The Actual and Future Aspects of Using the Inductive Transmisson of Electromagnetic Energy

Dr. MIRCEA-EMILIAN ARDELEANU, BOGDAN RĂSCĂCEA

Electrical Engineering Faculty,
University of Craiova
B-dul Decebal nr.107, 200440 Craiova,
ROMANIA
mircea_emilian@yahoo.com , brascacea@yahoo.com

Abstract: - The discovery of the electromagnetic induction phenomena by the English physicist Michael Faraday and his scientific underlining constitutes important marks in the technical and scientific development of human kind thus being the catalyst of the industrial progress from IXI and XX centuries.

The industrial uses of the electromagnetic induction law (a series production of electric transformers, engines and electric generators) led to the apparition of one of the most important and performant economic branches, namely the Electrotechnics.

In this article, firstly, several relevant aspects from the pedagogical, scientific activity and life of the English physicist Michael Faraday, are presented. His experiments which led to the enunciation of the electromagnetic induction law are presented.

Likewise, several biographical aspects regarding the life and the opera of the eccentric and genius Serbian engineer Nikola Tesla, are also presented

In this article, the use of the electromagnetic induction law was proposed (inductive transmission of electrical energy) in the technical achievements in electrotechnics and namely electric transformers and rotary electrical machines.

Also, a reference is made to the genius Tesla's idea regarding the possibility performing wireless transmission of electric energy over long distances.

At the end of the work, some actual and future applications regarding the inductive transmission of the electrical energy are presented and listed in what regards to recharging an electrical vehicle, a mobile phone or a pacemaker.

Key-Words: - electromagnetic induction, resonant circuit, wireless transmision, electromotive force, battery; induction current; resonance conditions, induced electromotive voltage.

1 Introduction

The discovery of the phenomenon of electromagnetic induction and its scientific justification are milestones in the history of physics and electrical engineering in particular.

This article aims to present a brief history of the discovery of this phenomenon and its use in the service of scientific and technical progress of humanity (making transformers, motors and electric generators, etc.) and current and future uses in the wireless transmission of electricity.

The simple, clear and convincing experiments and conclusions of M. Faraday on electrical induction are presented.

The classical uses of electromagnetic induction in the electrotechnics industry are presented, namely the electrical transformers and rotary electrical machines (electric motors and generators) without which the technical and scientific progress of mankind from the XX and XXI century wouldn't have been.

Particular attention is shown to brilliant personality of engineer N. Tesla and his tenacious, ambitious work which by the spectacular achievements and experiments conducted at Wardenclyffe tower, at the beginning of XX century, promoted the idea of the possibility of wireless transmission of electricity over long distances.

Some current applications of wireless transmission of electrical energy and important future uses such as wireless power of laptops, charging batteries in electric cars and mobile phones etc. are presented.

In conclusion are presented perspectives and technical and economic advantages of future uses of wireless transmission of electricity both for industrial purposes as well as household uses.

2 Electromagnetical induction
2.1 Michael Faraday – father of electrotehnical engineering

On September 22, 1791, in the house of a poor blacksmith from Newington, near London, Michael Faraday saw daylight. He had a difficult childhood, full of indigence. At the age of twelve he is forced to abandon primary school, where he had managed to learn to read and count at all, and works as a bookbinder apprentice. In addition, he read books to the bound, being interested in physics and chemistry books.
After completing his apprenticeship he works for a traveling bookbinder.
Thus, by unknown destiny games, he gets to know the famous Professor of Chemistry, Humphry Davy at the Royal Institution. This impressed with young Faraday hires him in 1813, as laboratory – assistant at the Royal Institution. Perseverance, dedication, thoroughness, diligence, desire to know as many things as possible made young Faraday to be noted not only by Davy but also by other teachers who needed his services.
During 1813-1815 he accompanies the famous professor in a course of lectures in the great European capitals.
Due to its scientific and experimental merit and qualities faculty in 1815 at the Royal Institution unanimously agreed that Michael Faraday to be employed as an university assistant
In his brilliant scientific and teaching career that has lasted over thirty years, he carried out many, varied and original works. He developed extensive studies, meticulously prepared, accompanied by convincing experiments in support of the conclusions set [1].

