

## THE SCIENTIFIC RHETORIC OF NIKOLA TESLA

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### ABSTRACT

The world's topmost scientists and engineers admire the elegant solutions of Tesla's patents. However, his theoretical expositions possessed the same amount of rhetorical elegance as well. *The Man who Invented the 20th Century*, as evidenced from his theories and discoveries, was ahead of his time most of the time. His successful speeches and lectures on discoveries were rather inspirational. In his research notes and articles in the popular scientific magazines he effectively used deductive reasoning, causal relations, carefully selected analogies, metaphors. In the late 19th century he discovered an „unusual, pencil-thin stream of light“ which he metaphorically described as „the death ray.“ The particularly successful analogy is between the Arc of the Covenant and the condenser which he calls the „uncanny agent“ on which he experiments by using regular tin cans. Needless to say, his ideas of wireless transmission, teledirected weapons, „fire balls“ and „death rays“ are no longer considered odd and have come to be subsequently implemented. He rightfully disliked being called a visionary, but time has proved that he was a brilliant scientist and sourcerer. Tesla's clear, elegant and metaphorical style undoubtedly enriched the rhetoric of science.

Key words: Nikola Tesla, scientific rhetoric, reasoning, analogy, probability, metaphor

## 1. INTRODUCTION

Almost all records of Tesla's scientific research date back to 1884 when he arrived in the USA at the age of 28. He was a scientist, an engineer, an inventor, and he perceived himself as a “sourcerer”<sup>1</sup> since he made a distinction between a sourcerer and an inventor, the latter being less scientific because the inventors only used the scientific discoveries of the real sourcerers. This distinction resulted in an experiential animosity towards Edison. Various sources mention his pride of Serbian parentage and Croatian homeland. In 1891 he became a citizen of the United States.

Numerous examples of *antonomasia* are related to him: The man who invented the twentieth century, The father of the 21st century and the new technological era, Prodigal Genius, Electrical Genius, Titan among the scientists, The Engineer who Tamed the Niagara Falls<sup>2</sup>, Prophet<sup>3</sup>: „Nicola Tesla's acceptance speech on receiving the Edison Medal“, (<http://www.tfcbooks.com/tesla/1917-05-08.htm> ) (7. April 2014), The Master of Lightning, God of Lightning (Lomas, 2006: 111), The Father of The Wireless. He was especially proud about the last *antonomasia*. According to his notes, he was called *The Father of Wireless Transmission* after the lecture titled “About electrical resonance” that he delivered at Frankline Institute, Philadelphia, (February 24, 1893) in The National Electric Light Association (March 1, 1893). Tesla referred to this *antonomasia* in an article “The True Wireless” in a magazine – *Electrical Experimenter*<sup>4</sup>, May 1919 (according to: Tesla, 1995: 167). *Antonomasia The Poet among the Inventors* – is very significant. Not only did he write poetry, but he perceived scientific work as art as well;

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<sup>1</sup> From the term “source”, in the meaning of: a person who originates something, author's note.

<sup>2</sup> The newspapers called him that after the fire in the laboratory in 1895.

<sup>3</sup> Charles A. Terry called him Prophet on occasion of receiving The Edison Medal on May 18, 1917.

<sup>4</sup> Further in the paper as EE.

as a desire to complete the initial idea and as a pathway towards the truth and the perfection.

### 1.1 Tesla's publications

The published works of Nikola Tesla can be divided into five categories:

- (1) Reported inventions and patents
- (2) Public lectures held at professional associations meetings and speeches given on important occasions<sup>5</sup>.
- (3) Scientific notes with diary entries whose purpose was to document research (e.g. *Strasbourg Diary* (2002 edition); *Colorado Springs Notes*, 1899-1900; published posthumously in English (1978)<sup>6</sup>.
- (4) Scientific and popular papers meant for scientific and professional audience (e. g. *Electrical Review*; review *The Electrical Experimenter* (1919); *Manufacturer's Record*, *Dialectics*)
- (5) Newspaper articles addressing at a wider audience (1901, 1916 *Collier's Weekly*, 1919 *New York Herald*, *Century magazine 1900*: the article: NT: *The Problem of Increasing Human Energy* – in some of those articles he described his theory and the use of wireless transmission, as well as some photographs of the Colorado apparatus were also published.

The only scientific writings which were not written for the public are his working notes e.g. *Strasbourg Research Diary* and *Colorado Springs Notes*. The latter were written to record the research in Colorado Springs. Being published after Tesla's death they became

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<sup>5</sup> e.g. noted lecture held on May 16, 1888 in IEEE. The lecture was about the new system of alternating current. In 1895 he gave a speech in Buffalo on the occasion of commissioning the hydro powerplant on the Niagara Falls.

<sup>6</sup> The manuscript was translated to Serbian and published two years earlier in 1976 and the revised edition came out in 1999.

part of the scientific discourse interesting for electrical engineers and scientists interested in the field of electricity. Those writings represent a historical document about Tesla's research from 1899 to 1900. Tesla's notes and experiments from Colorado Springs are used by scientists today to research high-frequency radiation.

## 2. TESLA IN THE CONTEXT OF RHETORIC of SCIENCE

Contemporary rhetoric of science is aware that scientific knowledge is a social phenomenon. Therefore it is the result of persuasion, although it can be said that the findings themselves are not the result of rhetoric. However, even when describing their findings scientists mention the research background by listing previous results and citing authorities and doing so they build the ethos (credibility) of the scientists themselves. They also follow a certain outline regardless of the position they choose for the discussion.

