. Rods of aluminum or copper are fixed (or cast) in these openings and attached to two thick copper rings fixed on the bases of the cylinder, so that their shape is similar to the cage. The rotor is not directly connected to an external electrical source. Alternating current flows from the source into the field coils of the stator and generates a rotating magnetic field. This field generates an inductive current in the rotor resulting in another magnetic field. The magnetic field originating from the rotor interacts with the magnetic field generated by the stator, causing the rotor to move.

2- Synchronous Engine:

The stator of the synchronous motor generates a rotating magnetic field. But the rotor receives current directly from an external electrical source rather than relying on the magnetic field arising from the stator to generate an electric current. The rotor is moving at a constant speed, synchronized with the stator rotor field. The velocity is proportional to the frequency at which the alternating current originating from the stator is reflected. Since the frequency is always constant, synchronous motors, like combined current motors, have a constant speed even with a variable load. These motors also consume less energy and are ideal for watches and telescopes that require accurate timing and quiet rotation.

7 Charging The Electric Car

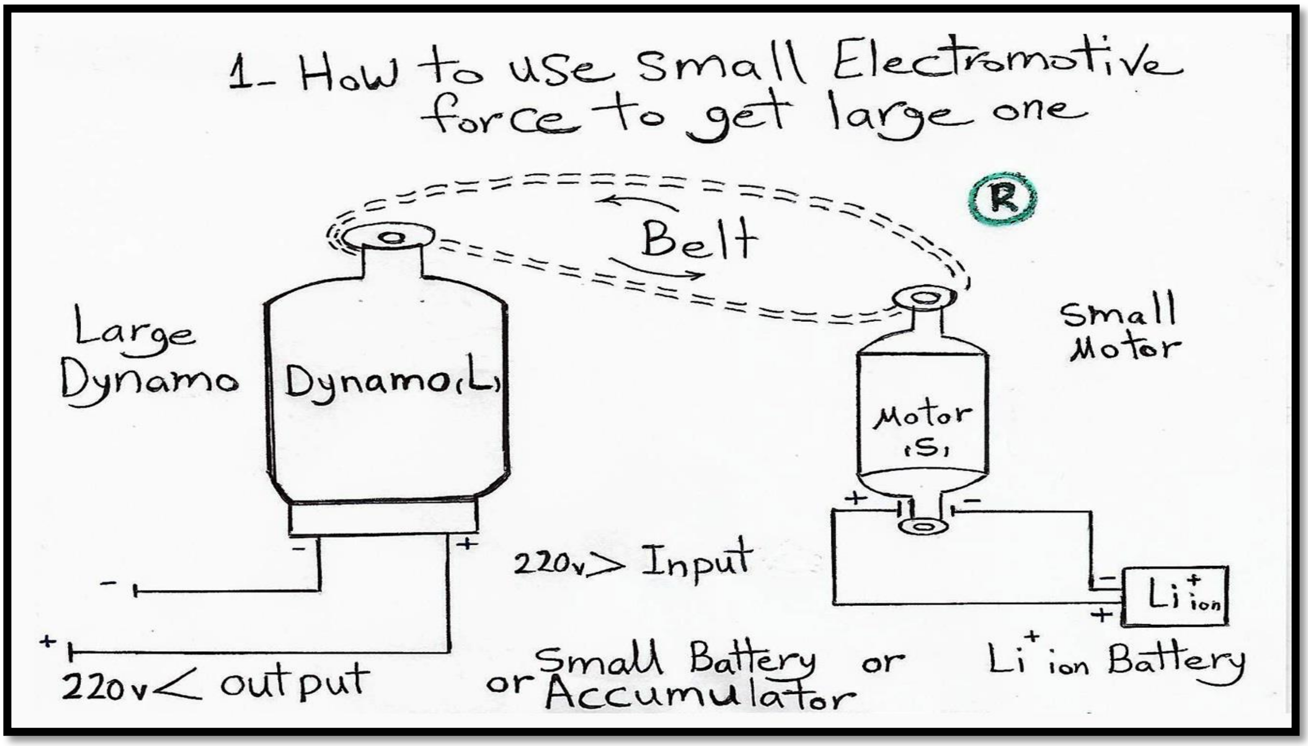
Do you ever think of what would happen if an electric motor is connected to a (dynamo) electric generator through one insulated, non-conductive terminal? By looking at the previous chapters, it was found that: The electrical circuit always begins with a generator (dynamo) through commercial power stations and ends with a motor that operates fans, air conditioners, and electrical washing machines in homes, as well as operating machinery, equipment and robots in factories, depending on the types of motors used as needed, but what if we connect the dynamo movement to the rotational movement of the motor by connecting them to a rotating (belt) from one side that is not conductive of electricity?