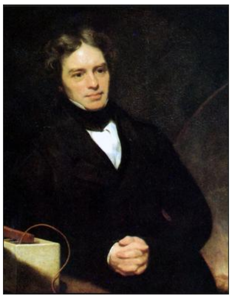

Fig.1 The young Michael Faraday [2]

For a decade, between 1821 and 1831, he carried out numerous experiments in order to demonstrate the idea which baffled him the most and namely: “to transform magnetism into electricity” as meticulousness characterised him, he noted that in his tender notes. Faraday dedicated himself to the find of experimental basis which established the link between magnetism and electricity, the thing that was missing from the observations of the contemporaneous illustrators as Ampère, Arago or Öersted

Fig. 2 Michael Faraday at maturity [2]

On August 29, 1831 Michael Faraday recorded in his workbook notes on the experience that says “that a circuit bathing in a variable magnetic flux, as long as the flow variation lasts, became the seat of electromotive force. If the circuit is closed in this phase of the magnetic flux change, it is crossed by an electric current. If the circuit is open at its terminals there is a potential difference.” He called this phenomenon that produces an *electromotive force* and an *induction current*, *induction*. [1] This day can be recorded as a historic day, a memorable page of physics, can be considered the birth date of discovery of the law of electromagnetic induction and of electromagnetic induction.
Discovering induction is regarded by the entire world as the highest academic achievement of Faraday, the phenomenon that gave a new course to electromagnetism and is the cornerstone of electrical engineering. Therefore, Michael Faraday is considered the *father of electrotechnical engineering*.

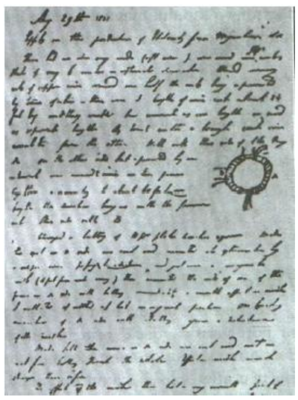

Fig.3 The manuscript page in which are shown the results of the “conversion of magnetism into electricity [1]
Scientific and laboratory experiments were doubled by a distinguished teaching activity.

The ability of experimenter, the simplicity, clarity and ingenuity with which his conferences were accompanied but also with the presentation in a more accessible and clear form of the content, most of the times abstract, made Michael Faraday famous, the Royal Institution theatre was becoming overcrowded for the ones whom wished to assist at his conferences.

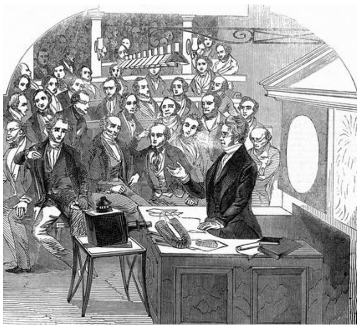

Fig.4 Michael Faraday at the Royal Institution presenting the electromagnetic induction law [2]

On 25 August 1867 after a simple and modest life dedicated with passion and a strong spiritual dedication to scientific discoveries, simple, clear conclusive experiments, understood by its auditor, although ill health forced at times to stay away from his laboratory, Michael Faraday died.

2.2 Faraday's experiments

With tenacity, dedication and interest in the phenomena of physics (with preference to electricity and magnetism) coupled with a soul kindness and modesty recognized by colleagues and collaborators, he managed through simple, clear, persuasive experiments, understandable to everyone to present and define electromagnetic induction law, the fundamental law of electrical engineering. Next we will briefly present Faraday's experiments.

2.2.1 Experiment 1

Consider a circular coil of conductive material on which is mounted a galvanometer (fig.5)[15].

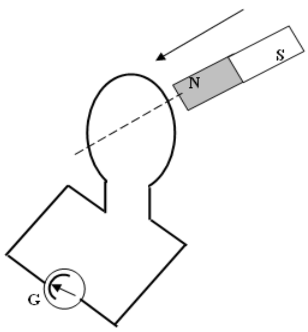

Fig.5 Figure explanatory for the first experiment

The coil is approaching a bar shaped magnet with the North Pole toward the coil. As the magnet approaches the coil, galvanometer needle deflects off indicating that an electrical current is flowing through the coil. If the magnet does not move relative to the coil galvanometer does not deviate.