Three persuasive appeals are usually present in scientific texts: logos, ethos, pathos (see Gross, 1990). In Tesla's papers, logos is the most prominent in the registered patents, both logos and ethos are evident in lectures given to experts (e.g. "The new system of alternating current motors and transformers", 1888, "Experiments with alternating currents of very high frequency and their application to methods of artificial illumination" 1891 (<http://www.tfcbooks.com/tesla/1891-05-20.htm>), etc. The appeal to pathos is present in some autobiographical descriptions of his first inventions, childhood and events occurring after the death of his mother (Tesla, 1919: *My Inventions*, "One strange event"); in popular scientific papers (Tesla, 1900: „The Problem of Increasing Human Energy“, *Century Illustrated Magazine* ), in articles intended for a wider audience considering the future (Articles published in *Collier's Weekly*, *New York Herald*) and in

speeches on special occasions (the speech "On electricity" held in December, 1897 in The Ellicott Club in Buffalo; the speech on the occasion of receiving The Edison Medal (May 18, 1917) at the American Institute of Electrical Engineers - AEII).

Tesla does not limit himself on similes and metaphors but uses logical reasoning to corroborate his theory. He uses different types of logical reasoning, however the most frequent is usage of metaphor and analogy because, like all scientist, he sees it as the best means to explain his theory to audience, so they can understand it and accept it.

### 2.1 Reasoning and particular audience

Tesla used experiments to verify his hypotheses and develop new scientific insights and discoveries. When explaining his ideas to a particular audience of educated experts, professionals, critics and readers he replied to their arguments. Tesla described his scientific approach that leads to the solving of the problem in the rebuttal. He put more emphasis on claims previously verified experimentally than on hypothetical theories. He also highlighted the importance of evidence, saying that the theory is valid only if it is based on experiments from which the scientist formed a theoretical claim.

In the lectures for the professional audience, he is focused on explaining the facts, he uses illustrations and specific instances regularly, performs mathematical operations using formulas - mathematical induction, and in the discussion he invites all the present authorities who have examined the efficacy of his inventions to describe what they did. This can be interpreted as a form of testimony (e.g. a lecture was held at the American Institute of Electrical Engineers , New York , May 16 , 1888 , by: Tesla 1995 : 23-40 ).

In explaining the theory he reinforced the theoretical assumptions and claims with strong forms of reasoning (deduction, mathematical induction, causal reasoning and

analogy). Tesla believed that experiments are very important; saying that he will find results faster through patent trying than solely by deduction or calculations (Tesla, 1900, according to: (<http://www.tfcbooks.com/tesla/1900-06-00.htm>), which is a rhetorical approach to scientific work. Although the trigger for finding a solution to the problem of a particular invention could be in the field of poetry (Goethe) or the descriptions of the Ark of the Covenant in Exodus and Apocalypse from the Bible, one should know that Tesla previously experimented with mental images in his head. If he found a solution he would build an experimental apparatus and his experiments were always conducted in front of the witnesses. Therefore, there is no contradiction when he said that the discoveries came like lightning, because they were preceded by gradual deduction. As he said, the discovery of the rotating magnetic field was for him a simple math, calculation, logical, gradual deduction (in a speech given on May 18, 1917 in the American Institute of Electrical Engineers (American Institute of Electrical Engineers - AIEE, NY , by: Tesla, 1995: 304-305). In the latter speech he said: “I realized I would not have produced anything without the scientific training.” (<http://www.tfcbooks.com/tesla/1917-05-08.htm>) (4. April 2014).

In the articles intended for a specific, particular audience, he used reasoning by analogy to persuade the audience of his scientific findings and theoretical conceptions. Today, the attitude that science addresses the universal audience is abandoned; scientific rhetoric is aimed at a particular audience. Undeniably, those scientific theories and inventions that are confirmed through time remain more important. Kitcher (1995: 47-66) states that there is no essential opposition between rhetorical and cognitive approach, indeed, rhetorical strategies act in science. Toulmin (1995: 3-11) noted that the rhetorical and rational aspects of science are intertwined, rhetoric persuades by reason. Therefore, the scholarly anti-rhetorical hypocrisy should be abandoned because scientific papers are

not written in a concise style with the main aim of summarizing the scientific thought and avoiding the rhetorical schemes and tropes.

## 2.2 The importance of analogy and metaphor in Tesla's work

Great scientists have used metaphors in scientific terminology and analogies for explaining and clarifying research or theoretical perspectives (e.g. Galileo's discourse, Darwin uses the famous analogies, for example, between "natural" and "artificial selection" (Kitcher, 1995: 63). Tesla also uses other rhetorical means - tropes like metaphors in appeals to the future and for the wider application of his findings. In this way he confirms the heuristic function of both metaphor and analogy. Explanations of the tropes (metaphor) were clear or they have subsequently become clearer. It is true that Tesla metaphorically called his *cosmic rays* the "death rays" in front of reporters<sup>7</sup>. These are known today as the Tesla particles (Paar, 2006: 80) and the scientists refer to them as Tesla's discovery of the laser light beam (Paar, 2006: 82). Tesla discovered X-rays before Röntgen and called them *streams* (Tesla, 1896 in Electrical review - 12 August 1896). He illustrates his system of wireless transmission of electrical signals with the a) theory, b) the pump analogy and c) the use of the system (Tesla, 1919, according to the translation from 2007: 22). Particularly successful is a heuristic metaphor of the discovery of the Earth as a natural conductor (Tesla, 1919, according to 1987: 66).