With that, we can generate new electrical energy through the dynamo, and we can use it to operate many electrical devices without consuming more electricity. The following applications illustrate this:

1 Obtaining a large electric motive force through the use of a small momentum - the following figure shows how we used a small battery of whatever type or accumulator (such as lead accumulator used in gasoline-powered cars) or a lithium-ion battery that is recharged and connected to a relatively small motor to run it and by Connecting it to a larger dynamo enables us to obtain a greater electric motive than the first used at start-up, this force may be used in the operation of many household appliances, light agricultural machinery, or simple devices used in plumbing, welding and carpentry workshops, and it is similar to the same physical principle used in a hydraulic press by using a small momentum to obtain a Large one that can lift cars and buses in the lubrication or oiling stations through the piston, so for example, the electric motive force entering is less than 220 volts and the exiting one from the dynamo is greater than 220 volts.

(See the first figure)

(Using a small electromotive force to obtain a large one)

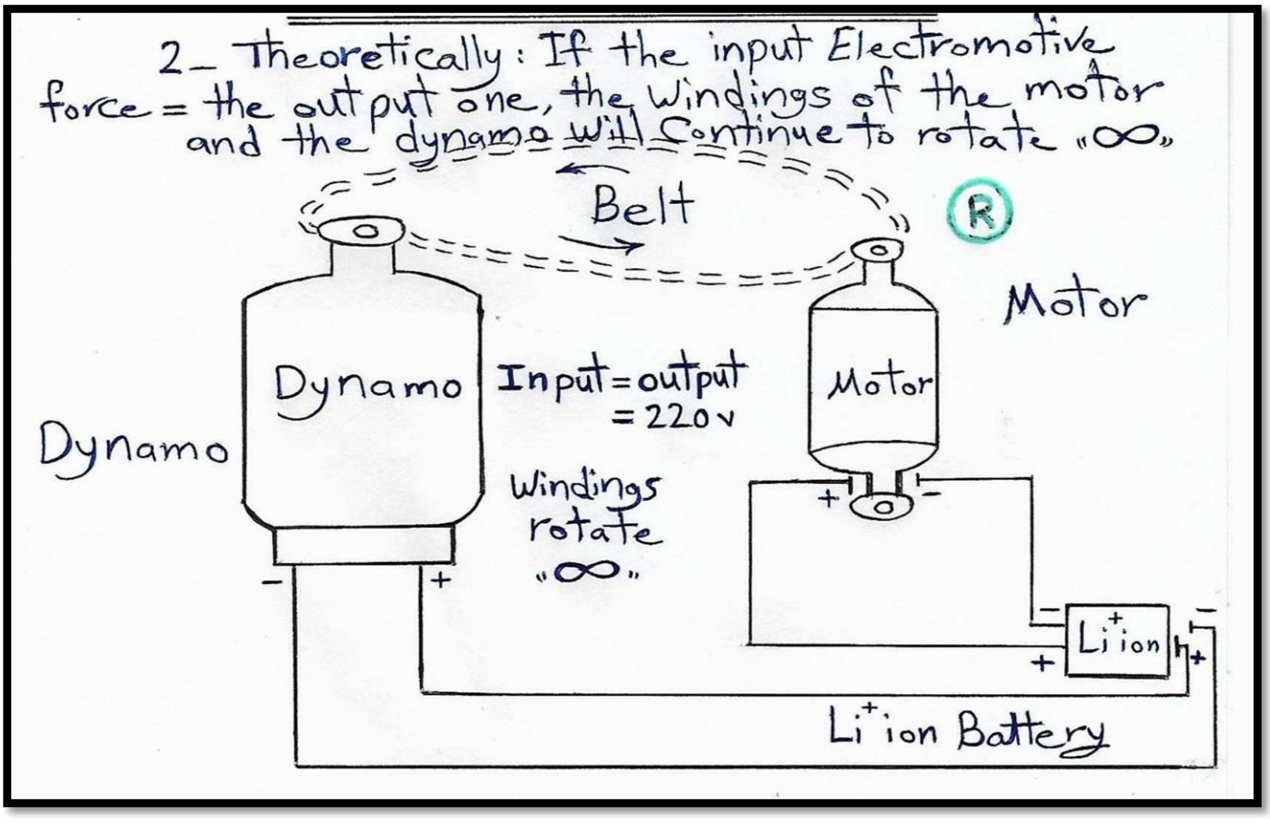


2 The second figure shows that, in theory:

The field windings in both the motor and the dynamo will continue to rotate if the incoming electric motive force = the exiting electromotive force when the motor is connected to the dynamo coil via a rotating (belt) from one end and reconnecting the dynamo output to the original input of the current - In the event that the original source is a lithium battery that can be rechargeable again, and the input voltage = the electrical power output = 220 volts.

In theory, the coil will continue to rotate "∞"

(See figure 2)



(A figure showing the constant rotation of the motor and the dynamo coils).

3 Recharge the electric car battery:

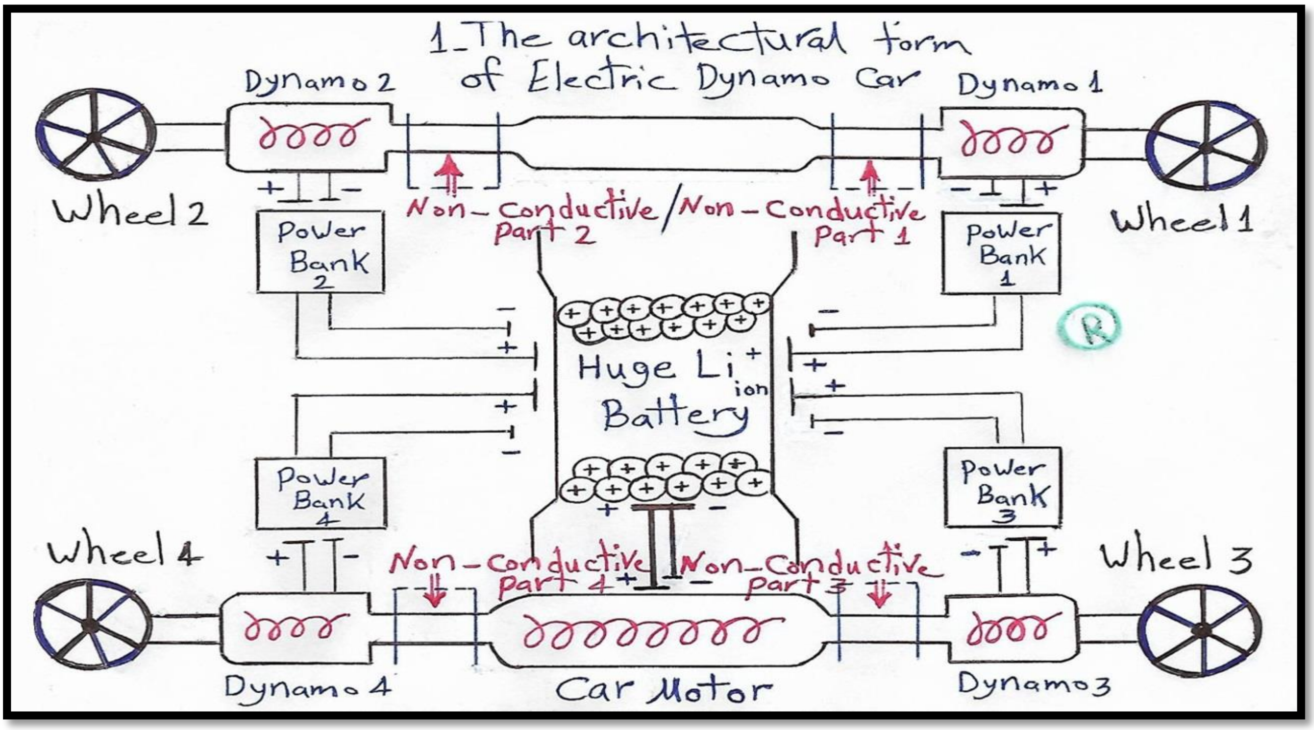
Every modern electric car contains a giant lithium-ion battery that enables it to run for several hundreds of kilometers, but after a certain distance, the battery energy will run out from a single charge and it will need to be recharged again through a source of electricity where:

The charging time depends on the vehicle's capacity and the type of current. An electric car with a capacity of 40 kWh needs about 11 hours to be charged with household current of one phase (16 amps, and 3.7 kW), while it is charged for 4 hours when connected to a three-phase current (16 amps, 11 kW). The electric car with a capacity of 10 kWh takes about three hours to charge at home (with single phase current), while it is charged with three phase current within 1 hour.

But what if we put a number of generators (dynamos) in the electric car that charge the car battery over and over so that the energy does not run out. The following figure (Figure 3) shows that the car's motor is directly connected to the giant battery and derives its energy from it. A (dynamo) generator has been connected to the right and left of the original motor coil to take advantage of its movement energy with the car’s wheels to generate electrical energy that is stored in a power bank recharges the giant battery again and with the movement of the front wheels, an internal power generator (dynamo) is connected next to each front wheel on the right and left, and each power generator is stored in a power bank that recharges the giant car battery again, and thus we have benefited from the kinetic energy of the motor in running 4 dynamos inside the car body to get electric energy from them that are stored in 4 power banks that supply the original battery with electricity again.

But note that there is an isolated non-conductive part separating the car's motor and the dynamo from the right and the left that does the same work as the rotating (belt) in the first and second figures, and therefore the electrical energy produced by the dynamo does not reflect the electrical energy used in the operation of the motor and we get a self-completed charging electrical circuit, that does not need an external source to recharge it.

(See Figure Three)



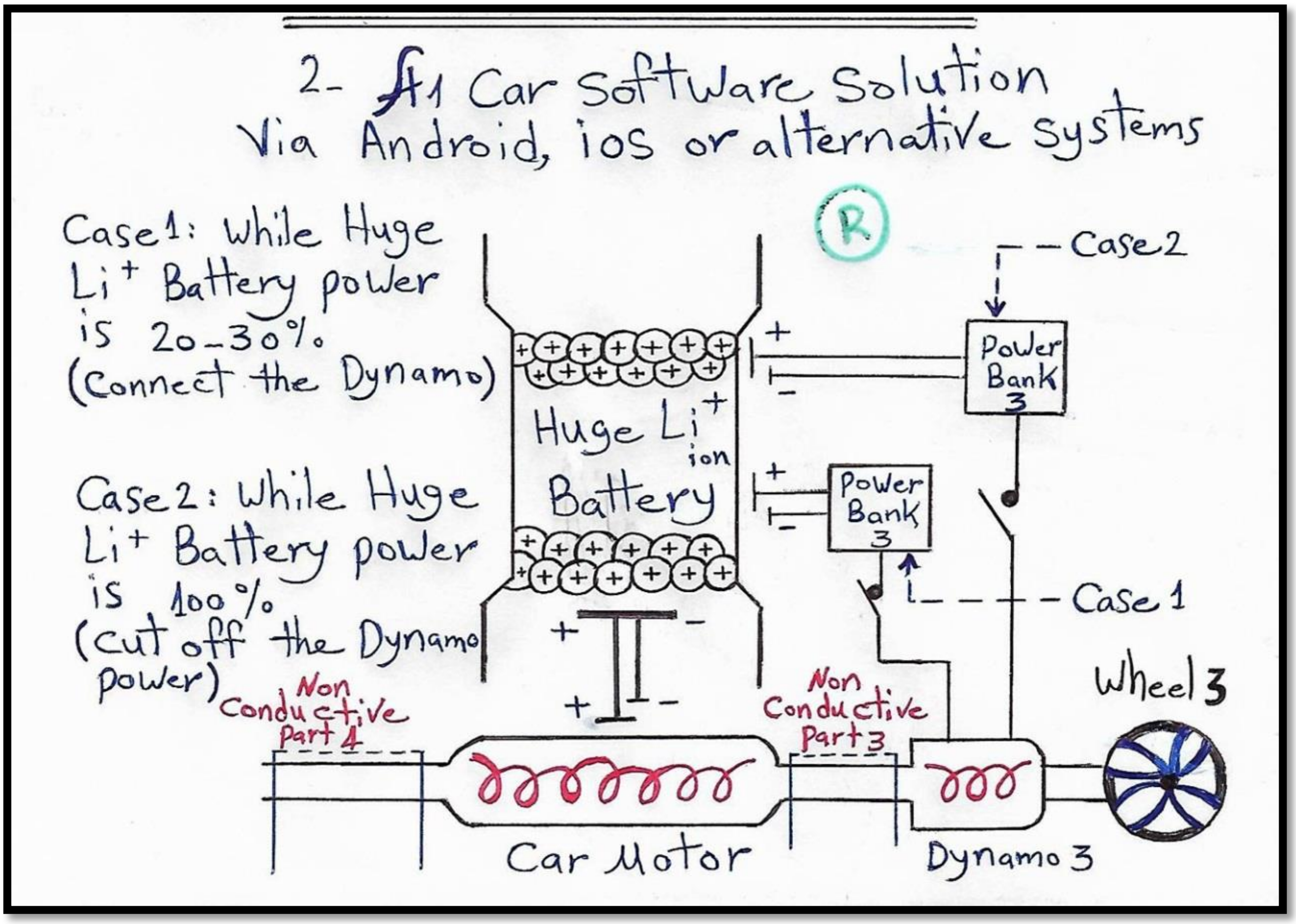
(Figure 3 - The anatomical shape of the electric dynamo from the inside).