When moving in reverse the magnet (the magnet remove coil) galvanometer needle deflects off but in reverse than before. If you repeat the experience but bringing close and then removing the magnet with South Pole toward coil galvanometer needle deflects off, but the direction of deviation is opposite than in the first experiment.

The conclusion that emerged from this experience extremely simple is that *what matters is the relative displacement of the magnet and the coil.*

It doesn't matter which is the element that is moving, namely the magnet toward the coil or vice versa.

The current that occurs in the coil is called *induction current* being determined by *induced electromotive voltage* [3].

2.2.2 Experiment 2

Another simple demonstration made by Faraday to explain the phenomenon of induction, he used a device similar to that shown in fig.6 [15] .

The experimental device is made up of two circuits. A circuit is made up of a coil with a galvanometer mounted at the ends (G). The second circuit is made up of a coil where there is a DC voltage source (E), a switch (K) and a resistor (R).

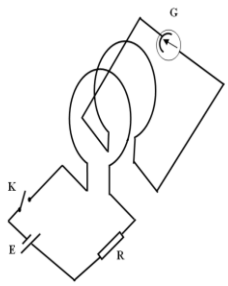

Fig.6 Figure explanatory for the second experiment

The two coils are arranged side by side (face to face) and in the rest one against the other, as shown in fig.6 When the switch K is closed, in the circuit of the other coil is established an electrical current notified by the galvanometer G through its indicator needle deflection. Deflection is short as the needle returns to zero.

If the switch K is open also it can be seen, for a short period of time, the deflection of the galvanometer needle, but in the opposite direction than before.

The experiment showed that in the coil with passive circuit (who does not have power supply) occurs an induced electromotive voltage whenever the current in the coil in the circuit powered by the power supply E ranges (closes or opens the switch K).

The conclusion that was drawn from this experiment is that what is important in this phenomenon is *the variation speed of current and not its intensity* [3].

2.3 Law of electromagnetic induction

Law of electromagnetic induction is an important and fundamental law to electrical engineering showing how to produce voltage always stating that the presence of a time-varying magnetic field is accompanied by an electric field [4].

The statement of the law of electromagnetic induction states that "u_e electromotive voltage induced in a circuit is equal to variation speed of magnetic flux taken with the opposite sign."

$$u_e = -\frac{d\Phi}{dt} \qquad (1)$$

Integral form of the law, both for bodies at rest and bodies in motion has the form:

$$u_e = \oint_{\Gamma} \vec{E} \cdot d\vec{l} = -\int_{\Sigma_\Gamma} \frac{\partial \vec{B}}{\partial t} d\vec{S} + \int_{\Sigma_\Gamma} rot\left(\vec{v} \times \vec{B}\right) d\vec{S} \qquad (2)$$

And local form is:

$$rot\vec{E} = -\frac{\partial \vec{B}}{\partial t} + rot\left(\vec{v} \times \vec{B}\right) \qquad (3)$$

In relation (2) :

$-\int_{\Sigma_\Gamma} \frac{\partial \vec{B}}{\partial t} d\vec{S}$ - represents the variation in magnetic flux due to local variation of magnetic induction, the contour is assumed stationary and is called electromotive voltage induced by transformation;

$\int_{\Sigma_\Gamma} rot\left(\vec{v} \times \vec{B}\right) d\vec{S}$ - corresponds to the variation of the magnetic flux due to the movement of contours with the body, the magnetic induction is assumed invariable in time and represents electromotive voltage induced by motion.

3.Nikola Tesla and Wireless Transmission of Electricity

3.1 Nikola Tesla – engineering genius

Nikola Tesla saw the light of day on July 10, 1856 in the small village Smilijan in the province of Lika in Croatia. He was the fourth child of Milutin and Djouka Tesla. He was born and raised in a family educated and devoted to the principles of family and Orthodox faith, his father being an appreciated priest.

Primary School classes begin in Gospic, where his father received a new parish, proving to be a good student who likes to read a lot, even obtaining a job in the school library.

Destiny makes that in Karlovac (Carlstad) where he continued his studies at the village high school he knows physics Martin Sekulic who stimulated and impressed him with the experiments he made for the young students, opening the way to the sciences.