Furthermore, he uses names such as fireballs, the teledirected weapons – the 'Great Wall' defense, the terrestrial stationary waves are compared with a tuning fork (Tesla, 1919, according to 1987: 67). Tesla forms an analogy Ark of the Covenant - the condenser and generator (Tesla transformer) (Tesla, 1915), he explains the wireless

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<sup>7</sup> Orson Welles used Tesla's metaphor "the death rays" in his famous adapted radio play "War of the Worlds and The Invasion from Mars", based on the book *The War of the Worlds* written by H. G. Wells. The radio play was broadcast in October 1938.

transmission with the hydraulic analogy, etc. Imaginative persuasion is achieved when magnetic resonance is explained by the snowball; snowball and snow avalanche are compared by analogy with the relationship between the amplifier and transmitter (Magnifying Transmitter): *phor* is initially a small snowball and a tiny spark (Tesla, 1919, according to 1987: 59); The ‘Tesla transformer’ is compared to gunpowder in warfare, amplifier and transmitter (The ‘Magnifying Transmitter’) are compared with a telescope in astronomy (Tesla, 1919, according to 1987:66), the rotational magnetic field is called Tesla's Egg of Columbus etc. Tesla used analogies to verify his inventions.

In the article entitled "Famous Scientific Illusions" (*The Electrical Experimenter*, February 1919, Tesla, 2007: 24; 2006: 452) Tesla said that in the summer 1897, the famous philosopher from London, Lord Kelvin visited him in his lab in New York, and he assured him of the theory of wireless transmission. Initially, Kelvin considered it impossible and condemned the Tesla’s project calling it "an illusion and a snare." (<http://www.tfcbooks.com/tesla/1919-02-00> (4. April 2014)). Tesla was disappointed, and he wanted to reassure Kelvin during his visit the next day. After Kelvin realized that Tesla did not use the Hertz waves, Tesla persuaded him of the transmission process that can be achieved at the maximum distance without noticeable loss. Tesla used mechanical analogy in persuasion to explain both his and Hertz’s wave system. The analogy included Earth as a ball and the hand pump. He said that he changed the opinion of a skeptic and made him (Lord Kelvin) the warmest of supporters.

“He parted from me not only thoroughly convinced of the scientific soundness of the idea but strongly expressed his confidence in its success.<sup>8</sup>” (Tesla, 1919 according to Tesla in 2007: 24, 2006: 52; <http://www.tfcbooks.com/tesla/1919-02-00> (4. April 2014)).

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<sup>8</sup> author's note – the author corrected typing mistakes



It is also possible to use humor to present new scientific ideas and findings, because the effects of humor are to establish solidarity between speaker and audience and to enable the speaker to present serious claims without having to defend them (Pinch 1995: 153-176). Tesla really knew how to utilize humor for rising funding for further research, to name just the analogy of Tesla's Egg of Columbus.

### 2.3 Tesla's persuasion and questioning the truthfulness of the claims

For rhetoric of science questioning the truthfulness of the claims is essentially a rhetorical process (Gross, 1990). As noted in Husserl (1954), science is the subject of human interaction, and the rhetoric of science links science to human needs.

Scientists in the field of theory of electricity acknowledged Tesla's greatness and the most prominent scholars took into consideration his opinion due to his *habitus* regardless of the disagreement. As Tesla said, there are three important parameters in the theory of electricity: oscillation, frequency and resonance (vibration). Tesla provided the rhetoric of science with numerous examples of how to use persuasion for familiarizing the audience with scientific findings and theory. As a scientist, Tesla always addresses certain audience hoping they will accept his ideas and findings. He wanted to persuade the audience and all the Doubting Thomases among them that his theory and experiments are valid and to convince future donators and financiers to invest into his research. If he does not demonstrate the purpose of the complex scientific laws of electricity, further research and possible application of his findings will not occur. He used persuasive means rhetorically in his lectures for the professional audience to demonstrate the benefits of high-frequency alternating current:

“(…) if you will be convinced of the truth of the arguments I shall advance—your aim will be to produce high frequencies and high potentials; in other words, powerful electrostatic effects.”<sup>9</sup>

(<http://www.tfcbooks.com/tesla/1891-05-20.htm>) (7. April 2014).

Tesla was an idealist and it was more important for him to conduct experiments and question the ideas that intuitively developed like images in his mind, than to use his patents commercially, which backfired on him on numerous occasions. However, this does not mean that he was unaware of the industrial potential of his inventions, but he was willing to release some businessmen from contractual obligations to succeed in the application of his findings. With his many lectures he persuaded the important scientific audience, and those who benefited immediately from some of his inventions, such as alternating current, did not always think positively about the possibility to earn less because of his inventive spirit (e.g. Morgan, Westinghouse). Others have tried to prevent the development of his new ideas because they were afraid that their own systems would no longer be used. For example, in “The battle of the currents” - AC/DC Edison used all available means to prevent commercial use of Tesla's alternating current (AC).

This kind of environment, a scientist and sourcerer cannot be closed only in his laboratory. Tesla tried to present his findings to professional audience as much as he could. He had to express his scientific ideas rhetorically, not only to scientists, but also to those who were expected to finance and support his research - financiers (Wall Street, Westinghouse and business tycoons like J. Pierpont Morgan).

He is a scientist in a rhetorical act when he has to show that some other research was dependent on dominant theories (e.g. Tesla on those who formed their hypotheses in

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<sup>9</sup> From Tesla's lecture, delivered on May 20, 1891, AIEE, Columbia College, New York.

accordance with the dominant Maxwell's theory), or when he has to respond to allegations about his project.

It was on a single occasion that he was not able to give a clear answer and that was to explain why the project of high frequency transmitter (Magnifying Transmitter) was abandoned on Long Island, famous as Wardencllyffe Tower.

“My project was retarded by laws of nature. The world was not prepared for it. It was too far ahead of time. But the same laws will prevail in the end and make it a triumphal success.”<sup>10</sup> (According to 1987: 69; <http://www.tfcbooks.com/tesla/1919-00-00.htm>) (4. April 2014).

Indeed, Tesla had the tower dismantled (the “death rays” machine) after the great Tungusic explosion in the Russian tundra in 1908. He concluded that experiments with wireless energy direction (Tesla particles) are too dangerous for further research.