Note that we can combine the four voltages of the 4 dynamo in series to get one main high voltage (V) and high power (P) charger to recharge the giant battery from one socket.

But there is still an existing problem, which is that the lithium batteries are designed to be recharged again and again after their energy runs out in a single charge, and here comes the dependence on the software for the smart system pre-loaded on the car because modern cars have become adopting smart operating systems to operate them, such as: Android Auto or Apple Car Play or others.

By adjusting these systems to control electronically all the car's functions, we can set an electronic program that delivers (closes) the dynamo circuit when the car's giant battery power reaches 20-30%, then opens the dynamo circuit and separates it from the power bank and so the giant battery, when the battery power reaches 100 % And fully recharged. In this way, we can charge the car battery many times and many times during its course taking advantage of the kinetic energy of the motor to generate electricity from the four power generators (4 dynamos) without stopping for refueling or recharging again from an electric power plant or an external source.

(See Figure 4)



(Figure 4 - shows the software solution to reconnect or disconnect the giant battery from the four power generators "4 dynamos").

Done ….

A short science booklet

✓ The scientific material for the book is borrowed from the Wikipedia site (the free encyclopedia) of electrical physics and its most important scientists.

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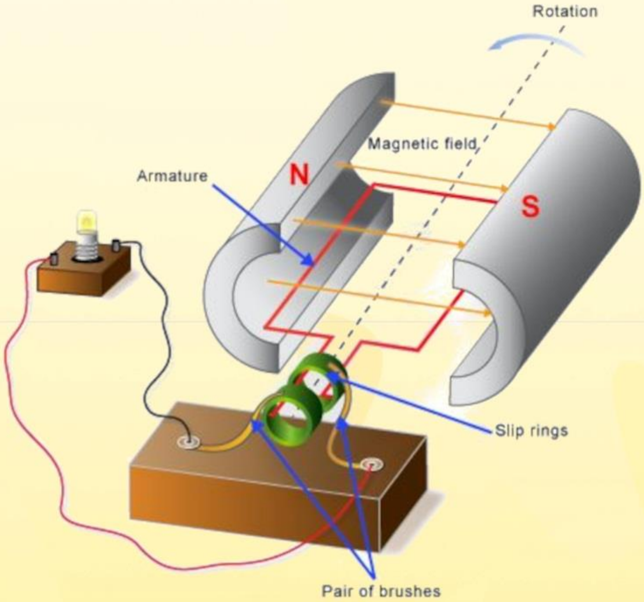

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