Wanting to become an electrical engineer he enrolls at the renowned Ecole Polytechnique Graz, where he meets famous teachers such as: Rogner, Poeschl, who initiated him into the mysteries of physics and superior mathematics. From financial reasons is forced to abandon studies. He never graduated from Ecole Polytechnique Graz and received no grade for last semester spent there [5].

Fig. 7 The young Tesla [2]

Later, in 1880, he manages to participate in some summer courses of the University of Prague, one of the most famous and important university in Europe with famous rector Professor Ernst Mach.

After a spell in Budapest, where he works in the telephone company, and then to Paris where he was employed at the newly founded company Continental Edison Company, in 1884 decides to go to America.

United States of America, a country growing economic, industrial and financial, country where each newcomer saw the Promised Land proved a fertile area for the development and flourishing of the technical ideas ingenious and courageous of young Nikola Tesla.

With the recommendation of the Director of Continental Edison Company in Paris he gets to work for the company of famous Thomas Edison, a personality that will mark much his life and activity.

At one point Tesla said: "The meeting with Edison was a memorable moment of my life. I was amazed by this wonderful man who has achieved so much with no scientific training." [6]

In 1887, he built the first induction motor, brushless, AC power, which he presented at the *American Institute of Electrical Engineers* (now IEEE, Institute of Electrical and Electronics Engineers) in 1888 [2].

As a child he was fascinated by the native water mills and water power to move the mill wheel. Since then cornered in small Nikola mind the idea of using flowing water energy for the production of electricity.

Making the great project for the power plant at Niagara Falls has raised many specialized issues constructively, finding many ingenious technical solutions, but also created great controversy, much publicized at the time, between Thomas Alva Edison and Nikola Tesla, the American and world's electrical engineering titans at the time.

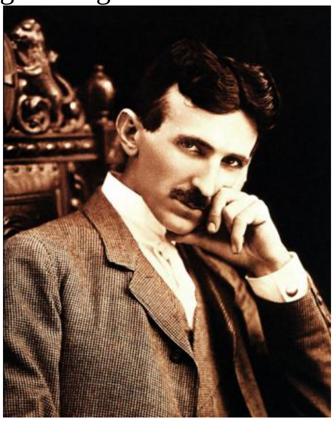

Fig.8 Nikola Tesla at maturity [2]

After five years of great human and technical endeavor, points of renunciation and distrust, financial crisis and millions of dollars invested in November 1886 Niagara Falls hydropower plant project was completed. The first hydropower plant in the world was now functional, the author of this project, greeted by many with distrust and suspicion, considered likely to fail, was Nikola Tesla.

Making the large hydropower plant from Niagara in the last decade of the nineteenth century brings Tesla at no forty years, a great victory and enhances the reputation and respect in the world of engineering. He managed to defeat the favorable trend of DC supported by Edison which was financially supported by tycoon J.P.Morgan requiring alternating current generators.

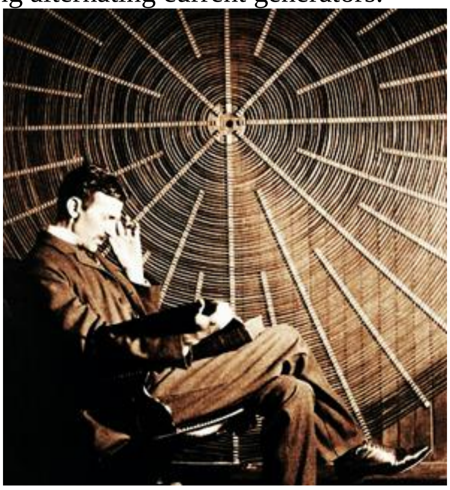

Fig.9 Tesla in his laboratory [2]

3.2 Tesla's vision on wireless transmission of electricity

For instance, he understood that wireless power transmission is possible, but did not know that there are limits to the amount of energy transmitted in this way.

Towards the end of 1898 he begins a systematic research, undertaken over several years in order to perfect a method for transmitting electricity through the natural environment.

Thus, in 1899 Tesla moved to Colorado Springs. Colorado Springs a plateau located at 2,000 m altitude above sea level and covers an area of 1,000 km^2. Here he designed the new laboratory to achieve his goals.