Tesla believed that the invention of the Magnifying Transmitter will be the most important and the most valuable invention for future generations because it will enable numerous other achievements. He appealed to scientists not to free the energy of atoms, because he believed that this discovery could be catastrophic for the mankind instead of being a blessing (Tesla 1919, according to 1987:72-73).

His articles aimed at a wider public in reviews such as *Century* are rhetorically interesting, because he explains his inventions which are already applied in industry and therefore aimed at the future. His explanation followed the classical rhetorical scheme with claims grounded on facts which are based on preliminary findings. These are further strengthened with reasoning and the conclusion supports the claim (e.g. the topic of cheaper iron manufacturing).

### 2.3.1 The strength of certainty – degrees of probability

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<sup>10</sup> According to Tesla's paper published in June 1919 in *Electrical Experimenter*.

It should be emphasized that as a scientist Tesla used varying degrees of probability in persuasion and that is the area of rhetoric. He mentions the highest degree of probability in the cases of reported inventions and patents which were applied in industry, although they were considered strange in the beginning, e.g. the use of soft Bessmer steel instead of cast iron gives better effect in induction motors (Tesla in 1900, according to Članci 2006: 120-121). Besides, he expressed the highest degree of probability in lectures he held for experts, scientists, engineers as well as businessmen and financiers, who had to be persuaded of advantages of some inventions such as alternating current (AC) compared to direct current (DC) which was used in the distribution (e.g. lecture in AIEE, New York, May 16, 1888, according to Tesla 1995:23-40). Rhetorically, the lectures were extremely successful, because, as we know, soon after the lectures the alternating current (AC) was accepted for distribution. Degrees of probability, from certainty to lower degrees such as possibility can be illustrated in papers that discuss future development of science and the use of energy (quote 1) and the possibilities of establishing wireless interplanetary communication (quotes 2 and 3):

1 “ It is possible, and even probable, that there will be, in time, other resources of energy opened up, of which we have no knowledge now. (...) magnetism or gravity for driving machinery without using any other means. Such realizations, though highly improbable, are not impossible.” (Tesla 1900, according to 2006 Članci: 128; acc. [http:// www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

2 “(...) its effect (op. a. he is referring to electrical movement of great magnitude) will be perceptible on some of our nearer planets, as Venus and Mars. Thus from mere possibility interplanetary communication has entered the stage of probability.” (Tesla 1900, acc. 2006 Članci: 143; acc. [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

3 “That we can send a message to a planet is certain, that we can get an answer is probable: man is not the only being in the Infinite gifted with a mind.” (Tesla 1900, according to 2006 *Članci - Articles*: 143; [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

### 2.3.2 Persuasion in the article “The Moon's Rotation”

Tesla's scientific rhetoric, types of reasoning and persuasive strategies he used can be illustrated with the general physical laws of satellite motion in the article “The Moon's Rotation” (April, 1919, according to: 2007: 41-42). The paper is primarily aimed at young professionals, engineers, as well as other professional audience. In this article Tesla responds to the counter-arguments expressed after his article “Famous Scientific Illusions” was published (Tesla, February, 1919: according to: 2007: 20-25): saying that the Moon rotates only around the Earth and not on its axis i.e. as any satellite and he says: “It revolves, to be sure, but none of the evidence is a proof that it turns on its axis. (...) The view I have advanced is NOT BASED ON A THEORY but on facts *demonstrable by experiment*. It is not a matter of definition as some would have it. A MASS REVOLVING ON ITS AXIS MUST BE POSSESSED OF MOMENTUM. If it has none, there is no axial rotation, all appearances to the contrary notwithstanding.” (Tesla, April 1919: according to: EE, 2007: 42); (<http://www.teslauniverse.com/pdf/articles/19190400-01.pdf>) (7. April 2014).

He gives further explanation with examples and cases with a ball and only after experimental cases and ball analogy and following formulas does he provide rebuttals and their refutations leading to a conclusion that supports the claim – the Moon does not rotate around axis:

“But from the character of motion of the satellite it may be concluded with certitude *that it is devoid of momentum about its axis*.” (Tesla, February, 1919: acc.: 2007: 42 Tesla, February, 1919: according to: EE, 2007: 42; <http://www.teslauniverse.com/pdf/articles/19190400-01.pdf>) (7. April 2014).

## 2.4 Patents

Due to formal instructions for the description of patents there is a difference in style from the scientific articles published in magazines. Tesla reported 250 patents to the US patent bureau (212 were officially accepted: Beckhard, 2006). Over a hundred of his patents were already used during his life and 110 are widely applied today. The registration of an invention and of a patent are not equal. A patent has a broader meaning, including the improvements of reported patents as well. Tesla's patents belong to the field of electrical engineering (patents in the field of electric power). Patents are a specific form of scientific discourse, simple in style, short in form. The inventor describes the outcome of invention and refers to illustrations that are usually associated with the patent, with the exact number, the signature of the inventor, witnesses (usually two) and a lawyer. In the beginning, as in any contract, there is scientists' personal information and details on authorship rights.

At the beginning of every patent the scientist addresses the public in the first person stating his finding and announcing description, for example:

“Be it known that I, NIKOLA TESLA, of Smiljan Lika, border country of Austria-Hungary, have invented an Improvement in Dynamo-Electric Machines, of which the following is a specification.” (Tesla 1886, acc.: <http://www.teslauniverse.com/pdf/articles/19190400-01.pdf>) (7. April, 2014).

Later, when he became an American citizen, it was stated in his patents and patent supplements, for example: “To all whom it may concern: Be it known that I, NIKOLA TESLA, a citizen of the United States, residing in the borough of Manhattan, in the city, county, and State of New York, have invented (...)” (Tesla, U.S. Patent Office, “Method of Insulating Electric Conductors”, Specification forming of Reissued Letters Patent No. 11,865 dated October 23, 1900)

Tesla's style in patents is adequately simple, the names do not have metaphorical coloring as in articles and are rather simple, such as "Apparatus for transmission of electrical energy" (US-Patent No. 645.576, New York of 20. 3. 1900). He uses scientifically justified metaphors such as "natural medium" when he refers to the natural conductor - the Earth, its resonance and transmission of electric energy through the natural medium (US-Patent No. 787.412, New York 18. 4. 1905).

On the other hand, when he discusses his inventions and patents in papers published in different magazines and journals, his style is not only simple and scientific but he introduces various arguments; evidence and reasoning but also figures of speech that further explain his inventions e.g. description of the condenser and transformer – generator.

2.5 Scientific and popular work written for the scientific and professional public and for the wider audience

Hoping he would persuade Tesla to write for *Electrical Experimenter* the editor Hugo Gernsback appealed to Tesla's ethos, giving him compliments by comparing him to Moses and knowing that Moses has great significance for Tesla. In any case, some articles published during 1919 in *Electrical Experimenter* are a classic example of Tesla's writing about some of his findings and theories aimed at professionals and young engineers. Those articles with autobiographical elements are interesting in a special way because in them he describes how he developed an idea for some inventions (induction motor, a rotational magnetic field), famous under the title *My Inventions*.

In some of the articles published in magazines Tesla explained his theory and argued for the advantages of wireless transfer, invention which could make manufacture

of steel cheaper and he presented some of his observations. He published bigger article titled – „The problem of increasing human energy“ in *The Century Illustration Mon. Magazine*, (June 1900. A-109; Tesla 1900, according: 2006 *Articles*: 91-146), where he described some experiments in Colorado Springs and also published images of Colorado apparatus during the experiments and which in that time looked spectacular for most of his contemporaries and scientists compared to a well- known apparatus at that time. Based on that the claim that notes from Colorado were never intended for public is partially incorrect regardless of the fact that he wrote in *Century* because his friend and publisher of a magazine Robert Johnson persuaded him to do so.

His article is significant for Tesla`s scientific rhetoric and not just for weird idealistic ideas which were sometime ascribed to him because of his extremely positive orientation toward the future. Tesla used that article after some of his inventions were implemented and popular journals made him recognizable by a wider audience. He was well aware of the public, which is corroborated by the expression he uses when addressing the readers, like “imagine” after which he give examples, illustrations and analogies which provide an easier explanation of his ideas about, for instance, the automatic apparatus – “automation”, „let us think for a second“. He frequently uses questions for the purpose of gaining his audience`s attention and a more profound understanding of a problem. For example: “The question was, could such a condition be attained? Could we produce artificially such a “sink” for energy of the ambient medium to flow in?” (Tesla 1900, acc.: [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm) (4. April 2014)).

“But can we produce cold in a given portion of the space and cause the heat to flow in continually?” (Tesla 1900, acc.: [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm) (4. April 2014)).



In the article „The problem of increasing human energy“, Tesla argues by the classical rhetorical pattern corroborating his claims with facts from preliminary experiments and logical reasoning. He emphasizes the great importance of empirical experiments for the results, saying that results will be arrived at through patent trying than through deduction or calculation. (Tesla 1900, “patent trying”: acc. [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

The usefulness of cold electrolytic procedure is further on argued for by the advantages of the industrial benefits of using aluminum over copper and by anticipating that this metal is going to be widely used in the next century because of his economical features, and which was a justified assumption. (Tesla 1900, according: 2006 „, Articles “: 117-121).

His arguing about for the advantages of using his inventions of the electrical transformer and using electric current of High Frequency with which its high magnetic power can be achieved without iron and in that way resulting in cheaper manufacturing, is very clear and elegant. (ibid., 122-123). It has to be stressed that Tesla could be self-critical and admitted some false estimation for instance about the dynamo machine which would be driven by a gas-engine. He admits that some problems are more chemical and less physical (ibid., 126), for instance he is aware that windmills, solar engine and engines driven by solar energy have an unlimited source of energy power (ibid., 129). However, limits in energy usage were inspiration for further heuristic approach in solving problems and not giving up the search for solutions. Descriptions like that are useful in scientific rhetoric, because they show ways how to reach invention to wider audience which is not necessarily universal. In fact, time is a factor which will show the endurance of some assumptions. Tesla`s interpretations of humans as automatic beings who react to

environment stimuli was declared weird, but they were the sources for inventions like wireless navigation and latter on some of the ideas were realized like cars on electrical power in the 21st century. Those Tesla`s articles are interesting because some of them are the first descriptions of his early inventions like the principles of the mechanical oscillator, which he introduced at the presentation during the summer of 1893 at the World Exhibit in Chicago. During his early intensive research period he did not have time to write papers for the wider audience about his inventions.

Tesla frequently asked for the conformation his own credibility by authorities and showed admiration for scientists who made inventions which made possible further development of science and civilization. He was not reluctant to say that experiments by Professor Dewar with liquefied gases which he saw in London helped him to find solution for the engine which Tesla had named “mechanical oscillator” (ibid., 133). With that attitude he confirmed his ethos which is indisputable in the scientific sense today. In some other articles the issues he presented were more philosophically even metaphysically orientated in the field of conjectural and plausible (e. g. Forsen, 2006: 23).

Some of those articles published in *Collier's Weekly*, *New York Herald* were considered to be „controversial“ and in medial covered with eristic and *ad personam* attacks which Tesla refuted with scientific arguments, professionally and not by attacking anyone.