Atmosphere of Colorado Springs allowed him to make some important scientific observations noting "Consequently, lightning in the atmosphere are very frequent and sometimes incredibly violent. Once occurred about twelve thousand lightning in a span of two hours, all on distance less than fifty miles around the laboratory. Many of them resembled giant fire trees with trunks facing when upwards when downwards. I have never seen ball lightning, but as compensation for my disappointment I succeeded later to determine how they are formed and I could produce them artificially" [6].

Publication of scientific observations made during the period when he worked at his laboratory in Colorado has attracted the attention of many scientists and interests of businessmen. Morgan, initially taken by Tesla's ideas, accepted such a giant project financing by providing the scientist and his team a significant amount of money, namely $ 150,000 to build a transmission tower and a power plant.

Full of energy, thoughts and brilliant ideas, surrounded by a team of collaborators Tesla ventured may be into the most deep, known and publicized scientific adventure – achievement of wireless transmission of electricity.

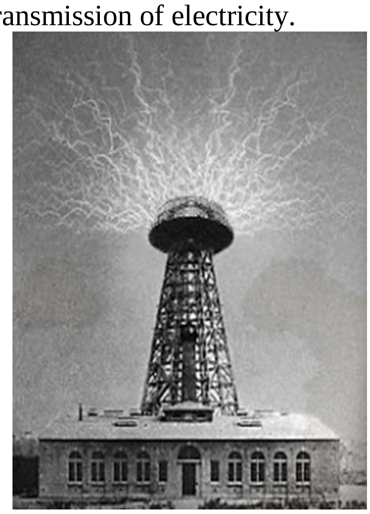

Fig.10 Tesla Wardenclyffe tower [2]

To implement his plan Tesla begins the construction of the famous tower Wardenclyffe in Long Island (fig.10). In September 1904 the tower had reached a maximum height of 55 m. Remaining with little money he failed to complete the dome atop the tower. With reduced funding Tesla continued his work and experiments.

J.P.Morgan was concerned, more obsessed with the possibility that Tesla's achievements can provide the transmission of "unlimited amounts of energy" wireless, although Tesla ensured him that the plant at Wardenclyffe can send only "small amounts" of energy.

A close friend of Morgan suggested him "Look, this man has gone crazy. What he does is that he wants to give them all free electricity and you do not have to put counters. We'll go bankrupt if we support this man."[6].

This was the straw that broke the camel's back and prompted tycoon J.P.Morgan to remain deaf to all Tesla's attempts to continue its research and investments.

Lacking funds, preset by the lenders, Nikola Tesla was forced to stop in 1904 the work on Wardenclyffe complex.

Thus due to more pragmatic than visionary thinking on long term of potent American businessmen and bankers was interrupted a brilliant idea that could have well changed the lifestyle of mankind.

Tesla has lost a battle but happily continued to have a brilliant mind and ideas that today amaze the scientific world and are waiting to be applied to peaceful purposes.

Along his prestigious career the genius but also controversial Serbian engineer Nikola Tesla left mankind a lot of patents of inventions, over 200 patents, most applied, others pending to be used, maybe some are still secret.

He was solitary, surrounded mostly by his ideas and preoccupations.

The idea was speculated that he entered in contact with alien beings. It may be true? These may not be the only enigmas of his life.

The scientific authority of the Nobel foundation wished to award the Nobel Prize in physics in 1915 to Tesla, trying, at the same time to repair a previous injustice (granting the Nobel Prize in 1909 to Marconi) but he refused. In 1916 was too late. The humankind was in full world war and the prize was never granted.

In the date of 7th of January of 1943, at eighteen years Nikola Tesla passed away..

4 Current Uses of Wireless Transmission of Electricity

4.1 Classical utilisations in electrotechnical industy [7,8]

4.1.1.The electric transformer

By definition, the electric transformer is an electromagnetic static equipment with two or more electrical windings arranged on a magnetic core, ensuring the transformation of electrical parameters (tension and current) of the alternative current of the electrical power, the frequency remaining unchanged.

Constructive, an electrical transformer is composed of:

- *The ferromagnetic core*

The core is composed of layers of electrotechnical iron sheets allied with silica (approx. 4%), hot rolled or textured with a thickness of 0.35 ÷ 0.5 mm. They are insulated between them with paper, varnish or ceramic oxides. By allying electrotechnical steel with silica we can achieve the reduction in losses by swirling currents and the ones due to hysteresis phenomena

It plays the role to ensure the closure of magnetic field lines.