### 3. IMPORTANCE OF ANALOGY IN TESLA`S WORK

#### 3.1 The True Wireless

Tesla was very well aware of the importance of analogy whenever it was needed to explain something new. Of course, the purpose was for it to be understood as something relevant for the development of science. In his paper „The True Wireless“, (EE, May – 1919: 49) writing about wireless transmission he was aware that his audience might be confused by the fact of a possible irreversible electric supply through one wire because it was something completely new. Therefore by using adequate analogies it could be better explained and he used pictures. Electrical transfer through one wire and the hydraulic analogy were meant to prove that it is possible to build an economical system of energy transfer through a single wire. In that way analogy is used to corroborate the claim.

Tesla`s world-known system of wireless transfer of electric signals gets illustrated by theory, analogy and realization. He emphasizes that analogy between his own and Hertz`s system of radiation is what persuaded lord Kelvin and by publishing analogy and illustration of the wireless system he persuades experts – readers of the journal *The Electrical Experimenter* in his article „Famous Scientific Illusions“ (February, 1919; according to 2007: 21, 24-25).

First, he argues that Electromagnetic Hertz waves radiated horizontally from a vertical conductor and are slightly affected by conducting the Earth surface so the energy is unrecoverable. On the other hand, in his system there is a real radiation – *true conduction* which theoretically can be accomplished from the highest distance without any appreciable loss (Tesla 1919; acc. <http://www.tfcbooks.com/tesla/1919-00-00.htm>, 4. April, 2014.). Then, he proves his theory by using the analogy of Earth Wave Vibration Theory of Earth as a flexible spherical envelope filled with water which is periodically injected and ejected with a hand pump. If the hand pump moves in intervals bigger than

an hour and 48 minutes, which is enough for the impulse transfer through the whole mass, the ball is going to spread and shrink and specific movements are going to be transferred to the Pressure Indicator Gages (manometers) or hand pumps with the same intensity, regardless of the distance. If a hand pump works faster, "(...) shorter waves will be produced which, on reaching the opposite end of the bag, may be reflected and give rise to stationary nodes and loops, but in any case, the fluid being incompressible, its inclosure perfectly elastic, and the frequency of oscillations not very high, the energy will be economically transmitted and very little power will be consumed as long as no work is done in the receivers."<sup>11</sup> (Tesla EE -1919, acc. "Famous Scientific Illusions": <http://www.tfcbooks.com/tesla/1919-02-00.htm>) (4. April 2014). Therefore each pulse has the same power in all parts of sphere. That is the short demonstration of Tesla`s system of radio wireless transfer (wireless theory). Further on, he illustrates realization of oscillating energy which penetrates through Earth to each point on Earth so electrical energy, light and force can be produced at every part of the Earth from the universal central station (used for boat navigation, airplanes...) (Tesla 1919; according 2007: 21, 24-25).

### 3.2 The Ark of the Covenant analogy between condenser and his generator (Tesla`s transformer)

"The Wonder world to be created by electricity" which was published in *Manufacturer's Record* (September 9th 1915) starts by an imitation of the fairytale structure saying that the history of electricity development is more "wonderful than any tale from Arabian Nights" (<http://www.tfcbooks.com/tesla/1915-09-09.htm>) (4. April 2014) calling upon the magic properties and precious substance of electron by amber of Thales, Theophrastus and Plintus (Pliny) and the myth about amber which appeared from the

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<sup>11</sup> author's note – the author corrected typing mistakes

tears of the Heliades, sisters of Phaeton. Research of light is poetically compared with the mythological Phaeton (gr. *phos photos*, photon – light) and Phoebus carriages, Roman vestal fires with static electricity, power of water with rainy clouds and crystal is perceived as a human being. The Ark of the Covenant is compared with the condenser and generator (Tesla`s transformer). It is known that Tesla had a nervous breakdown just after his mother died, which was probably related to great exhaustion and series of lectures around Europe. Since his mother always encouraged him to read the Bible, during the period of two months he does that and in the paper entitled “My Inventions” (1919, according to 1987) he writes about non-material force as guidance which does not conform to the religious dogmas about “cosmic pain”.

“I experienced a singular and undefinable pain which, for want of a better term, I qualified as ‘cosmic’ (...)” (Tesla, 1987: 83).

“The gift of mental power comes from God, Divine Being, and if we concentrate our minds on that truth, we become (*sic*) in tune with this great power. My Mother had taught me to seek all truth in the Bible.” (*My Inventions*, acc.: [http://www.teslauniverse.com/nikola-tesla-quotes-start\\_30](http://www.teslauniverse.com/nikola-tesla-quotes-start_30)) (1. October, 2014).

Those kinds of claims were not taken with benevolence by many people. Even Lomas, who is an expert on Tesla, cannot resist saying that Tesla was fascinated by the natural forces but he never explained what exactly he found in the Book of Apocalypses, although Lomas believes that this had led him to taming the Niagara Falls (2006: 91). It is not completely true that Tesla did not explain what he found in the Book of Apocalypses where images of Exodus are repeated and to which he refers when talking about his inventions. In his paper “The Wonder World to be Created by Electricity” published in *Manufacturer's Record* (September 9<sup>th</sup> 1915) Tesla sees Moses as a practical and skillful electrician, which was ahead of his time. Comparison and analogy between

the Ark of the Covenant and condenser is remarkable. The condenser is called an “uncanny agent” and is empirically tested with regular metal tin cans. In that paper Tesla was fascinated by the Biblical insight into Moses’s skills. Differentiating historical facts from myth is impossible without interpretation. Here we will focus only on Tesla’s interpretation of the description of Arc from Exodus and in the end description of God’s throne. In the context of Arc he saw images of the condenser and the generator with its solution, which are manufactured even today. Tesla writes about the assumption that Aaron’s sons were killed by a high tension discharge and that engineers of that time needed to know about the transmission belt. Such a phenomenon is explained by static electricity and Tesla writes that under the right atmospheric conditions the belt can transfer into a dynamo – generator. Further on, Tesla describes how he turned light in that way, started engines and experimented with electricity from belts which were than stored in tin cans constructed as condensers (Tesla 1915, according to 1973, 1987).