- *Windings*

The windings of the transformer are done from a good electricity conductive material (Cu or Al) being insulated with cotton, enamel or paper

One of the windings is connected to the alternative current source and it is named *primary winding* at the terminals of this winding, the transformer takes the electromagnetic power supply network which transmits it by the electromagnetic field to the secondary circuit. At the terminals of the other winding, named *secondary winding* that is connected to the receiving circuits.

- *The box*

The power transformers are emplaced in a protective box.

The transformer's box is made out of metal sheet or it is foreseen with cooling pipes in order to increase the cooling surface (by convection phenomena). The oil based transformers are done for high power of 50kVA and high tensions of 6 kV.

The oil, due to some physically and chemically superior properties towards the air and namely the specific heat and a better thermal conductivity, plays the role, on one part, to help the transmission of the active heat (core and windings) to the cooling environment and to a better electrical insulation of the windings one from another and also towards the core and the other constructive parts of the transformer.

Through the electrical transformers, electrical networks are able to connect to different nominal tensions and can be adapted to the receivers built for a different nominal tension, other than the electrical supply network tension (the power transformers thus being tension rising or lowering transformers).

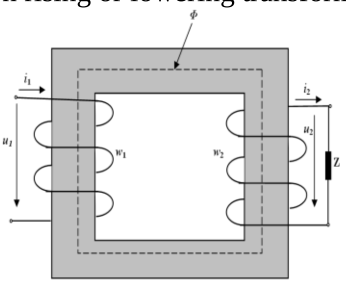

Fig. 11. The schematic representation of a single-phase transformer

4.1.2 Electrical rotary machines

The electrical rotary machines (electrical motors or generators) have a similar construction with the main constructive elements as:

- *The stator*

The stator, as the name suggests, is the motionless part of the machine, it being the inductor, in case of an asynchronous engine or the inductee in case of synchronous generators.

a) the ferromagnetic core

The ferromagnetic core is a cylindrical form and it is done from circular embossed plates out of normal allied siliceous sheet (electro technical steel) of 0.35 or 0.5 mm thickness, hot or cold rolled. The plates are isolated between them with a thin insulating varnish film (Bakelite varnish), or by a layer of oxides. On the interior part of the plates the spacing uniformly distributed are embossed/punched on the circumference of the stator core, spacing/channels where the windings are settled.

b) the stator winding

The stator winding is connected to the AC electrical network with which the machine carries out the main exchange of electrical power. The winding is done from an insulating copper enamel, cotton, paper or fibreglass, micanite etc. At small and medium sized machines often the aluminium enamel insulated conductor is used.

The winding can be single phased, double phased and triple phased as the machine is also single phased, double phased, triple phased (or poly phased).

c) the cover

The case/cover plays the role of protecting (mechanically, electrically, meteorologically etc.) the inner components of the machine and also the specialty electrician personnel whom maintains and commissions the respective machines.

- *The rotor*

The rotor constitutes, as its name mentions, the mobile part of the rotary machine.

It is made out of the ferromagnetic cylindrically shaped core and at the exterior periphery spacing/channels are executed in order to emplace the poly-phased winding. The core is mounted on the axle of the steel based machine.

The axle spins in rolling or sliding bearings, fixed on the port bearing shields or on separate supports. At medium and large sized machines which have an increased torque, a ventilator is mounted on the axle in order to improve the cooling of the machine.

a) the ferromagnetic core

The ferromagnetic core of the rotor is made out of 0.5 mm thickness plates from the same material as the stator (electro-technical steel) most of the times isolated between them with varnish. At the edge of the rotor, through the outside, channels are punched, which are uniformly distributed on the circumference of the rotor, where the rotor winding is emplaced. On the interior, the plates are foreseen with one or two guiding and fixing channels towards the axle of the machine.

b)the winding of the rotor

In the case of asynchronous machine, the following ways of achievement in what regards to the rotor windings are distinguished:

b1) Winded rotor (with collective rings)

The winding coils are situated on the channels of the rotor. The winding coil is made as a coil shape, similar to the ones of the stator windings and are done by a copper conductor or an isolated aluminium.

The winding coils are triple-phased windings and are star or triangle (rarely) connected, and their ends are linked to the collective rings, fixed on the axle of the rotor, isolated from both the axle and between them.

On the collector rings, some special graphite or graphite covered metal (bronze-graphite) brushes enter into contact. By these brushes the link with the triple-phased starting rheostat, star connected, is achieved.

b2) Rotor in short-circuit (in a cage)

Caged windings are made out of aluminium, copper, bronze or brass bars (the aluminium cage is achieved by casting).

The caged windings are poly-phased windings with the cage bars being frontally short-circuited by the conductive rings.

The built rotors with caged windings are more simpler, robust, and more reliable and cheap than the ones with the coiled rotor and that is why, in certain situation from the functional point of view, special conditions are not imposed (when starting, altering the rotation speed etc.) they are preferred from the constructive variant point of view, being used on a large scale in small and medium power engines in different systems of electrical operations.

Fig.12 An electrical motor [14]

In what regards to the synchronous machines, specially used as an electrical generator of triple-phased alternative tension, the rotor winding, also named the *excitation spooling* is fuelled by DC current.

5 Modern and future uses of wireless transmission of electricity

5.1 Electric vehicle battery charging system

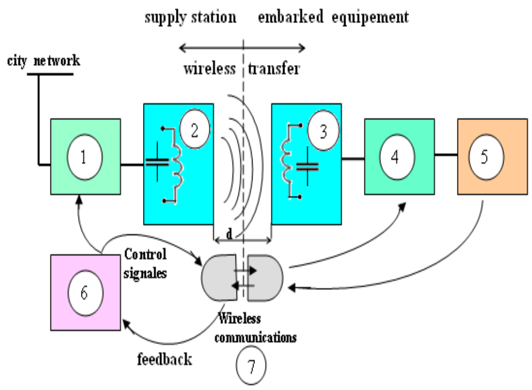

Fig.13 Block diagram of a system for wireless transfer of energy and data for batterry charging of power electric vehicles
1.) AC power converter (50Hz)-medium/high frequency AC; 2.) transmitter circuit; 3.) receiver circuit; 4.) medium/high frequency AC converter–c.c.; 5.) storage battery; 6.) monitoring and control block;7.) wireless communication

The schematic diagram in Fig.13 [9] the energy transfer takes place between the emitter circuit (2) or base station and receiver circuit (3) or mobile station (located on the vehicle) separated by a variable distance (d) of ground clearance time. The transfer is one of the inductive type, such as that described above, the power transmitted to the load (5) can be of the order of kW and provides charging the battery in a time equivalent to the duration of the charging process using a galvanic coupling type.
Variable frequency static converter (1) used in this scheme is adaptive type to ensure, on the one hand, the resonance conditions of the transmitter and receiver circuits, and on the other hand can automatically compensate for variable load caused disagreement. Converter (4) is designed to provide battery charging regardless of its status (degree of discharge) in an optimal regime. Status and battery charging system is monitored and information about them is transmitted through a wireless communication channel (7) to monitor and control block (6) who has command over converters (1) and (4) so that yield global transfer of the system to be maximum regardless of battery status and power factor at the point of power supply to the equal [9].

5.2 Pacemaker battery charging system

A heart stimulator (pacemaker) is a medical device of small size (3-4 cm) emitting electrical impulses, transmitted by means of electrodes which are in contact with the heart muscle in order to regulate the heartbeat. The miniaturized electronic device delivers regular rhythm excitations to a heart with physiological centers unable to provide normal heart rhythm.

Implantation of a pacemaker is a minimally invasive surgery under local anesthesia by which the boxy of pacemaker is buried in a place specially prepared between the chest skin and pectoralis major muscle. For power of electronic circuits of this pacemaker, it is fitted with lithium batteries which ensure a smooth operation for several years (5-7 years) [10].

In fig.14 there is a block diagram of a wireless inductive system of pacemakers power battery.

The system consists of an outer and an inner coil. Outer coil is supplied by an external source of AC. Internal coil takes over inductive power transmitted by the external coil and adapts it to the needs imposed by electronic implants.