“The Bible describes precisely and minutely the arrangements constituting a machine in which electricity was generated by friction of air against silk curtains and stored in a box constructed like a condenser. It is very plausible to assume that the sons of Aaron were killed by a high tension discharge and that vestal fires of the Romans were electrical. The belt drive must have been known to engineers of that epoch and it is difficult to see how the abundant evolution of static electricity could have escaped their notice. Under favorable atmospheric conditions a belt may be transformed into a dynamic generator capable of producing many striking actions.” (Tesla 1915, according to 1973: 6; acc. <http://www.tfcbooks.com/tesla/1915-09-09>) (4. April 2014).

In fact, it is surprising that it took 2000 years from the Bible description for Gilbert to publish the first scientific paper on electricity and magnetism assuming that

science has long been the privilege of a few, so all information was jealously guarded (Tesla, acc. 1973: 6; acc. 2014a:1). In the context of great scientific discoveries (Franklin, Galvani, Volta, Oersted) Tesla mentions the condenser as a “magic fluid” and “uncanny agent”, which was kept in a phial by Kleist and Leyden in 1745 and which might be “(...) the most marvelous electrical device ever invented (...)” (Tesla 1915, acc.: 1973: 6; acc. <http://www.tfcbooks.com/tesla/1915-09-09.htm>) (4. April 2014). He continues the sequence to Faraday which in 1831 as a peak of all inventions produced electricity from a magnet.

In Apocalypse, Divine presence is described on the hills through the signs of thunder and lightning and thick cloud (signs also present in *Exodus* and *Apocalypse*). It is also interesting how God`s throne was described and thunder, arc and see of glass are present with Moses, golden belts of angles. We can guess how much the description of city light at the end of Apocalypse influenced Tesla. We know that he tore apart the contract with Westinghouse just to make his dream about alternating current come true and to give his present to the mankind. He talks about it himself and as an idealist he wanted his inventions to be free and available to all people.

It was common for Tesla to visualize inventions in his head and to use reasoning. That was objected to by many engineers, because for them everything needed to be graphically illustrated. So, illustrations were necessary in submitting the patents, during lectures, in papers...because they were part of an argument, regardless of the fact that everything was clear to Tesla through multidimensional mental images.

### 3.3 Tesla's Egg of Columbus

In *Electrical Experimenter* (1919) Tesla describes how he got the idea of presentation of his polyphase system. During the „battle of currents“it was required to show that alternating current is not dangerous and World exhibition in Chicago in 1893 was

dedicated to Columbus and the 400th anniversary of his “discovery” of America. It was called the Columbian Exposition. It was an ideal opportunity to demonstrate the idea. Tesla got the same attention as the idea and got his own space to demonstrate different inventions. He explained the theory of rotational magnetic field and how it affects the spinning of the metal egg around its axis. It happened at the same time as the victory of the multiple phase system (Tesla Polyphase System) in the production and distribution of electrical energy. He got the attention and acknowledgement of all scientists, engineers and business people for his theory, which was demonstrated with the analogy and realization. In the magazine *Electrical Experimenter* from March 1919 editor (Hugo Gernsback) in his editorial titled “Tesla’s Egg of Columbus” writes an anecdote on how Tesla performed the Columbus trick – without cracking the egg and illustrated the polyphased coil and rotating magnetic field which are moved by the eggs of copper.

Based on the discoveries of rotating magnetic field in 1883, during the next 10 years Tesla submitted around 40 patents. After the series of discouraging business meetings, Tesla got the idea on how to attract more financial means for research and the implementation of alternating current, just before the Columbian Exhibition. It is a well-known story (or a myth) that Columbus got the means for his exploring journeys by asking his opponents to put an egg on its top, which naturally they failed. Columbus by lightly cracking the egg managed to do it. Supposedly after that he got an audience with Spanish queen Isabella which gave him financial support (with her jewelry) to equip three ships for expedition. Inspired by that story Tesla wanted to persuade business people, lawyers and bankers from Wall Street of the usability of his inventions by asking them if they are familiar with the story of Egg of Columbus. When they said yes, he



asked what would happen if he managed to put an egg on top without cracking it. They admitted that by doing that he would surpass Columbus. After that he asked if they would support his project. One lawyer among them humorously said that they do not have Queens's jewelry, but only golden coins in bags. The famous demonstration of the polyphase rotary magnetic field with the egg of copper, with a few balls of brass and iron discs he performed the next day in his laboratory. The exhibition sample of the apparatus was constructed by Albert Schmid in 1893 according to Tesla's instructions. Originally it is a two-phase schema and Tesla transformed the two-phase into the three- and four-phase schema.

First, he put an egg on the top which was ran by the power of the rotating magnetic field. Everyone was stunned at the demonstration. He received the means for further research. The rotating magnetic field was the basis for the induction motor and Tesla had an image of an engine without any experiment and all functioned perfectly (he wrote about it in "My Inventions"). The induction motor is still in regular usage today.

#### 4. POETICAL DESCRIPTIONS AS AN INSPIRATION FOR THE THEORY OF ELECTRICITY

As mentioned above, papers titled as "My Inventions" can be regarded as an autobiography. It is, however, specific that some of Tesla's life events are connected with his inventions and although descriptions are vivid, Tesla does not forget that his audience are young experts, so natural events are explained with physical factors from which images of his inventions were derived. Figures and poetical descriptions are part of rhetorical argumentation in the context of explaining scientific claims, hypothesis and

theory. Their purpose is to explain the theory. Wasn't it Derrida who said that metaphors which cannot be understood are worthless?

#### 4.1 Heuristic meaning of poetry and poetical descriptions

The famous German writer, poet and dramatic, Johann Wolfgang Goethe (18. ct.) is very important inspiration for scientific imagination and discoveries of physical truth in the work of Nikola Tesla. Tesla became familiar with Goethe in his youth. He was affected by verses from Faust (I. part "In front of the city gates") which he recited during walks through Budapest city park in 1882 with his friend and colleague Antal Szigety after which he got inspiration for the idea as a "flash" and truth about induction motor and implementation of the revolving magnetic field (Tesla 1915, according to *Articles* published in 2006: 77-83, 1919: 38; Tesla 1919, according 1987: 44)

(<http://www.tfcbooks.com/tesla/1917-05-08.htm>) (7. April 2014). It was February and the sunset reminded Tesla on Goethe's verses written originally in German in the paper „My Later Endeavors – The Discovery of the Rotating Magnetic Field“:

„Sie rückt und weicht, der Tag ist überlebt,  
dort eilt sie hin und fördert neues Leben.  
Oh, dass kein Flügel mich vom Boden hebt  
Ihr nach und immer nach zu streben!  
Ein schöner Traum indessen sie entweicht,  
Ach, z udes Geistes flugeln wird so leicht  
Kein körperlicher Flügel sich gesellen!“

English translation of Goethe verses is in the same paper „My Later Endeavors – The Discovery of the Rotating Magnetic Field“ and first 4 verses, probably according to the same source in *Electrical Experimenter* (1919) mentions O'Neill (1944: 26)<sup>12</sup>

„The glow retreats, done is the day of toil;  
It yonder hastes, new fields of life exploring;  
Ah, that no wing can lift me from the soil  
Upon its track to follow; follow soaring !

A glorious dream! though now the glories fade.

Alas! the wings that lift the mind no aid

Of wings to lift the body can bequeath me!“ (Goethe verses from “Faust” according to Tesla 1919, according to 1987, p. 44; acc.: <http://www.tfcbooks.com/tesla/1919-00-00.htm>) (4. April 2014).

Further on he writes how Archimedes was his role model and that at the moment he got an idea he was drawing schemes in the sand which he later on combined as illustration to his patent submission in May 1888. He corroborates his primacy over the invention with conducted experiments in 1883 which repeatedly confirm his theory of the rotary magnetic motor by alternating current without commutator stating the fact that it was the method in which he got patent rights.

Tesla got a lot of public attention for the extensive article which consisted of 6 chapters titled “The problem of increasing human energy” published in 1900 in the journal *The Century Magazine*. Article described his experiments in Colorado Springs in the period btw. 1899 to 1900. Although that was the paper intended for a wider audience,

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<sup>12</sup> O'Neill, J. J. (1944). *Prodigal Genius: the Life of Nikola Tesla*. [http://www.ebook3000.com/Biographies/Prodigal-Genius--The-Life-of-Nikola-Tesla\\_118192.html](http://www.ebook3000.com/Biographies/Prodigal-Genius--The-Life-of-Nikola-Tesla_118192.html), (13. October 2014).

he often uses logical reasoning, but it is also interesting for the adequate placement of poetical figures by which his ideas become closer to his audience and by which he presents his scientific ethos as poetic. In the introduction he gives a poetic touch on eternal metaphysical questions and continues with figures of speech, contrasts and metaphors.

The poetry of great Goethe could have been a trigger for some inventions, but he also uses him for the purpose of poetical presentation concluding one chapter on wireless energy transfer in the future with verses of Goethe's "Hope". Poetical conclusion of a chapter is the ending of the extensive article in *The Century*.

"The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter – for the future. His duty is to lay the foundation for those who are to come, and point the way. He lives and labors and hopes with the poet who says:

'Schaff' das Tagwerk meiner Hände,  
Hohes Glück, das ich' s vollende  
Las, o lass mich nicht ermatten.  
Neine, es sind nicht leere Träume;  
Jetzt nur Stangen, diese Bäume  
Geben eins noch Frucht und Schatten.' "

(Tesla 1900, according to 2006 *Articles*: 145-146; "The problem of Increasing Human Energy", *Century Illustrated Magazine*, June 1900, [www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

Daily work – my hands'  
employment,  
To complete is pure enjoyment!  
Let, oh, let me never falter!

No! there is no empty  
dreaming:  
Lo! these trees, but bare poles  
seeming,  
Yet will yield both food and  
shelter!”<sup>13</sup>

([www.tfcbooks.com/tesla/1900-06-00.htm](http://www.tfcbooks.com/tesla/1900-06-00.htm)) (4. April 2014).

## 5. CONCLUSION

Tesla`s published works give significant contribution to scientific rhetoric for informing and persuading different audiences (universal audience about patents and particular audience in lectures, papers, autobiographic descriptions of inventions). Also, he adapted the rhetorical structure in various kinds of papers and presented various rhetorical styles – from the purely scientific (patents, lectures for experts), elegant heuristic with poetic elements (“My Inventions”; “About Electricity” etc.).

He gave an insight into the scientific process (experiments – deduction, theory – analogy – realization) and used various modes of probability depending on type of paper and audience in persuasion. In persuasion Tesla takes different modes of probability in consideration. When referring to past inventions which showed usability in industry and when he has to persuade the professional elite of the advantages of alternate-current (AC) instead of direct current (DC), he is persuading with highest probability – certainty. However, when he is talking about future science development, for instance about energy without other expandable resources of energy, about usage of wind or Earth gravity, he is aware that it is just a possibility.

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<sup>13</sup> Goethe`s “Hope” translated by William Gibson, Com. U. S. N.

In his work he used metaphors and figures for support the theory of electricity, and also analogies which are helpful in understanding that theory. We should state Tesla`s ethical appeals: his work is permeated with hope that scientific achievements and inventions have to serve the wellbeing of mankind and restoration of peace.

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