The system shown in fig.14 [11] is a series-parallel resonator type. The outer member is composed of an inductor L_{ext} and a capacitor connected in series C_s. The inner member (mounted in the body with the pacemaker) is made up of a coil L_{int} and a capacitor mounted in parallel C_p.

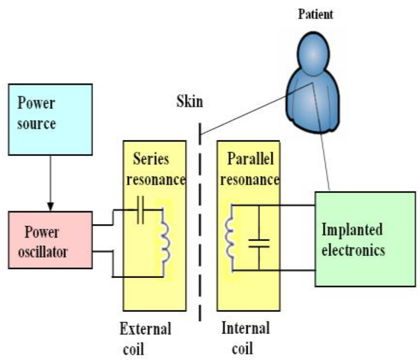

Figure 14 Block diagram of a wireless inductive system of pacemakers power battery.

At resonance is satisfied the relationship known for pulsation:

$$\omega_0 = \frac{1}{\sqrt{L \cdot C}} \qquad (4)$$

Optimum working frequency for such a resonator used for medical purposes for cardiac implants is between 5 ÷ 10 MHz for both coil size reduction and compliance with rules imposed by international medical bodies. For use in medical purposes of such implants, an electronic device based on inductive power transmission must release a power of around 10 mW [11].

5.3 Supply of electric devices equipped with rechargeable batteries

The explosive development of electronics by implementing new technologies that ensure miniaturization increasingly sharper of circuits and electronic devices has led to a technological revolution. Thus, both production and market of “devices” portable is in permanent mobile content diversification and full expansion. These products such as mobile phones, laptops, tablet, camera, etc. heavily penetrated everyday life, so for many people they have become virtually indispensable.

Use of wired chargers, although widely used and available today becomes thick, unsightly (wires across your office or home, a possible danger of accidents, etc.).

Modern solutions, which are expected in the not too distant future, to supply such low power consumers is the use of wireless transfer of electricity

In figure 15 [12,13] are some aspects which appear to be detached from a science fiction movie, on the use of wireless transmission of electricity to power the equipment of an apartment or office

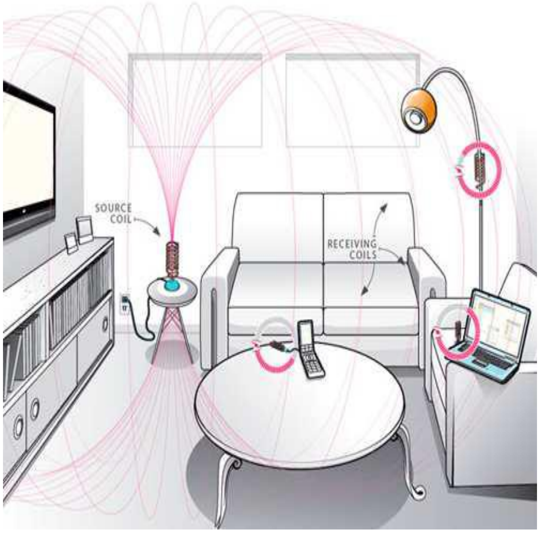

Fig.15 Supply of electronic devices equipped with rechargeable batteries

Modern solutions, which are expected in the not too distant future, to supply such low power consumers is the use of inductive transfer (wireless transfer) of electricity.

6 Conclusion

Discovery and presentation of simple, clear, persuasive experiments and understandable to anyone of the law of electromagnetic induction by Michael Faraday was a moment of crossroad in the evolution of the electromagnetic field theory. Making electrical transformers and motors and generators, whose operation is based on the phenomenon of electromagnetic induction started a major industrial branch, Electrotechnical Engineering Industry.

Nikola Tesla, a brilliant and visionary engineer, took the principle of electromagnetic induction not only to improve design and functionality of electric motors or generators but also to achieve a larger project that foresees the possible transmission of electricity over long distances wirelessly. From financial reasons his experiments in the wireless transmission of electricity could not be completed.

Today, over a century after this attempt of Tesla, the idea acquires new meanings and more and more engineers and researchers lean forward towards realizing it.

Modern technologies allow for electrical equipment to perform wireless voltage supply of portable devices such as mobile phones, tablets, laptops or electric road vehicles.

This paper presents several such proposals.

Future achievements in the field of wireless transmission of electricity will materialize Tesla's unfulfilled dream.

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